AND LET US NOT FORGET MEMORY: THE ROLE OF MEMORY PROCESSES AND TECHNIQUES IN THE STUDY OF JUDGMENT AND CHOICE

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I. Introduction

Can you remember the last time that memory was *not* involved, in some form or other, in a decision or judgment you had to make? When asked to predict the July temperature in your city on the occasion of an impending in-laws' visit, you probably recalled July temperatures over the last few years. When thinking about a new car, you probably retrieved car models you had recently seen and admired on the highway. When deliberating about the job offer from the East Coast, you might have remembered the good times you had in that city during college and weighed those memories against the traffic congestion and high housing prices you recalled from your recent visit there. Considering the prevalent use of memory at many decision stages—including the generation of feasible alternatives, the determination of the utility of different outcomes, and the prediction of the likelihood of outcomes—it may come as a surprise to nonspecialists in the area of human judgment and decision making (J/DM) that, with some notable exceptions, most models of decision or judgment performance do not explicitly combine considerations of memory processes and of the representation of information in memory with other stages of the decision process.

This is not to say that memory considerations are new to J/DM researchers. However, the integration of memory concepts into theoretical and empirical work has been uneven and nonsystematic. Thus, memory processes have been adduced as explanations for particular phenomena, as in Tversky and Kahneman's (1973) theory that people judge the relative frequency of events by their availability, that is, by the frequency and ease with which instances can be retrieved. Hindsight bias is usually explained as a reconstructive memory problem, that is, as an inability to reconstruct one's prior state of knowledge after additional information has been added (Fischhoff, 1975; Hawkins & Hastie, 1990). Memory-related mechanisms such as the biased encoding and biased retrieval of information are also used to explain why people fail to learn the relationship between variables from experience (Brehmer, 1980), why their predictions are typically overconfident (Einhorn & Hogarth, 1978; Lichtenstein, Fischhoff, & Phillips, 1982), or why the utilization of base rate information appears to be sensitive to elicitation procedure and the knowledge base of respondents (Gigerenzer, Hell, & Blank, 1988; Weber, Böckenholt, Hilton, & Wallace, 1993).

Moreover, beyond the explanation of particular phenomena, memory considerations have had a broad, if indirect and diffuse, effect on general theory in J/DM research. Recognition that human working memory is of limited capacity (e.g., Miller, 1956) has had lasting impact on J/DM models through the work of Simon (1955, 1956), whose theories redefined the image of the typical decision maker from that of a "rational calculator" to that of a creature of finite resources forced to find practicable strategies for processing information in a "satisficing," and not necessarily optimal, fashion. This image of the decision maker as a limited capacity information processor contributed to the subsequent identification of different decision heuristics (Kahneman, Slovic, & Tversky, 1982) and decision strategies (Payne, 1982).

This indirect effect of memory considerations probably presents its greatest impact to date because of the central role that has been accorded in J/DM research to the concept of *decision strategy.* Numerous task and context effects have been attributed to the use of different decision strategies, that is, to the operation of different rules and procedures for the weighting and combination of information. For example, decisions have been shown to be sensitive to a variety of task and context characteristics, including "irrelevant" filler alternatives (Goldstein & Mitzel, 1992), time pressure (Ben Zur & Bresnitz, 1981; Böckenholt & Kroeger, 1993; Busemeyer, 1985), and the response mode subjects use to report their decisions (Goldstein & Einhorn, 1987; Huber, 1980; Lichtenstein & Slovic, 1971; Mellers, Ordóñez, & Birnbaum, 1992; Tversky, Sattath, & Slovic, 1988). To contain the proliferation of decision strategies postulated to account for these effects, unifying metatheories have been suggested to explain how adaptive and goal-directed organisms select strategies to tailor their decisions to the information, constraints, and tasks at hand (Hogarth & Einhorn, 1992; Payne, 1982). One widely held metatheory states that decision strategies are selected on the basis of an error–effort trade-off analysis (Payne, Bettman, & Johnson, 1988, 1990, 1993; Smith, Mitchell, & Beach, 1982). Metatheories about contingent strategy selection also exist in the domains of problem solving (Friedrich, 1993) and hypothesis testing (Klayman & Ha, 1987). In summary, memory *limitations* have impressed J/DM researchers more than other findings about memory, and J/DM researchers have mostly made use of memory limitations to motivate a concern for issues of strategy selection.

The idea that people select their decision strategies on the basis of an error–effort (or, more generally, cost–benefit) trade-off analysis represents one of the two main metatheoretical frameworks that have been proposed to account for the sensitivity of decision behavior to manipulations of the task and context (Payne, Bettman, & Johnson, 1992). The other approach is a perceptual framework, which attributes behavioral variability not to shifts in strategy, but to changes in the way that relevant information is framed (e.g., Tversky & Kahneman, 1981, 1986).

Strategy selection and information framing are important explanatory constructs within J/DM research and will continue to explain a broad range of phenomena. However, there is an increasing concern within the J/DM community that the theoretical and empirical focus of the field may be too narrow (Beach, 1993; Frisch & Clemen, 1994; Holbrook, 1987; Lopes, 1994). Much of this concern raises questions about the relative merits of psychological versus economic approaches, discussing, for example, whether descriptive or prescriptive models should serve as a theoretical starting point in the explanation of choice behavior. In this chapter, we argue that there is a need to enlarge the current set of explanatory constructs and experimental tools even *within* the confines of descriptive, psychological models of decision making, and we argue further that insights from the field of memory can help to supplement and enrich the explanatory constructs that are the focus of the strategy selection and perceptual frameworks.

