JUDGMENT AND DECISION:
Theory and Application

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INTRODUCTION

Judgment and decision making are topics that for many years have stood apart from other areas of psychology. They are presumably facets of human information processing and part of the larger field of cognitive psychology. An informal survey of current textbooks suggests, however, that if the study of judgment and decision making is an important part of cognition, the fact is not widely recognized. Nevertheless, investigators studying these processes have recently shown an increased interest in their relationship with other cognitive mechanisms. The interaction between judgment and decision research and
other topics in psychology reflects important theoretical developments in the area.

A judgment or decision making (JDM) task is characterized either by uncertainty of information or outcome, or by a concern for a person's preferences, or both. Unlike other tasks, there may exist no criterion for determining whether a single choice or judgment is correct, since the response is based in part on personal opinions or preferences. It is possible, however, to impose a mathematical or logical structure on the task that defines the consistency of a set of responses. The prescriptions for consistent behavior are generally derived from formal probability theory and from Expected Utility (EU) theory,¹ a prescriptive model of choice founded on axioms proposed by von Neumann & Morgenstern (1947). Bayesian decision theory (e.g. Raiffa & Schlaifer 1961) is a prescriptive theory of choice based on a combination of probability theory and EU theory. The validity of these prescriptive models as descriptions of human behavior has for many years been a dominant theme in this area.

Numerous authors have demonstrated that judgments depart significantly from the prescriptions of formal decision theory (see Kahneman et al 1982). An earlier review of behavioral decision theory (Slovic et al 1977) was largely devoted to a description of these inconsistencies. To account for the findings, investigators have explored the information processing strategies, or heuristics, that people use when making judgments. The significance of these inconsistencies, and the status of judgmental heuristics, has been a matter of dispute. The inconsistencies may point to limitations of prescriptive models rather than to limitations of human judgment; heuristics may be adaptive mechanisms for coping with a complex, dynamic environment, not just efforts to overcome cognitive limitations (Hogarth 1981, 1982). Since theorists are also human, and hence liable to the same biases as their subjects, there may exist a "bias heuristic" that leads psychologists to see biases in all forms of judgment (Berkeley & Humphreys 1982). The last chapter in this area in the Annual Review of Psychology included a critical discussion of the adequacy of prescriptive models for evaluating judgment and decision making (Einhorn & Hogarth 1981). The debate is important and interesting; nevertheless, it should not distract attention from the cognitive mechanisms on which judgments are based. We are primarily concerned, therefore, with the degree to which prescriptive models clarify the JDM process itself.

One reason for the concern with prescriptive models is that they provide guidelines for aiding the decision process. The interaction between basic research and applied problem solving has been of continuing interest to investigators in this area (see, e.g., Humphreys et al 1983). Errors of judgment

¹The following acronyms are used in this chapter: EU, expected utility; IIT, integration theory; IDM, judgment or decision making; MAU, multiattribute utility; SJT, social judgment theory.
suggest ways in which performance might be improved, especially if one understands why the errors occurred. For this reason alone it is important to know if inconsistent judgments indicate human failures, biases in research methods, or the superiority of human judgment over prescriptive analyses.

**THEORETICAL ORIENTATIONS**

*Historical Background*

The current state of theory in judgment and decision making represents a blend of formal prescriptive approaches, other algebraic representations of JDM processes, and models based on hypothetical cognitive mechanisms. The influence of prescriptive decision theory has been strong, although it may in the past have served to keep the study of decision making separate from other topics in psychology. Basic concepts of decision theory have been used in other areas to account for behavior ranging from signal detection (Green & Swets 1966) to word recognition (Atkinson & Iuola 1973). Prescriptive models apparently have been more successful in describing these simpler, automatic processes than in describing judgments that require thoughtful deliberation.

Within psychology, JDM theory has its origins in theories of perception, especially the probabilistic functionalism of Egon Brunswik (see Hammond 1966), and the methods of psychophysical measurement and scaling (Hammond et al 1980). Such traditions as associationist theory and information processing theory have until recently had little impact on JDM theory. While several authors have pointed out the relevance of theoretical developments in cognitive psychology for understanding decision behavior (Pitz 1977, Svenson 1979, Payne 1980), there is as yet little systematic formulation of any topic in JDM research based on associationist or information processing principles.

Apart from the EU tradition, the most important influences on research in judgment and decision processes have been the functional measurement methodology developed by N. H. Anderson (1970) and social judgment theory (Hammond et al 1975). These approaches share a concern with the information integration process and use algebraic models to show how judgments are related to stimulus information. In their origins these theories have little in common with other approaches to cognition. Recently, however, theorists using algebraic models have used the models to test hypotheses about the details of information processing (Lopes 1982b, Wallsten & Barton 1982, Wilkening & Anderson 1982).

*Prescriptive Theories*

Prescriptive decision theory provides a set of rules for combining beliefs (probabilities) and preferences (utilities) in order to select an option. The theoretical distinction between beliefs and preferences has been one of the most
significant of decision theory's contributions to the study of behavior. In evaluating formal decision theory as a foundation for descriptive models, it is helpful to keep this distinction in mind. For example, it is possible in principle to validate a statement of belief but not a preference or value judgment. Because a prediction of future events can be verified, the probability theory component of formal decision theory has rather more prescriptive force than assumptions about the structure of a person's value system. The result is that the prescriptive role of EU theory remains controversial. Suppose, for example, that a person's stated preferences are inconsistent with the theory; should one try to convince him that the behavior is irrational, or seek a prescriptive model that is consistent with his stated preferences? The former solution is difficult, since there is no criterion other than personal judgment that can determine the validity of the prescriptive model (Einhorn & Hogarth 1981).

Two forms of criticism can be raised against prescriptive models: the general constraints may be unrealistic, or a specific model may be applied in a context for which it is not suitable. The particular axioms of EU theory have not been universally accepted. Recently the relevance of the more general principle of consistency has also been questioned. Hogarth (1982) points out that there are costs associated with consistency, that consistency is just one of several desirable properties associated with judgments. Inconsistency may itself have desirable properties, while forced consistency may interfere with a search for novel or creative solutions. Consistency, then, is just one attribute to be considered in choosing a problem solving strategy.

Apart from general concerns with EU theory, one might argue that it is often applied inappropriately. For example, Lopes (1981) discusses its limitations for prescriptive purposes when a person must make a single, isolated decision. Taking a different point of view, Hogarth (1981) makes a distinction between the natural, "continuous" environment, for which the usual prescriptive models are perhaps inappropriate, and the limited, "discrete" environment in which tests of prescriptive models are normally carried out. He suggests that the heuristics that lead to errors in the discrete environment may be quite adaptive in a continuous environment. An important point raised by Berkeley & Humphreys (1982) is that a judgment or decision problem involves multiple sources of uncertainty, some of the most important of which are not addressed by any prescriptive model.

Such criticisms suggest that a broader formulation of prescriptive theory is needed in which the distinction between description and prescription is made less important. One approach is to adopt a multidimensional definition of utility in which as many attributes are used as is necessary to describe the decision maker's preferences. Lopes (1981) suggests that additional attributes be incorporated into the analysis of a problem to provide a more realistic representation. Formal analyses that adopt a multiattribute perspective have been de-
veloped. Fishburn (1980) described an EU model that incorporates a separate utility for gambling, a concept that violates the spirit of the original theory, yet which may describe a person's preferences more accurately. Bell (1982) discussed the role of "regret" in the analysis of decision making. He assumes that the decision maker compares an obtained outcome with other outcomes that were not obtained, and that reduced monetary gain may be accepted in order to minimize this retrospective regret. Rohrbaugh et al (1980) provided evidence that the equity of the distribution of outcomes across people is an attribute that a decision maker might want to treat independently of total gain; a multiattribute extension of EU theory (Keeney & Winkler 1982) enables the theory to deal with concerns about equity.

The use of multiattribute utility (MAU) theory has greatly increased the scope of application of formal decision theory (see Keeney 1982). An analysis of a problem using MAU theory still requires the construction of a logically coherent value structure, but it may be possible to resolve inconsistencies by adding more elements to the structure. MAU theory then becomes little more than a description of a decision maker's preferences, rather like the result of functional measurement or social judgment theory. This by no means reduces the practical value of the analysis, of course; more emphasis is placed on the clarification of a person's preferences and less on prescriptions for action. The use of the theory for explanatory purposes, however, demands that other constraints be imposed to provide parsimony of explanation.

The multiattribute application of prescriptive theory has had an important impact on psychological theory at a different level. It is widely recognized that JDM processes are not invariant across task environments (Payne 1982) and that a person might use any of a number of strategies to arrive at a judgment or decision. Beach & Mitchell (1978) and Russo & Dosher (1983) suggest that the choice of strategy depends on the cognitive effort that it requires (see also Smith et al 1982). There exists, therefore, a higher level process of cost-benefit analysis (Payne 1982) that might be used to select a strategy. The degree of effort used to reach a decision will be considered, along with the expected benefits of a more elaborate strategy. One problem with this approach is that it can lead to an infinite regress: since a cost-benefit analysis of possible strategies may itself require cognitive effort, how does a person decide to employ such a cost-benefit analysis? Is that decision also subject to a cost-benefit analysis? The problem of leaving a person paralyzed with indecision about his decision process can be solved by assuming that the analysis occurs automatically without deliberate control. As in the case of, say, word recognition, a prescriptive model may find its most suitable application in describing automatic, nondeliberate processes.

Schoemaker (1982), in a review of EU theory, concluded that the theory has been and continues to be productive. In spite of its limitations from both the
prescriptive and descriptive perspective, "much of the research would not have resulted without the existence of EU theory in the first place. As such, the model has yielded deeper insights and more refined questions, both descriptively and normatively."

The interaction of prescriptive and descriptive theory through multiattribute formulations of decision problems promises to increase further its prescriptive value (e.g. Kunreuther & Schoemaker 1981), as well as its descriptive power.

Algebraic Models of Judgment and Decision

The prescriptions of EU theory and its extensions can be presented in algebraic form. There are other algebraic models of judgment and decision that are not derived from normative considerations. The best known is N. H. Anderson's information integration theory (IIT: Anderson 1981), which uses algebraic formulations to describe judgments based on multiple sources of information. Hammond's social judgment theory (SJT: Hammond et al 1975), based on Brunswik's (1952) lens model, makes use of correlation and regression analysis to relate judgments to environmental variables. SJT generally uses external measurements of environmental cues; IIT provides a technique for establishing scales of psychological magnitude for external cues. Both theoretical approaches are concerned with the process by which information from different sources is combined. Theoretical methods for determining the integration rule are well established for IIT. Functional measurement (N. H. Anderson 1970) was designed to provide a simultaneous validation of the scale values and the algebraic model of the integration process, although Birnbaum (1982) has criticized some of the claims made for functional measurement in this respect.