First, we will argue that recent models of memory representation and memory processes have the potential to enlarge the set of explanatory constructs that J/DM researchers bring to bear on issues of strategy and strategy selection. Specifically, we describe some recent assumptions about the *format* in which information is represented, stored, and retrieved from memory, which offer new perspectives on whether the integration of information necessarily requires the deliberate use of an effortful decision strategy. We show in Experiment 1 that judgments thought to require the use of effortful information integration strategies (under traditional assumptions about memory) may, in fact, arise more effortlessly, as the automatic by-product of the way information is stored and retrieved. Not only does this show that the "work" of a decision strategy (i.e., information integration) might be accomplished nonstrategically, that is, without the use of processes deliberately invoked for this purpose, but this result also suggests that definitions and measures of cognitive "effort" should be reconsidered. We also review the gains in the predictability of judgment and decision making performance that arise from making several functional distinctions about the *content* of memory (i.e., semantic vs. episodic memory; declarative vs. procedural memory).

Second, we will consider the implications of memory research for the perceptual framework, which emphasizes the influence of information encoding. Research on information encoding within J/DM has been surprisingly circumscribed. Although Kahneman and Tversky's (1979) prospect theory included an editing phase that encompassed a variety of coding operations, J/DM research within the perceptual framework, with some notable exceptions (e.g., Brainerd & Reyna, 1992; Reyna & Brainerd, 1991), has concentrated mostly on just three: (1) the framing of outcomes as gains versus losses relative to a reference point (Kahneman & Tversky, 1979), (2) the aggregation versus segregation of events and options (Thaler, 1985), and (3) the restructuring of alternatives to reveal or create a dominance relation (Montgomery, 1983). Without denying the importance of these three coding operations, we consider the implications of memory research for relevant issues that may have been overlooked by this focus. Memory researchers are certainly not the only psychologists to have considered matters concerning the encoding and representation of information. However, because memory researchers traditionally divide their field into issues of encoding, storage, and retrieval of information, they have given more thought than most to matters of encoding. Specifically, we discuss the influence of prior experience (as opposed to concurrent task conditions) on the encoding of information. Then, in Experiment 2, we present an example in which short-term memory limitations lead to preference reversals, not as the result of changes in decision strategy, but as the result of simplification in the encoding of presented information. We conclude with a discussion of the way presented information may be elaborated in light of prior knowledge.

Finally, we will argue by review and by example that apparently unobservable mental events can be studied by means of experimental procedures that examine the memorial aftereffects of information encoding and prior processing. That is to say, memory can be used the way physicists use cloud chambers: to study otherwise unobservable events via the residue they leave behind. The use of memory techniques as experimental tools may thus allow researchers to distinguish between J/DM models that make similar outcome predictions but differ in their assumptions about underlying processes.

II. Memory Structure and Processes in J/DM Models

A. Beyond Strategy: An Expanded Set of Explanatory Constructs

1. Microlevel Assumptions about Memory

Most decision models, either explicitly or implicitly, assume a structure of knowledge representation that dates back to the 1960s and 1970s, that is, to a Newell and Simon (1972) cognitive architecture with localized representation of information and serial storage and retrieval processes. Alternative cognitive architectures with distributed representation of information and parallel storage and retrieval processes have since found widespread use in research on learning and memory, but their implications for models of judgment and decision making have not yet been fully investigated. We suggest that J/DM researchers consider new assumptions about cognitive architecture that include the possibility of distributed representation and parallel processing (Humphreys, Bain, & Pike, 1989; Metcalfe, 1990; Murdock, 1993; Rumelhart & McClelland, 1986; Townsend, 1990). We show that these distinctions are important, because different assumptions about the properties of memory representation and processes allow for different mechanisms by which information can be stored and combined and thus make different predictions about the cognitive "effort" required to implement particular processing strategies.

a. Distributed versus Localized Representation of Information. Cognitive architectures modeled on the architecture of a serial computer (e.g., Newell & Simon, 1972) have assumed that an item of information is represented in a localized way such that it can be stored in and subsequently retrieved from a single memory location. However, different cognitive architectures have since been suggested, including architectures modeled on a hologram in which an item of information is represented in a distributed way. *Distributed representation* gets its name from the fact that an item of information is distributed over numerous memory locations. A given item should thus be thought of as a vector of features, where a "feature" in a distributed-memory model is an abstract, usually numerical, variable that need not correspond to any physical or psychological feature, and the representation of a typical item is a vector of several hundred such "features." An advantage of such a distributed representation is that distinct vectors representing several different pieces of item information can all be placed and stored into a common memory vector; that is, different vectors can be superimposed without losing their individual identities. As a result, an overall impression can thus be created by the superposition of individual item vectors. A visual example of such a composite memory is a "photograph" in the front pages of a conference volume edited by Hockley and Lewandowsky (1991) that provides an impression of the prototypical attendee through the superposition of the negatives of the portraits of all conference participants.

The combination of different pieces of information into a composite impression of a judgment or choice alternative, which lies at the heart of many decision strategies, is similar to the formation of a prototype as a composite of multiple exemplars. In many current memory models applied to categorization, and in contrast to analogous decision models, prototypes emerge without deliberate, strategic, or effortful computation as the consequence of a single memory store into which the (distributed) representations of all exemplars are superimposed and merged (J. A. Anderson, Silverstein, Ritz, & Jones, 1977; Chandler, 1991; Metcalfe, 1990). The integration of exemplar information into prototypes or composite impressions may also occur at the time of information retrieval rather than storage (but still without deliberative computation), an assumption made by a different set of models (e.g., Kruschke, 1992). Superposition of memory traces (e.g., different exemplars of a category) allows for the emergence of an average impression or prototype in the form of a composite memory vector. Thus, assumptions about memory representation and processes different from the localized representation and serial processing of a Newell and Simon (1972) cognitive architecture have some desirable by-products. One emergent property of the superposition of distributed representations of information into a common memory vector is that prototype formation and composite-impression formation are "automatic."