Most algebraic models (including EU and MAU theory) rely on some version of a linear combination rule, at least as a first approximation. One advantage of a linear rule is that it serves as an excellent approximation to many nonlinear processes, which means that for prediction purposes a simple linear model is often sufficient (Dawes 1979). When one wants to know more about the process being modeled, however, a simple test of a linear model is rarely sufficient. Anderson's functional measurement methods provide a logic for testing a model of information integration. Birnbaum (1982) has extended the logic further, using the criterion of scale convergence to assess the adequacy of the algebraic model. He uses judgments of composites of stimulus features and judgments of differences between features to show that both can be accounted for by the same model.

The central concern in using algebraic models is to find an algebraic rule—e.g. adding, multiplying, or averaging—that can be used to describe judgments. At first the research consisted primarily of a catalog of tasks that give rise to each kind of integration process. Recently there has been progress toward a higher level of understanding that relates the integration rules to more
general principles. For example, perhaps the most widely observed integration process is an averaging rule (see Shanteau & Nagy 1982 for a summary). Significant departures from an averaging rule can be observed, however, and Birnbaum (e.g. Birnbaum & Stegner 1981) has proposed a configural-weight averaging model to account for some of the failures of a simple averaging model. In these models the effect of a stimulus feature depends in part on its relation to other features. By including such contextual effects in the algebraic model, it becomes capable of describing a variety of cognitive operations.

In many respects, the most interesting findings in studies using algebraic models of information integration are the failures of the model. In a study of judgments based on MMPI profiles, Wallsten & Budescu (1981) found that failures of the additive model occurred more often with experts than with less expert subjects, presumably because of the experts’ ability to use more complex rules. Hammond (1980) has proposed that an averaging process reflects an intuitive strategy that is more likely to be used when the task is complex and unfamiliar, a hypothesis that is supported by the Wallsten & Budescu results. Wallsten & Barton (1982) used an additive model to describe the processing of probabilistic information. While the model is of interest in its own right, violations of additivity do occur. The authors suggest that subjects use a two-stage judgment process; the first stage, suggestive of Hammond’s intuitive processing, leads to a tentative judgment; the second incorporates a more complex, configural analysis.

Information Processing Orientations

The growing interest in cognitive mechanisms is the result of two sets of findings: the changes in judgments that occur as a function of changes in the way a task is presented (Payne 1982), and the observation that people use simplifying heuristics to deal with complex judgment tasks. These findings are interconnected; many demonstrations of task-dependent results, such as the effect of the “framing” of a task on judgments (Tversky & Kahneman 1981), show that the invariance demanded by prescriptive models is not present. What is significant for a cognitive psychologist is that the context in which a judgment is made affects that judgment. Many variables other than those to which a person is asked to respond can be shown to affect the judgment: the thematic background (Einhorn & Hogarth 1982b), the number of alternative choices given to or provided by a subject (Einhorn & Hogarth 1982b, Koriat et al 1980), the availability of irrelevant references (Gilovich 1981), and the kind of judgment required (Hershey & Schoemaker 1983). None of this is surprising, of course. The results emphasize how significant are factors that affect the salience of task features, and how important is the encoding of a problem and its representation prior to an attempted solution (Griggs & Newstead 1982). A review of findings in this area led Payne (1982) to conclude that an understand-
Ining of psychological mechanisms is emerging that relies on a "time-dependent" or process analysis of JDM tasks, and which involves a "contingent mixture" of several decision processes.

Studies of heuristics and task-dependent judgment processes generally adopt one of two perspectives that reflect different views of the automaticity of the processes. Some authors, notably Kahneman & Tversky (1982a), have drawn an analogy between judgmental heuristics and perceptual processes. They suggest that errors, biases, and context-dependent judgments are the result of cognitive mechanisms of which subjects are largely unaware (Tversky & Kahneman 1981). An alternative view is that strategies of judgment are under a person's deliberate control. This view is implied in studies that use process tracing techniques to examine strategies. Several studies have examined information search patterns to infer the underlying strategy (e.g. Herstein 1981, Montgomery & Adelbratt 1982, Shaklee & Fischhoff 1982). Subjects may be asked directly what decision rule they would use (Adelbratt & Montgomery 1980), or the decision rule may be inferred from verbal protocols (Crow et al 1980, Klein 1983). There has been some dispute concerning the suitability of verbal reports as a source of data (see Ericsson & Simon 1980). Kellogg (1982), in a study of concept learning, suggests that such reports are useful sources of information if the process is deliberate, but not if it occurs automatically. It is likely, therefore, that verbal protocols can provide useful information about deliberately selected judgment strategies but not about the more automatic, intuitive processes. Hammond (1980) makes much the same point.

Both automatic, perception-like heuristics and more deliberate information processing strategies are involved in most JDM tasks. So far neither has been the subject of a formal model or systematic body of research as have, say, EU theory or IIT. Process tracing studies have been successful in describing strategies, but generally not in predicting their use (Klein 1983). Theories of judgmental heuristics have often been ad hoc; Wallsten (1983) points out that much of the literature consists only of a catalog of biases. Such an approach is obviously limited in explanatory power unless it includes a statement of the principles that govern the use of each heuristic. A systematic theoretical presentation has not yet been developed, in part because it has proved difficult to specify the conditions under which a given finding will be observed. Consider one of the most widely used concepts in heuristic theory, representativeness. A dispute between Bar-Hillel & Fischhoff (1981) and Manis et al (1981) concerning the effect of base rates on inference illustrates the difficulty of making predictions based on the supposed representativeness of stimuli. A recent paper by Tversky & Kahneman (1982) does much to clarify the definition of representativeness, but it also implies that this is not a unitary concept.

Theories often proceed from loosely stated ideas to more formal model building. Loosely defined concepts abound in information processing accounts
of JDM. Prescriptive and other algebraic models are readily given precise formulation, but formal models of encoding processes, judgmental heuristics, and decision strategies are rare. Apart from algebraic models, there are two other ways to formalize a theory: use complex information processing models to simulate the sequence of operations postulated by a theory (Simon 1979), or define elementary cognitive operations that can be used to predict performance in several tasks (Posner & McLeod 1982). Although initial steps in these directions have been taken, neither approach is well developed in the study of JDM. A positive development is the increasing integration of algebraic models and process models of cognitive mechanisms. Einhorn et al (1979) concluded that these are complementary approaches concerned with rather different aspects of the JDM task. That they are complementary is clear; that they must deal with different processes is less so. Lopes (1982b) has shown how process models might be integrated with algebraic models of the information integration task. Wallsten's research (Wallsten & Budescu 1981, Wallsten & Barton 1982) relies on algebraic models to test hypotheses about information acquisition processes. The stage seems to be set for the integration of theoretical orientations through the combined use of different methodologies.

JUDGMENT AND DECISION PROCESSES

If a general theory of judgment and decision making is to be found, it would be helpful to establish a compendium of basic cognitive mechanisms involved in JDM tasks. We organize this section of the review by assuming the existence of a sequential process that passes through separate stages. We recognize that it is a recursive activity; at each stage there may be subsidiary decisions to be made. When a problem is presented, salient features are identified, other information is retrieved from memory, and a meaningful organization of this information is created. The various sources of information are evaluated and integrated, and a judgment or choice is generated.

Sources of Information and Uncertainty

The description of a problem includes many features arranged in complex patterns. Before a person can respond he must encode the information and develop a representation for the problem. One way of describing the representation is as a "mental model" (Johnson-Laird 1981) that relates the problem to other knowledge. In building the mental model there are many issues left uncertain by the problem statement, uncertainties that must either be resolved or represented in the model in some way. These uncertainties include the unpredictability of future events, together with such less obvious unknown factors as one's likely feelings after a choice has been made (Berkeley & Humphreys 1982). The way in which these uncertainties are represented in the
mental model has marked effect on the subsequent judgment. The nature of this effect is dependent in part on the way a problem statement is worded (Tversky & Kahneman 1981, Slovic et al 1982) and in part on the idiosyncratic perspective adopted by the decision maker; the result is not always easy to predict (Fischhoff 1983).

The perspective adopted by Berkeley & Humphreys (1982) suggests that judgments and decisions occur as responses to uncertainty; the initial statement of a problem leaves many questions unanswered, and a person's subsequent behavior is a reflection of efforts to remove or cope with the uncertainty. To resolve uncertainty, information is retrieved from memory and used to fill in missing details of the mental model. For example, while the hypotheses to be evaluated or the options to be considered are sometimes defined as part of the problem, in many cases they too are unknown and must be generated before a decision can be made. Mehle (1982) and Mehle et al (1981) suggest that people are unable or reluctant to search for more than a small number of plausible options.

Because recall is constructive rather than reproductive, the use of information is guided by the model itself in an interactive way. There are numerous sources of information that are likely to have different effects on construction of the model. Kahneman & Tversky (1982b) distinguish between external (environmentally determined) and internal (knowledge based) uncertainty, and between uncertainty based on event frequencies and uncertainty based on reasoned argument. The use of event frequencies is perhaps best understood and appears to be easiest for a person to deal with. Assuming that events are equally salient, information retrieved from memory can be used accurately to assess relative frequencies (Howell & Kerkar 1982), and tasks that demand the direct use of this information are performed more accurately than tasks that require frequencies to be translated into, say, probability judgments. The effect of other kinds of information is more complex. The more information is given directly or retrieved from memory, the less uncertainty the person feels, but there is often an unwarranted increase in confidence as additional information becomes available (Fischhoff & MacGregor 1982). If one draws attention to potentially conflicting information, it may be possible to reduce this overconfidence (Koriat et al 1980), but it is not always possible to direct attention exclusively to relevant information (Fischhoff & Bar-Hillel 1982).

No account of the JDM process is complete unless it speaks to the representation of the problem; the representation in turn depends on how prior experience is incorporated into the mental model created for the problem. In the study of deductive inference it is well known that the conclusions drawn from a set of premises are generally consistent with a person's experiences, but not necessarily with principles of deductive logic (Johnson-Laird & Wason 1977). If an abstract problem can be formulated in terms that are consistent with experi-
ence, the person responds appropriately (Cox & Griggs 1982). Thus, a critical variable in the successful application of an abstract principle is whether the wording of the problem leads to a representation that is consistent with the principle (Griggs & Newstead 1982). Kahneman & Tversky (1982a) draw similar conclusions concerning inductive inference: "human reasoning cannot be adequately described in terms of content-independent formal rules." A full understanding of the judgment process depends on how experience is organized. To obtain a complete specification of a person's knowledge is an overwhelming task, but there may be certain prototypical situations that are widely recognized (Cantor et al 1982); it may be possible to define general principles of judgment for these prototypes.

**Bases for Inference**

The use of existent information to derive further propositions about the problem is the basis for inference in a JDM task. The most frequent accounts of the inference process rely on the concept of "representativeness," a term that Tversky & Kahneman (1982) define as a relation between a hypothetical process and some event associated with the process. Use of the term for theoretical purposes is complicated by the fact that in different contexts it means different things. Sometimes it describes the relationship between a population (e.g. the population of undergraduate students at some college) and a sample selected from the population. In other situations representativeness is determined by the similarity of a hypothetical process (e.g. a possible disease) to observed outcomes (e.g. symptoms exhibited by a patient), or by the perception of a causal relationship between process and outcome.