A well-developed theory of distributed memory representation and processes that is capable of reconstructing both individual item information and overall impressions from such composite memory vectors is Murdock's (1982, 1983, 1989, 1993) theory of distributed associative memory (TODAM). Weber, Goldstein, and Busemeyer (1991) used TODAM to model observed dissociations between people's evaluative judgments of alternatives and their memory for the alternatives' characteristics and found that some of TODAM's assumptions (e.g., the assumption of memory decay) predicted observed phenomena such as serial position effects in the judgment task different from those in the memory task. However, other memory theories exist that also assume distributed representation of information but postulate different storage and retrieval processes, for example, Metcalfe's composite holographic associative recall model (CHARM; Metcalfe Eich, 1982; Metcalfe, 1990) and the matrix model of Humphreys et al. (1989).

b. Automatic versus Controlled Processing. Decision strategies describing the nature of information use and combination are often depicted as something requiring mental effort. However, Schneider and Shiffrin (1977) showed in visual search experiments that the effortfulness of the task depends on the learning history of the person performing the task, and that effortful processing can sometimes (with sufficient practice in consistent environments) become automatic. Automatic processing is fast, autonomous (i.e., grabs attention in an obligatory way), unavailable to conscious awareness, and relatively effortless (Logan, 1988). Strategic processing, in contrast, is both under conscious control and effortful.

There is a growing literature that documents unconscious influences of memory on performance for a variety of tasks (for reviews see Bargh, 1989; Bornstein, 1989; Jacoby, Lindsay, & Toth, 1992; and Roediger, 1990). Implicit memory, that is, effects of prior experience on task performance in the absence of any intent or instructions for memory and without any conscious awareness, seems to be accessed automatically and effortlessly by a different set of processes than explicit, consciously controlled use of memory. Young and DeHaan (1990) found dissociations between performance on direct versus implicit memory in amnesics, consistent with different routes of access to stored knowledge that make it possible to interfere with consciously controlled access without affecting unconscious automatic access. Jacoby, Toth, and Yonelinas (1993) had people study a list of words, then later presented them with the first three letters of each word as a cue for one of two tasks. In the exclusion condition, people were instructed to complete the word stem with a word that was *not* on the studied list. The proportion of such words that were produced anyway (i.e., contrary to instructions) permitted Jacoby et al. to estimate the joint probability that a word would fail to be recalled consciously (and thereby rejected as a permissible response) and yet would be produced by unconscious, uncontrollable memory processes. In the inclusion condition, people were instructed to complete the word stem with a word that *did* appear on the studied list. Performance in this condition reflects conscious recall as well as unconscious memory processes. Thus, the *difference* in performance between the two conditions yields a measure of conscious recall. This measure, in turn, can be used to obtain an estimate of the contribution of *un*conscious processes to performance in the exclusion condition. By using this method of obtaining separate estimates of the conscious and unconscious components of memory, Jacoby et al. demonstrated that a manipulation of attention during study of the initial word list (i.e., attention divided between visual list learning and auditory monitoring of digits) impaired the conscious component of memory while leaving the unconscious component unchanged. Thus, there are memory processes that in addition to being unconscious and obligatory seem not to be affected by attention and effort during study.

Payne et al. (1988, 1990, 1993) characterized decision strategies as sequential series of effortful production rules. In the next section, we apply the work on distributed memory and automatic processing to a judgment task. We offer an information integration process (i.e., superposition) in which a distributed memory representation does the work of an information integration strategy, but does so in an apparently automatic, effortless manner. The following results of Experiment 1 suggest that current assumptions about the effortfulness of information integration may need to be qualified.

2. *Experiment 1: "Effort-free" Impression Formation*

Hastie and Park (1986) suggested that overall impressions of people or objects can be formed by two types of processes. The first type is *on-line* processing of information; that is, new information is integrated into an overall judgment as the information is seen, while the overall judgment is constantly being updated. The second type is *memory-based* processing; that is, in the absence of an up-front warning that information needs to be integrated, people have to recall the relevant information from memory when asked at a later point to form an overall impression and thus base their impression on what they recall. In the study described in this section (and in greater detail in Weber, Goldstein, Barlas, & Busemeyer, 1994), we hypothesize the operation of a third mechanism for impression formation, a different type of memory-based processing, namely the retrieval of a composite impression that is formed effortlessly in memory by the spontaneous superposition of informational items during memory storage. We will refer to this mechanism as *composite-memory recall.*

The study was designed to demonstrate that impression formation can be achieved relatively effortlessly and without prior warning or conscious strategy by this third mechanism as the by-product of a "distributed" memory representation which makes it possible to place different pieces of information or different impressions into a common storage vector that represents the category to be judged. The critical evidence is the response time (RT) needed to integrate several impressions into a single overall judgment. As further explained, if an overall impression is produced by composite-memory recall, then the RT to make the judgment will not depend on set size, that is, on the number of items that need to be integrated. This set-size logic was first introduced by Lingle and Ostrom (1979) to discriminate between retrieval versus nonretrieval judgment strategies.

a. Dependent Measure. The use of RT as a dependent measure is widespread in many areas of cognitive psychology. Payne et al. (1988) used choice RT as a proxy for the effort involved in making a decision. In the effort–accuracy framework of their metatheory for strategy selection, they model the cognitive effort of a decision strategy as the weighted sum of the effort associated with the elementary information processing steps (eips) necessary to execute the strategy in a given situation. Weights represent the hypothesized effort of different eips (e.g., reading an attribute value in short-term memory or adding the values of two attributes in short-term memory), and total effort is assumed to be proportionate to RT. Payne et al.'s (1988) implicit assumption of a cognitive architecture with localized representations of items and serial processes leads to the prediction that the effort (and thus RT) for the formation of an overall impression should increase with the number of items of information that need to be recalled and integrated; that is, RT should increase with set size.

When arriving at an overall impression through the process of recalling a composite memory into which individual items have been stored, set size should have no effect. The overall impression (be it a composite vector of superimposed item feature vectors or a composite matrix of superimposed negatives, as in the example of the group–prototype photo mentioned earlier) requires only a "readout" from the common vector or matrix into which the individual items have been superimposed, an operation that is not a function of a number of items that went into the vector or matrix. A photograph that is the composite of 25 researchers is just as easily processed as a photograph that is the composite of only 5 researchers. In each case, we see a single composite portrait; in the case of the Hockley and Lewandowsky (1991) conference honoring Bennet Murdock, the image was of the prototypical memory researcher, a spectacled and balding middle-aged man with just the hint of a moustache. Set-size effects occur at storage, where it takes longer to place more items into the composite store, but not at retrieval.

We hypothesized that set-size-free composite-memory-based impression formation would occur when task and instructions made it possible for people to superimpose relevant item information into a single vector. According to our model, the composite storage vector represents the category that is to be evaluated, and the superposition of item vectors into the category-representation vector yields a prototypical impression or overall judgment as a "free" by-product of the storage operation (namely, superposition). We hypothesized that such composite memory storage would happen spontaneously, that is, without conscious attention or effortful strategy initiated by task instructions as long as people were aware that all item information describes the same category, and that people need not be prewarned about having to make the final overall category evaluation to store information in this way.

b. Design and Instructions. This microcomputer-administered experiment was advertised as a consumer-research study. Respondents ($N = 350$) were informed that their task was to help the designer of a TV game show to assess whether a recently developed show (the Green Show) was better in terms of its prizes than the previously cancelled Blue Show: "This study investigates how young people like yourself evaluate consumer goods that they might win as prizes in a TV game show." Respondents were divided into nine groups that differed factorially in the instructions they received about the evaluation of the list of prizes they were shown (three Tasks) and in the number of prizes to be won in the show and thus the number to be evaluated (three levels of Size that ranged from 4 to 20 prizes). Participants saw one prize at a time and were asked to evaluate either how safe it would be to take the prize home assuming that they had a toddler at home (Task 1) or how attractive the prize was to them (Tasks 2 and 3). Respondents in Task 3 (but not in Tasks 1 or 2) were also *forewarned* that they would be asked later to rate the overall attractiveness of the Green Show. To encourage them to integrate the information about the attractiveness of individual prizes into an overall attractiveness impression for the show (i.e., to do on-line processing), respondents in Task 3 were asked to indicate how much they liked the show so far after every two prizes. After evaluating all prizes, participants in all three Task groups were asked to evaluate the overall attractiveness of the Green Show. For respondents in Tasks 1 and 2, this request came as a surprise. The magnitude of people's evaluations (of individual prizes and of the show's overall attractiveness), as well as their RT for these judgments, were recorded. Respondents had an incentive to make the final overall attractiveness evaluation as fast as possible while still being confident of its consistency with their previous evaluations: A $50 prize was awarded to the person with the fastest response that was consistent with his or her individual item evaluations, for which "consistency" was deliberately left undefined.

c. Results. We predicted and obtained a Task–Size interaction for the RT required to make the final overall attractiveness judgment ($F(4, 340) = 5.89$, $p < .0001$). The mean RT (in 1/100 sec) of people's final judgments of the overall attractiveness of the Green Show are shown in Fig. 1. Because

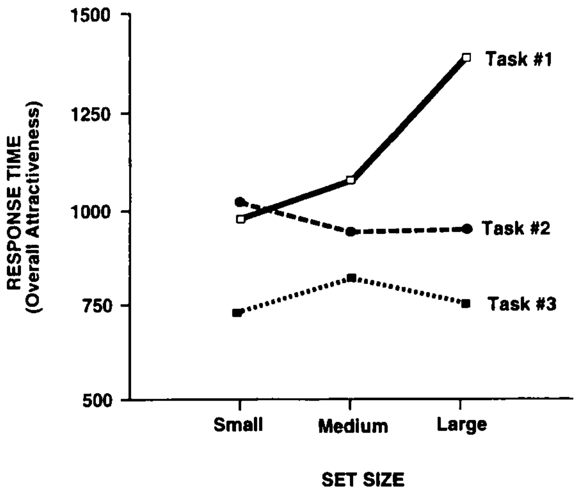

Fig. 1. Mean response time for final judgment of overall attractiveness of game show as a function of the number of prizes evaluated (i.e., set size). Respondents in Task 3 were forewarned about the final overall attractiveness judgment. Respondents in Task 2 were not forewarned, but judged the attractiveness of the individual prizes. Respondents in Task 1 were also not forewarned, but judged the safety of the prizes.

respondents in Task 3 updated their overall game show impression *on-line*, as the prizes were seen and evaluated, no set-size effect was predicted for the final judgment RT in this group, and none was observed. Because respondents in Task 1 did not know that they would have to evaluate the show's overall attractiveness and did not even evaluate the attractiveness of individual prizes (but instead the prizes' "safety"), *memory-based processing* in the Hastie and Park (1986) sense was necessary to make the overall show attractiveness judgment: Subjects had to recall the different prizes, evaluate their attractiveness, and integrate those into an overall game show impression at the time that they were asked for that final judgment, resulting in the prediction of a strong set-size effect for their RT, which was clearly observed. Finally and most crucially, we hypothesized that respondents in Task 2 would spontaneously store their evaluations of the attractiveness of the different prizes to be won on the Green Show into a common memory storage vector. By categorizing all prizes as belonging to the same show (the Green Show) and by showing them on the computer screen in green color to facilitate such common-category encoding, we hypothesized that people would "set up" such a common-memory storage vector for their individual prize-attractiveness judgments without any instructions to do so. If so, then the surprise question about the game show's overall attractiveness should be answerable by a single operation that retrieved the value of the composite vector, that is, by *composite-memory recall,* with the result of no set-size effect in RT. In the absence of such composite storage, set-size effects in Task 2 should be similar to those of Task 1. Figure 1 clearly shows the absence of any set-size effect for Task 2, whose nonsignificant slope makes it more similar to Task 3 than to Task 1. The difference in intercept between Tasks 2 and 3 can be attributed to different memory retrieval operations: The prewarned respondents in Task 3 needed to recall only their last explicitly stated overall game show impression that they had generated on-line. For respondents in Task 2, on the other hand, the request for an overall impression of the game show's attractiveness came as a surprise. To give this judgment, they could recall all prizes and integrate their attractiveness at the time of the request, like the people in Task 1. However, the absence of any set-size effect argues against this mechanism. Instead, the results for Task 2 are consistent with the assumption that respondents in this group retrieved the composite-memory vector for the show's attractiveness that was created when the show's individual prizes were judged for attractiveness. This retrieval operation took longer than the simple recall of a previous overall judgment (an average of 9.7 sec for Task 2 rather than 7.7 sec for Task 3), probably because a composite-memory trace is noisier than a simple item trace and thus may take longer to disambiguate. This difference in retrieval time provides evidence against the alternative explanation that Task 2 respondents may have generated overall show attractiveness on-line, just as Task 3 respondents did, even though they were not prewarned to do so. The results of Experiment 1 demonstrate that information can become integrated under some circumstances relatively effortlessly. The assumption of a distributed memory structure that allows for composite storage is one way in which such effortless information integration can occur, as a by-product of the storage operation.