For some problems the perception of representativeness is mediated by judgments of similarity, for example, the similarity of a personality description to a general stereotype. It has proved as difficult to define similarity satisfactorily as it is to define representativeness. One traditional approach is to use multidimensional geometric models in which the proximity of two items in space determines their perceived similarity. The difficulties with such models have been pointed out by Gati & Tversky (1982) and Tversky & Gati (1982). For example, by adding a common feature or extra constant dimension to two stimuli, the apparent similarity is increased; geometric models cannot account for such a result. Tversky and Gati propose instead a feature-based model in which similarity depends on a linear combination of common and distinctive features. For the most part their model applies to tasks that require direct perceptual judgments, using stimuli such as simple schematic figures. It is presumably easier to define relevant features for schematic figures than it is for complex decision problems. Nevertheless, these theoretical developments may be the first steps toward a general characterization of judgments based on perceived similarity.
A model of similarity judgments must consider not just single features or dimensions, but also the pattern of co-occurring features. For example, Bar-Hillel (1980) suggests that the judged likelihood of a sample is determined by the similarity of configural patterns in the sample (e.g. the configuration of test scores for a sample of students) to a prototypical sample. Studies of concept learning and categorization (e.g. Hayes-Roth & Hayes-Roth 1977) suggest that a person abstracts information about patterns of common events, so that the similarity of an event to a prototype depends on whether a pattern has occurred frequently for that prototype. There is much in common between judgments of category membership and judgments of representativeness. Like other judgments, covariation is evaluated in the context of a more general mental model. For example, Pitz et al (1981) suggested that frequency judgments in a complex environment are mediated by hypotheses about the structure of the problem; changes in judgment occur only if information disconfirms a current hypothesis. Perceptions of covariation are jointly dependent on observed information and prior assumptions about the problem setting; there is an interaction between the judged frequency of co-occurrence and knowledge of causal connections between the events (Adelman 1981, Jennings et al 1982). Thus, Abelson (1981) has argued that abstract generalizations of cause-effect relationships, or scripts, mediate the perception of covariation among events.

If perceived causality is an important determinant of how a person represents a problem and uses the information, it is necessary to know what determines the perception of causality. Einhorn & Hogarth (1982b) have conducted a detailed study based on the hypothesis that the perception of a causal relationship between two events is a function of several "cues to causality" that might be present. They assume that cues such as temporal order, contiguity in space, and similarity, combine additively to determine the strength of an impression of causality. A similar approach to defining indicators of causality was used by Schustack & Sternberg (1981), who used a regression analysis to determine the effect of various indicators.

It is unlikely that the outcome of these studies will be a simple definition of necessary and sufficient conditions for causality to be recognized. The perception of causality, like covariation, is a dynamic process. When people can select information relevant to a causal hypothesis, they seek mostly to confirm their current hypothesis rather than explore others (Shaklee & Fischhoff 1982). Einhorn & Hogarth (1982b) emphasize that judgments of causality depend on the context in which judgments take place; two events may be seen as causally connected in one context but not in another. In addition, an important determinant of perceived causation is the absence of other explanations for the phenomenon.

Inference can be regarded as filling in gaps in the representation of a problem. Building a mental model involves fitting known details of a problem
to a network of abstract propositions in order to extrapolate beyond explicit information. Perceptions of causality are important in guiding this inference process. The process is apparently designed to make optimum use of a person’s general knowledge; for example, when using categories to represent events there are certain “basic level” concepts: DOG is more basic than either POODLE or MAMMAL (Rosch 1978). The basic level category maximizes within-category similarity relative to between-category similarity, suggesting that there exists an optimal level of detail for descriptive and inferential tasks. Compare this result with one of the demonstrations of bias due to representativeness: an event such as “Bjorn Borg will lose the first set of a tennis match but win the match” is considered to be more probable than the more general event, “Bjorn Borg will lose the first set” (Tversky & Kahneman 1982). People do not recognize in this case that the probability of an event must decrease as the event is described in more detail. Presumably the added detail provided for the first event makes it more representative, i.e. more plausible given one’s general knowledge, so it is judged more probable. While a person responding this way has clearly made an error, there is an important question not addressed: has the probability of the more general event been underestimated, the probability of the more detailed event been overestimated, or both? In other words, is there an optimum level of detail for making inferences, and does it correspond in some way to the optimum level of detail that applies to the use of categories? The answer to this question would have important practical as well as theoretical implications.

**Conflict, Integration, and Tradeoff**

Complex problems are characterized by conflict, either in the inferences to be drawn from the information or in the decision maker’s preferences for outcomes. To resolve the conflict it is necessary either to eliminate all but a subset of mutually consistent features or to integrate the conflicting information to produce a composite judgment. Linear models of information integration, especially those that presume the existence of an averaging process, imply that integration occurs by averaging the values assigned to each feature according to their relative weight. The ubiquity of the averaging process is one of the most interesting findings to emerge from the information integration literature (Lopes 1982a, Shanteau & Nagy 1982).