Complementing and supporting our demonstration of relatively effort-free information integration, courtesy of a distributed memory store in Experiment 1, is a recent study by Kashima and Kerekes (1994), who provide a model of impression formation that capitalizes on distributed representations of both item information and rating scale anchors. In contrast to the semantic network representations commonly assumed in person memory research (e.g., Hastie, 1988) in which a concept or proposition is localized in a single node or unit, person information in their model is represented by a pattern of activation over a set of units. Memory storage takes the form of a matrix into which associated item vectors are placed, with storage and retrieval operations similar to the models of J. A. Anderson

(1972) and Humphreys et al. (1989). The model further assumes that the anchors of the judgment scale on which the person impression is reported have a distributed representation that is compatible with the distributed representation of person information, such that new information is integrated by vector operations that compare it to the upper and lower anchors of the judgment scale. Kashima and Kerekes (1994) show that N. H. Anderson's weighted averaging model of impression formation (e.g., 1981), which has been shown to fit empirical data but has been criticized as a judgment strategy for being cognitively too effortful (e.g., Fiske & Neuberg, 1990), actually falls out as the natural consequence of their hypothesized encoding, storage, and retrieval processes. Their data suggest that it may be misleading to speak of the use of the weighted averaging rule as a conscious strategy, and that averaging behavior may not be cognitively effortful.

Bruce, Hockley, and Craik (1991) provide evidence consistent with composite-memory storage and recall under appropriate conditions in a different domain, namely, category frequency estimation. Although some studies have found a positive correlation between the recall of exemplars cued by the category name and frequency estimation (e.g., Tversky & Kahneman, 1973, whose availability theory is based on this positive correlation), other studies have failed to find one (e.g., Barsalou & Ross, 1986). Bruce et al. (1991) produced both the presence and the absence of a significant correlation between availability measured by cued recall and frequency estimation of category size under different conditions. When they encouraged exemplar encoding of the type previously described in Experiment 1 as enabling overall category impressions by composite-memory recall (e.g., by having people name the category name of exemplars during list presentation, possibly allowing them to "set up" a composite memory vector for each category into which exemplars can be placed), the correlation was not significant. After such encoding, judgments about the frequency of exemplars in each category presumably could be made on the basis of composite-memory strength of the category storage vector, rather than by inference from the recall of exemplars. When such encoding was not encouraged by experimental instructions, there was a positive correlation between the number of exemplars recalled per category and category frequency judgments.

3. *Macrolevel Assumptions about Memory*

We now turn our attention away from issues concerning the format of stored information (i.e., distributed vs. localized representation) to consider some distinctions related to the source and content of information in memory (i.e., semantic vs. episodic vs. procedural memory). In contrast to the preceding section, in this section, we do not find that memory considerations reveal alternatives to the concept of strategy so much as they present ways to broaden the notion of strategy, and embed it in a richer context with both theoretical and methodological implications.

a. Semantic versus Episodic Memory. For more than 20 years, memory researchers have maintained a distinction between (1) episodic memory for information about specific experiences, outcomes, or events, and (2) semantic memory of abstract knowledge, for example, rules abstracted from a series of prior experiences or prototypes abstracted from a series of exemplars (Tulving, 1972). This distinction offers an interesting parallel to different philosophies of instruction. Both theory-based learning and learning by apprenticeship or case study can lead to the establishment of "rules." The first approach does so directly, whereas the second approach requires induction from episodic knowledge on the part of the learner.

A great deal of controversy in social cognition and categorization research has centered on the twin issues of memory representation of categories (exemplar storage in episodic memory vs. prototype formation and storage in semantic memory) and memory processes (induction of prototypes from specific exemplars at storage vs. at retrieval) (Smith, 1990; see also Nisbett, 1993). Early models assumed that knowledge about categories was abstract, and was represented in semantic memory as prototypes (Posner & Keele, 1968) or as networks of associations or rules (Elstein & Bordage, 1979). Later models favored the representation of specific, concrete knowledge about category exemplars in episodic memory (Brooks, 1978; Medin & Schaffer, 1978). Barsalou (1990) argued that it may be difficult to differentiate between these different types of memory representations on the basis of behavioral data, because any difference in representation can usually be compensated for by appropriate retrieval processes. However, in some special cases differences may be detectable (Nosofsky, 1992). Recent evidence has favored hybrid models of memory representation that include memory for particular exemplars, that is, an episodic memory component, as well as generalized semantic knowledge. Evidence for such hybrid models has been found in medical diagnosis (Brooks, Norman, & Allen, 1991; Weber et al., 1993) and in people's judgments of the frequency of past events (Means & Loftus, 1991). Whittlesea, Brooks, and Westcott (1994) demonstrated that people acquire both types of knowledge during categorization learning, but that the subsequent utilization of general semantic knowledge versus particular episodic knowledge depends on subtle characteristics of the judgment task and information display.

The implication of this controversy for decision researchers is that behavior that appears to involve the manipulation of abstract information may, in fact, reflect the (possibly unconscious) comparison of the current situation to concrete episodes encountered in the past. Decision researchers have tended to conceive of decision strategies as sets of abstract rules and procedures for evaluating the attributes of choice alternatives (e.g., elimination-by-aspects, additive rules, lexicographic rules, etc.). Undoubtedly, people often do implement abstract rules (Nisbett, 1993), and semantic knowledge clearly plays a role in "analytic" rule-based decisions, as well as in people's post hoc justifications of their decisions. However, decision researchers have tended to overlook the fact that episodic knowledge about prior decisions and their outcomes may also play a role, for example, in "intuitive" decisions that are made on the basis of similarity to previous experiences (see Goldstein & Weber, 1995). There has been more attention to these issues in the area of artificial intelligence, for example, the work on case-based reasoning (e.g., Kolodner, Simpson, & Sycara-Cyranski, 1985). These considerations suggest that decision researchers may have been unduly restrictive in conceiving of strategies as the application of semantic knowledge only.

As an illustration of the utility of distinguishing between the use of semantic and episodic knowledge in decision making, consider the issue of whether people utilize base rate information when making predictive judgments about the likelihood of future events. When base rate utilization is defined as the knowledge and application of Bayes' theorem to numerical base rate information (i.e., as an application of semantic knowledge), people without formal instruction in statistics fail at the task (Eddy, 1982; Wallsten, 1981). If, on the other hand, utilization of base rate information is operationalized as an episodic knowledge task, both undergraduates (Medin & Edelson, 1988) and physicians (Weber et al., 1993) can quite accurately incorporate the frequencies of different *experienced* events into their predictions and diagnoses. Episodic knowledge allows for the operation of similarity-based diagnostic strategies which reflect differences in the base rates of different diagnoses without any deliberate calculations or conscious awareness (see Weber et al., 1993). Semantic knowledge about differences in base rates, on the other hand, requires deliberate, conscious strategies (i.e., equivalents of Bayes' theorem) to utilize such knowledge.

b. Declarative versus Procedural Memory. J. R. Anderson (1976) contrasts procedural knowledge with the declarative knowledge of episodic and semantic memory in his taxonomy of functional memory systems, and neuropsychological evidence favors the existence of different memory systems. For example, some amnesics have been shown to have practically normal learning curves for new procedural skills (e.g., the Tower-of-Hanoi problem), without any episodic memory of ever having performed the task before (Cohen, 1984). As another example, patients with prosopagnosia show galvanic skin responses to familiar faces without the subjective experience of recognizing those faces (Young & De Haan, 1990).

As mentioned earlier, a number of metatheories have tried to explain how adaptive and goal-directed organisms select strategies to tailor their decisions (Hogarth & Einhorn, 1992; Payne, 1982; Payne et al., 1988, 1990, 1993; Smith et al., 1982), problem solutions (Friedrich, 1993), or hypotheses (Klayman & Ha, 1987) to the information, constraints, and task at hand. Implicit in these metatheories about strategy selection is the presupposition that people have a representation of different processing strategies that allows them to "compute" the relative pros and cons of each strategy for a particular task environment accurately on-line. Given the prominent role attributed to knowledge about procedures in strategy selection, there is a crucial need to better understand the representation, storage, and retrieval of procedures, as well as the knowledge people have *about* procedures.

J. R. Anderson (1987) likens the acquisition of (cognitive) skills (i.e., the establishment of procedural knowledge) to the "compilation" of general problem-solving methods that are applied to declarative knowledge about the content domain. The initially conscious, effortful, and verbalizable application of general rules to a specific problem produces a set of domain-specific production rules which, by repeated use, becomes "compiled" or automatized. Logan's (1988) instance theory of automatization similarly assumes that practice in consistent environments leads to the automatized retrieval of stored instances of previous exposures to the task, that is, a compilation of episodic memory retrieval into procedural memory. Compilation of skills into procedural knowledge explains why expert performance tends to be faster (Chase & Simon, 1973; Joseph & Patel, 1990), but at the cost of being less verbalizable and open to introspection (Adelson, 1984). Anderson's (1987) theory of the development of procedural memory through automatization thus has a variety of interesting and untested implications for the quality of novice versus expert metadecisions about strategy selection that may fruitfully be explored. Moreover, the fact that people may be able to perform certain tasks without being aware of all procedural steps also raises questions about the completeness of information obtained by methodologies like verbal protocols and the accuracy of self-assessment of cognitive effort in well-practiced judgment or decision situations. Finally, the fact that automatized procedures are less open to introspection implies that the selection of a procedure or strategy may often rely on metacognitive knowledge *about* the procedure, rather than information derived directly by introspection of the procedure itself. This suggests that metatheories about strategy selection should be elaborated with research on people's metastrategic knowledge about strategies, in addition to research on the performance characteristics of the strategies in operation.

B. Beyond Framing: An Expanded Set of Encoding and Representation Issues

Having considered the implications of memory research for one branch of metatheory in decision research, that is, the adaptive selection of a decision strategy, we now turn to the other main branch of metatheory, the perceptual framework. As mentioned earlier, J/DM research within the perceptual framework has concentrated mostly on (1) the framing of outcomes as gains versus losses relative to a reference point (Kahneman & Tversky, 1979), (2) the aggregation versus segregation of events and options (Thaler, 1985), and (3) the restructuring of alternatives to reveal or create a dominance relation (Montgomery, 1983). In this section, we first consider the effect of prior events and experiences on encoding; second, the simplification of information as a coding operation; and third, the elaboration of presented information on the basis of prior knowledge.

1. Differences in Perception Resulting from Prior Experience

Encoding has been defined as follows: "between the external world and a human's memorial representation of that external world there operate certain processes that translate external information into internal information. These processes may in part be selective, or elaborative, or transformational; some may be optional while others are obligatory" (Melton & Martin, 1972, p. xii). Given the basic ambiguity of information, encoding processes have elements of selection and interpretation (e.g., Fiske & Taylor, 1991) which frequently involve a loss of information (e.g., Brainerd & Reyna, 1992). Much of psychology, from early psychophysics to current social cognition, concerns itself with the question of how physical stimuli map into subjective experience (e.g., how choice outcomes map into utility). Subjective experience is important because it forms the basis for judgments, actions, and choices. The same "objectively" described outcomes of choice alternatives, if experienced differently, may and perhaps should lead to different decisions (Frisch, 1993). Differences in the encoding of outcomes as the result of adopting different references points relative to which the outcomes are perceived and evaluated have been recognized as important in decision making research at least since Markowitz (1959) and in psychology more generally even earlier (Lewin, Dembo, Festinger, & Sears, 1944). Differences in the framing of an outcome that leads to its encoding as a relative gain or a relative loss, with the associated assumption that people's value functions for losses are of a different shape and slope than their value functions for gains, is an important component of prospect theory (Kahneman & Tversky, 1979) that allows it to describe choices that violate traditional expected utility theory. Thaler (1980) extended the domain of prospect theory's value function from risky prospects to riskless (consumer) choice.