In spite of the widespread use of averaging models, not much is known about the cognitive determinants of the weighting process. Weights are often considered to be a function of the salience of problem features (Shanteau & Ptacek 1983), but such an account partly begs the question and is to some extent misleading. Several procedures can be used for estimating weights, and different methods give rise to different estimates, perhaps because the methods are subject to different kinds of errors (Arnold & Feldman 1981, Barron 1981,
Murphy 1982). The most productive account of weights is that which shows relationships between estimated weights and other behaviors. Birnbaum & Stegner (1981), for example, demonstrated that estimates derived from a configural weight averaging model are predictive of a person's judgments in a different context. Estimates of IQ, based on information about the intelligence of a child's biological and adoptive parents, generated weight estimates that were related to a person's attitudes concerning the determination of IQ. Birnbaum & Mellers (1983) discuss a number of studies which together suggest that information is weighted according to the trustworthiness of its source.

An averaging process is a compensatory integration mechanism in which a judgment represents a tradeoff among conflicting evaluations. In most cases the averaging process is assumed to be automatic and not subject to deliberate control or verbal report. The concept of an autonomous compensatory tradeoff process appears in several explanations of judgment processes: Einhorn & Hogarth (1982a) refer to such a process in the evaluation of diagnostic evidence and in judgments of causality (Einhorn & Hogarth 1982b). Cost-benefit theories of strategy selection suggest that a tradeoff exists between cognitive effort and judgmental accuracy. The problem with theories that assume a tradeoff mechanism is that they are hard to distinguish from noncompensatory, feature selection processes. Simply demonstrating that judgments of, say, causal connections are related to several different cues does not show that the cues combine in a compensatory fashion. It has been possible to distinguish between compensatory and noncompensatory deliberate strategies by examining verbal protocols, eye movement data, or other extended sequences of behavior (see below); no analogous procedure has been developed for the detailed study of automatic judgment processes.

At the other extreme from automatic processes that implement a cost-benefit tradeoff are the very deliberate tradeoffs required in decision analyses based on MAU theory. Applications of MAU theory are based on the assumption that compensatory tradeoffs can be made explicit (see, e.g., Edwards & Newman 1982). It is further assumed that preferences can be described by a hierarchical structure in which the more global objectives are defined by more precise objectives or attributes at lower levels. While these analyses are extensions of prescriptive EU theory, they depend for their validity on their accuracy as descriptive statements of a person's preference structure. Detailed tests of these assumptions have not been carried out, although a study by Shapira (1981) casts doubt on the ability or willingness of decision makers to establish tradeoff functions consistently.

**Behavioral Strategies in Judgment and Choice**

Whatever information processing occurs as part of the JDM process, the only observable behavior is a response—usually a judgment or a choice. This has

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PITZ & SACHS
not been a serious limitation for theorists using algebraic models, who have generally ignored the sequence of unobservable events that precede the response. Information processing theorists, however, have taken as their major concern the strategies that people use in acquiring and using information. By examining verbal protocols (e.g. Klein 1983) or eye movement recordings (Russo & Dosher 1983), it has been possible to examine overt behavior that precedes the final judgment or choice. From the protocols one can trace the sequence of operations involved in information acquisition and make inferences about the way the information is used. In spite of the promise of this approach, it is not yet possible to define the conditions under which particular strategies will be used. Klein (1983) attempted to relate traditional assessments of utilities to subjects’ decision rules; she was able to predict to some extent the attributes to which subjects would attend, but not the strategy they would use. Even the former result is subject to the usual caveats concerning correlational findings.

Most theories assume that evaluations of the information are translated into a response by procedures that are independent of the evaluation process. Functional measurement theory (N. H. Anderson, 1970) and Birnbaum’s (1982) methods of scale free model testing are two methods for separating the judgment process from the evaluation process. Within an information processing framework the most common account of the response process relies on the concept of “anchoring and adjustment”: an anchor point is selected that serves as a starting point for the response; it is then adjusted in a direction and by an amount determined by other features of the problem. The scope of application of such a process is very broad; it applies to any task in which a numerical response is required. Thus Einhorn & Hogarth (1982a) propose that anchoring and adjustment is a significant part of the inference process, Lopes & Ekberg (1980) show how the process might be used in evaluating the worth of risky gambles, and Lopes (1982b) uses a version of the process to explain how algebraic rules might be applied in an information integration task.

Some of the behavioral implications of judgment and decision strategies can be assessed by simulation studies. Using this approach it is possible to demonstrate the effect of any strategy that is defined explicitly for a given class of problems. Such an undertaking is a large one, because the results may depend on many problem parameters, but a first attempt has been reported by Kleinmuntz & Kleinmuntz (1981). The results can be helpful in providing a framework for describing observed decisions and for assessing the consequences of simplified heuristics from a prescriptive point of view. The latter concern is important because, as von Winterfeldt & Edwards (1982) demonstrate, large departures from the ideal strategy typically have little effect on the final payoff.
Development of Judgment and Decision Skills

There has been little integration of research on JDM processes with developmental theory (see Klayman 1982 for an exception). The neglect is unfortunate. Judgment processes are the consequence of many years of learning and maturation. Consider, for example, the assumption that preferences can be represented as a goal hierarchy and described by tradeoff functions among conflicting objectives. Very little is known about the organization of preferences from a developmental point of view, but a widely cited theory of moral development (Kohlberg 1979) suggests that values develop through separate moral stages. Is a hierarchical tree a suitable representation for values that represent different stages of moral development? Is it possible to establish tradeoffs between values at different stages? Rest (1979) claims that moral stages indicate different organization of thought processes. If this is so, the problems people have in establishing tradeoffs (e.g. Shapira 1981) may well be the result of an inability to integrate different forms of organization.