Much of the J/DM literature on differences in subjective experience contains investigations on the effects of *concurrent* factors, such as the effect of the nature of the description of outcomes by the experimenter on the framing or encoding of outcomes (Slovic, Fischhoff, & Lichtenstein, 1982; Tversky & Kahneman, 1981). Equally important in predicting people's subjective experiences of an event, however, are *preceding* events; in particular, people's prior experiences with the same or similar judgments or decisions. Sunk cost effects (Staw, 1976) are a prominent example of the effects of prior experience. Past experience also plays a role in projecting one's future utility for outcomes (Elster & Loewenstein, 1992; Kahneman & Snell, 1992). When looking at the influence of prior experience on subjective encoding, it is important to consider not just the conscious but also the unconscious influence of prior events (Jacoby, Lindsay, & Toth, 1992; Jacoby et al., 1993), as a growing body of evidence in cognitive psychology suggests that unconscious memory of prior experiences can affect judgments and decisions. One example that has been of considerable interest in marketing is the mere exposure effect, that is, the phenomenon that familiarity (prior exposure) breeds liking (for a review, see Bornstein, 1989). Familiarity, especially when acquired in low-involvement processing tasks also increases the perceived truth value of (advertising) statements (Hawkins & Hoch, 1992). Yet another example is the false fame effect, that is, the fact that people misattribute familiarity resulting from prior exposure, of which they are unaware, to fame (for a review, see Jacoby et al., 1992).

Prior exposure of a more extended sort leads to the development of expertise in a domain, with attendant changes in the encoding of information. In fact, studies looking for the source of expert–novice performance differences have often found the main difference that distinguishes experts from novices is the way in which they encode domain-specific information. The pioneering work of DeGroot (1965) on expertise in chess suggested that differences in the structure of domain knowledge with resulting differences in information encoding (rather than differences in information processing strategies or depth of processing) lie at the root of the expert–novice distinction. As the result of practice and experience (Kleinmuntz, 1968), experts tend to encode and represent information more holistically, as integral parts of larger, meaningful units. Such differences in the representation of information have been demonstrated for expert versus novice players of chess (Chase & Simon, 1973), computer programmers (Adelson, 1984), and auditors (Libby & Frederick, 1990), and have been shown to permit faster, more automatic information processing. To model expert judgment and decision making, researchers may thus be well advised to give more thought to knowledge representation and memory processes. Fox (1980), for example, was able to simulate the (episodic) knowledge advantage of expert diagnosticians by supplementing an artificial intelligence expert system using nonprobabilistic inference processes with a memory mechanism reminiscent of Morton's (1970) logogen model of recognition, which provided concepts (e.g., diagnoses) that are activated more frequently with a higher level of standing activation.

2. *Experiment 2: Selectivity and Simplification of Information*

Although the simplification of stimulus information was explicitly included among the editing operations discussed by Kahneman and Tversky (1979), J/DM researchers have not devoted much attention to issues of information selection or simplification, with the notable exception of Reyna and Brainerd (1991; Brainerd & Reyna, 1992). We demonstrate the importance of these matters with an experiment in which we manipulated the order in which information was presented for a preferential choice task.

The effect of serial position has been well established for a broad range of memory tasks. That is, the impact of a given item of information depends crucially on *when* it is presented in a list of items. Serial position effects have been found to differ for memory and judgment tasks, with, for example, recency effects for the recall of adjectives but primacy effects for the adjectives' impact on likableness ratings (N. H. Anderson & Hubert, 1963). A variety of studies document such memory–judgment dissociations under different information and task conditions (e.g., Dreben, Fiske, & Hastie, 1979). Hogarth and Einhorn (1992) provide an extensive review and model of order effects in belief updating, with additional empirical support and model extension provided by Tubbs, Gaeth, Levin, and van Osdol (1993). Serial position effects have also been documented in the retrospective evaluation of ongoing experiences. Evaluations of aversive outcome streams (Kahneman, Fredrickson, Schreiber, & Redelmeier, 1993) as well as positive outcome streams (Hsee, Abelson, & Salovey, 1991) incorporate not only the value of outcomes at different points in time, but also changes in value, with strong preference for improvements in outcome at the end of the sequence.

Although serial position effects are well documented for judgment tasks, they have been little studied for choice tasks. It is not clear to us why the acquisition of information over time has been less of a concern for choice tasks. Outside of laboratory experiments, information received about choice

TABLE I

Instructions for Experiment 2

On each trial you will be asked to choose between two gambles, one called Gamble T and the other called Gamble B. The payoff produced by each gamble depends on the throw of a fair die. Here is an example. If you had to choose between the following two gambles (Gamble T vs. Gamble B), which would you choose? Tell the experimenter your choice.

If the number showing on the die equals 3, then
you get +$8 by choosing Gamble T,
you get −$7 by choosing Gamble B.

If the number showing on the die equals 5, then
you get +$10 by choosing Gamble T,
you get −$5 by choosing Gamble B.

If the number showing on the die equals 1, then
you get +$3 by choosing Gamble T,
you get −$2 by choosing Gamble B.

If the number showing on the die equals 2, then
you get −$7 by choosing Gamble T,
you get +$5 by choosing Gamble B.

If the number showing on the die equals 6, then
you get −$9 by choosing Gamble T,
you get +$10 by choosing Gamble B.

If the number showing on the die equals 4, then
you get −$4 by choosing Gamble T,
you get +$5 by choosing Gamble B.