Judgment and decision skills must develop along with other abilities. For example, Brainerd (1981) shows that simple frequency estimation is a skill that parallels the development of working memory. There are numerous other skills involved in decision tasks: people do learn rules for making inferences, and heuristic strategies of judgment must be acquired in some way. Recently J. R. Anderson (1982) has proposed a general theory of cognitive skills acquisition that might throw light on the developmental issues; he suggests that skills are represented at first as declarative (verbalizable) knowledge and become automatic with extended practice. The autonomous stage is described by production systems that can be modified to reflect new learning; productions are generalized as a person learns new applications for a skill, and finer discriminations are added to make them more selective.

A theory such as Anderson's might account for many findings in JDM studies, and can also serve as a guide for the development of training procedures and decision aids. For example, the distinction between automatic and deliberate processes has been made at several points in this review; the distinction is based on the procedural, nonverbalizable nature of the former and the declarative, verbalizable nature of the latter. One would expect procedural and declarative judgment skills to be sensitive to different variables and be differentially modifiable. If judgmental heuristics, for example, are autonomous cognitive skills, their development and modification will be an important topic for research.

Many of the errors that result from the use of heuristics appear to represent inadequate refinement of principles that are normally quite adaptive; judgments by representativeness, for example, only lead to serious errors when a person ignores such other factors as base rates. Within Anderson's theory, auton-
omous skills are refined by learning successively finer discriminations in the use of productions, but the process is time consuming. To be most useful, therefore, efforts to debias judgments should focus on extended skills training; they may require far more extensive practice than is normally provided in studies of this sort. Decision aids should be designed from the perspective of a systems analysis, making optimum use of both human and mechanical skills in the analysis of complex problems (see Pitz 1983).

APPLICATIONS OF THEORY AND RESEARCH

The final test of an understanding of judgment and decision processes is to develop procedures for helping people make important decisions. Several investigators have described aids for application to a broad range of problems, including medical diagnosis and treatment (Wright & Ng 1981), program evaluation (Edwards & Newman 1982), managerial planning (Ballou & Mohan 1981), military strategy (Cohen & Brown 1980), and problems of personal choice (Sachs & Pitz 1981). The existence of biases and errors in unaided judgments is part of the motivation for aiding the judgment process; the assumption is that aided judgments are less subject to error. The aid is based on a prescriptive formulation that decomposes the problem into its separate elements and presumably helps the decision maker to overcome the limitations of unaided judgments. Thus the development of decision aids requires an understanding of the processes involved in performing the task, together with a suitable prescriptive theory that can serve as a normative formulation for the problem. We review several aspects of decision aids that are important in terms of both the theoretical and practical issues that arise.

Building a Structure for the Problem

Before an analysis of a problem can be implemented, it is necessary to define the elements of the problem and the structural interrelationships among them. Several authors have pointed out how critical the problem structure is to the decision aiding process. In a description of a career decision aid, for example, Wooler (1982) suggests that its most useful contribution may be in helping a person understand the interrelationships and conflicts among elements of the problem. To be successful, the structure must represent both the external features of the problem and the knowledge and values of the decision maker. If the structure is completely task-determined, it can be built into the decision aid prior to its use. Nevertheless, even if the structure can be predefined, it may still be more helpful to have the decision maker generate the structure (Sachs & Pitz 1981). It is important to know, therefore, how best to make explicit a person's knowledge about the problem.

The best approach to generating a problem structure is likely to be one based
on a theoretical model of the structure of knowledge (Humphreys et al 1980). Pitz et al (1980b) discussed a number of methods for using a decision maker's description of problem elements to help the person recognize further details of the structure, based on assumptions about the organization of the underlying knowledge. Different methods may serve different purposes, depending on the way that the knowledge is to be used. Pearl et al (1981) found that a goal-directed approach proved best for encouraging a person to generate more options, while a decision tree structure was most successful in helping a person to recognize the best action.

**Incorporating Judgments into the Aid**

Decision aids require the decision maker to provide input in the form of judgments which are then integrated to provide feedback concerning appropriate courses of action. Following the tradition of EU theory, the required judgments are generally of two forms, predictions of uncertain future events and expressions of preference. The former usually take the form of probability statements, although some have suggested the use of concepts from fuzzy set theory for this purpose (Whaley 1981). Fuzzy sets are in principle more closely related to natural language and the organization of knowledge than is probability theory, although the applicability of fuzzy set theory to descriptions of language and knowledge has been questioned by Lakoff (1982).

Probability assessments require a person to make inferences about future events from whatever relevant information is available. The existence of biases in inferential judgment suggests that probabilistic inputs to a decision aid may often be in error. It is important, therefore, to determine under what conditions biases do occur and to measure their impact on the output of the decision aid. One approach has been to assess the calibration of probability judgments. An individual is said to be well calibrated if, in the long run, for all events assigned a given probability, the proportion of events that do occur is equal to the probability assigned (Lichtenstein et al 1982). In studies of calibration the dominant finding has been one of overconfidence: events occur in a proportion smaller than the assigned probability. There are important exceptions to this rule, however, that are apparently related to task characteristics. Accountants, for example, have been found to be underconfident (Tomassini et al 1982), while weather forecasters are well calibrated (see Lichtenstein et al 1982). People are also better calibrated when predicting future events than when answering general knowledge questions (Wright 1982, Wright & Wishuda 1982). This last result is significant for two reasons. First, it may provide a clue to the cognitive operations underlying estimates of uncertainty. Second, practical applications of decision aids are generally more concerned with predictions of future events than with assessing the accuracy of a person's general knowledge.
Two recent theoretical articles imply that studies of calibration are limited in their theoretical and practical usefulness. Kadane & Lichtenstein (1982) discuss the conditions under which, from a Bayesian point of view, one might expect a person to be calibrated. Their results imply that calibration depends more on the task—the events being predicted and relationships among them—than on characteristics of the probability assessor. Yates (1982) argues that other measures of performance in a probability assessment task are more appropriate for evaluating the performance of the assessor. It is likely, then, that calibration measures will be of limited value either for training users of decision aids or for understanding the cognitive mechanisms underlying uncertainty.

The coherence of probability assessments, i.e. the consistency of a set of judgments with the axioms of probability theory, is also a matter for concern when using decision aids. Here is an area in which training does seem to be effective. Wallsten et al (1983) demonstrated that consistency could be improved with practice. As noted earlier, Lopes (1982a) has shown that judgments can be made more consistent with prescriptive principles if one can identify the process by which the judgments are produced. Although not directly concerned with probability judgments, studies by Gaeth & Shanteau (1981, 1983) showing that expert judgments can be improved by training judges to ignore irrelevant information are potentially important for teaching people to use information more effectively.

A MAU model is usually employed to describe the decision maker’s preferences. Preferences are assessed by means of single attribute utility functions, together with weights that determine the impact of each attribute on the aggregate utility. Some of the difficulties that arise in assessing utility functions have been discussed by Krzyztofowicz & Duckstein (1980) and by Hershey et al (1982). Considerable attention has been paid to the problem of eliciting weights for MAU models. When using MAU theory for decision aiding purposes, the attribute weights should accurately describe the decision maker’s preference structure. While it is not easy to evaluate assessment procedures on this basis, they can be compared in terms such as the reliability and consistency of the results, the acceptability of the procedure, and the results to the decision maker (see Shapira 1981, Stillwell et al 1981, Schoemaker & Waid 1982).

We noted earlier that multiattribute formulations of decision problems tend to blur the distinction between descriptive and prescriptive theory. The use of MAU theory for decision analysis leads to an emphasis on problem description rather than prescriptions for action. An important example can be found in the analysis of situations involving risk in societal or personal decision making. Risk has traditionally been defined in rather narrow terms. It is apparent that most definitions do not capture the significant features of, say, the problems of disposing of nuclear wastes or the use of novel surgical procedures. A multiattribute description of risk is more effective. Hohenemser et al (1983) addressed...
the problem by defining the term “hazard,” a multiattribute description of threats to people and to what they value. They show that the description accounts well for people's judgments of risk. Slovic et al (1983), in their criticism of analyses of accidents that are based only on the number of fatalities, argue it is the perceived implications of accidents to which people respond; to understand their reactions demands an analysis of mental models that might be used as framework for understanding an accident.

**Evaluation and Implementation of Decision Aids**

Systematic research to evaluate decision aids is rare, in spite of the excellent review by Fischhoff (1980) of the need for such research. Fischhoff’s parallel between decision aids and psychotherapy makes clear the difficulties of conducting an evaluation. There have been a few studies showing that decision analysis (like psychotherapy) can have a positive impact on the decision maker (Nezu & D’Zurilla 1981, Kanfer & Busemeyer 1982). Part of the problem in evaluating aids, however, is finding a suitable criterion for the evaluation. Rather than setting a single criterion, one might examine several benefits provided by a decision aid, including increased understanding of the complexities of the problem (Humphreys & McFadden 1980), as well as greater reliability and the absence of systematic error (Cornelius & Lyness 1980, Lyness & Cornelius 1982, Pitz 1980, Pitz et al 1980a). The designer and evaluator of decision aids might set limited but measurable goals for the aid and evaluate progress toward those goals. Following Fischhoff’s analogy between decision analysis and psychotherapy further, one might note Winnicott’s (1965) definition of the “good enough therapist”—one who is adequate for the purpose of helping a person work through conflicts. Rather than trying to define the “better decision,” one might look for the “good-enough decision aid” that helps the decision maker achieve clarification of the problem.

If the emphasis for evaluative purposes is placed on clarification of the problem rather than on prescriptions for action, a critical concern is ensuring that an aid is used by those for whom it is designed. The problem of utilization has been raised by Wright & Ng (1981) and by McArthur (1980). Failure to use a decision aid can occur because the decision maker was not involved in its design (Adelman 1982) or because of a failure by the decision maker to accept assistance (Dickson 1981). Designing successful decision aids, therefore, requires the investigator to consider more than the cognitive mechanisms involved in the decision task; cognitive and affective variables related to the acceptability of the aid may be just as important.

In an important article, Tornatzky et al (1982) discuss the general problem of utilizing social science technology. Their comments are relevant in the present context. Among the causes of underutilization they list the nonproprietary nature of social science research, the disaggregation of support for the social
sciences, and the isolation of the social sciences from political decision making. These are not concerns that can be addressed readily by an individual investigator, but they are issues that may increase in importance as the development of decision aids becomes more advanced.

CONCLUSION

We began by defining research in judgment or decision making as a part of cognitive psychology. We ended by pointing briefly to its role in the larger context of social science research, both theoretical and applied. As soon as one tries to use theoretical insights to solve significant social problems, the impossibility of disciplinary compartmentalization becomes apparent. Fortunately, narrowness of focus is not likely to limit further development; there are many theoretical and methodological tools available to an investigator in this area, and no shortage of critical discussions of these tools. There now exists the foundation of a technology for explicating both the processes involved in making important decisions and the preference structure that should guide those decisions. It may not be possible to define prescriptive rules for these preferences and the decisions; it is possible, however, to help the decision maker explore the implications of a set of judgments and recognize their relationship to more general cognitive and affective structures.

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