The die is fair so that each of the integers (1, 2, 3, 4, 5, 6) are equally likely to be selected. You can inspect the die if you wish. (Experimenter shows the die).

You will indicate your preference for gamble T or gamble B on a scale like the one below:

```
Certain T              Indifferent              Certain B
|---------------|---------------|---------------|---------------|
100/0         75/25           50/50           25/75          0/100
```

This scale is used to instruct the computer how to make the choice for you. You will move a pointer to a position on this scale. If the pointer is placed on 100 at the right-hand side, then the computer will always choose Gamble B. If the pointer is placed on 75 at the right-hand side, then the computer will choose Gamble B on 75% of the trials and choose Gamble T on 25% of the trials. If the pointer is placed on 50, then the computer will choose Gamble B on 50% of the trials and choose Gamble T on 50% of the trials. If the pointer is placed on 75 at the left-hand side, then the computer will choose Gamble T on 75% of the trials and choose Gamble B on 25% of the trials. If the pointer is placed on 100 on the left-hand side, then the computer will always choose Gamble T. You can place the pointer anywhere you wish.

In the above example, the payoffs produced by each gamble for each die number were shown all at once on the computer screen. However, in this experiment, you will see the payoffs produced by each gamble for only one die number at a time. Here is an example. (Example is shown in which only the payoffs for one outcome of the die are shown on the screen at a time, for approximately 3 sec, followed by the payoffs for another outcome of the die, and so on)

(*Continues*)

TABLE I (*Continued*)

You begin the experiment with $6. (Experimenter hands over $6.) The entire experiment involves 16 choices. Each choice problem is like the example shown above. At the end of the experiment, the computer will randomly select one of these sixteen choice problems. Then you will throw the die and actually play out the gamble that you chose for the selected problem. The amount you win or lose will depend on your choice and on the die number. You take home whatever money you have left after playing out the gamble.

alternatives is rarely provided completely and simultaneously. Given the prevalence of choices in which people receive information about the outcomes of different choice alternatives over time (Lynch & Srull, 1982), it is surprising that not more is known about serial position effects for input into preferential choice. If the order in which information is received influences the way it is perceived or evaluated, there could be differences in choice as a function of the order in which information is received. In Experiment 2, conducted in collaboration with Jerome Busemeyer, we investigated people's preferences in a choice pair as a function of the order in which outcome information was received. The pattern of results strongly suggests that respondents were trying to reduce the difficulty of retaining information in memory by encoding it in a simplified manner.

Table I provides the task instructions, including a description of two choice alternatives, that is, monetary gambles whose payoffs depended on the role of a die. The potential payoffs of the two choice alternatives under each of the six possible states of the world (outcomes of the roll of the die) were displayed sequentially, one state of the world at a time, on a computer screen for approximately 3 sec, until all six potential payoffs had been shown. Die numbers defining the six different states of the world were randomly assigned to serial positions across subjects to ensure that the die number was not confounded with serial position. Each die number appeared with equal frequency at each serial position. Thus, serial position effects cannot be attributed to different subjective probabilities for particular numbers (e.g., "3" being a lucky number).

Thirteen students at Purdue University judged their relative preference for 16 choice pairs displayed in this fashion. As described in Table I, respondents earned $6 plus any win minus any loss they incurred when the preferred gamble of a randomly selected choice pair was played at the end of the session. There were 6 experimental pairs, randomly interspersed among 10 filler pairs. The six experimental pairs, shown in Table II, were identical in terms of outcomes, and all gambles had an expected value of $0. One gamble in each pair had four (smaller) negative outcomes and two (larger) positive outcomes, whereas the other gamble had two (larger)

TABLE II

Choice Pairs Used in Experiment 2

Choice pair		Serial position of displayed outcomes 1	2	3	4	5	6
1	T	+$2.50	+$2.50	−$5	−$5	+$2.50	+$2.50
	B	−$2.50	−$2.50	+$5	+$5	−$2.50	−$2.50
2	T	−$2.50	−$2.50	+$5	+$5	−$2.50	−$2.50
	B	+$2.50	+$2.50	−$5	−$5	+$2.50	+$2.50
3	T	+$5	+$5	−$2.50	−$2.50	−$2.50	−$2.50
	B	−$5	−$5	+$2.50	+$2.50	+$2.50	+$2.50
4	T	−$5	−$5	+$2.50	+$2.50	+$2.50	+$2.50
	B	+$5	+$5	−$2.50	−$2.50	−$2.50	−$2.50
5	T	−$2.50	−$2.50	−$2.50	−$2.50	+$5	+$5
	B	+$2.50	+$2.50	+$2.50	+$2.50	−$5	−$5
6	T	+$2.50	+$2.50	+$2.50	+$2.50	−$5	−$5
	B	−$2.50	−$2.50	−$2.50	−$2.50	+$5	+$5

negative outcomes and four (smaller) positive outcomes. The pairs differed from each other in the order in which participants received outcome information in a 2 × 3 factorial design that crossed the presentation of a gamble in the top (T) versus the bottom (B) row of the screen with the serial position in which the two extreme outcomes of the gambles were presented (at the beginning, middle, or end of the presentation sequence). Clearly, if the students saw the six gamble pairs as they are shown in Table II, that is, with all outcomes being displayed simultaneously, there is no reason why their preferences should be different in the six choice pairs. Thus, any differences in preference as a function of the serial presentation of outcomes must be a result of outcome integration processes that are not commutative. A plausible explanation of differential preference includes memory limitations and resulting differences in the encoding and/or retrieval of information as a function of the serial order of outcomes.

Overall, respondents preferred gamble G1 = (+2.5, +2.5, −5, −5, +2.5, +2.5) with its four smaller positive and two larger negative outcomes over its mirror image, gamble G2 = (−2.5, −2.5, +5, +5, −2.5, −2.5) which was of equal expected value: the overall choice proportion for G1 over all six order conditions was .61. Thus the *number* of positive and negative outcomes seemed to play a larger role than the magnitude of outcomes, consistent with the notion that, under naturalistic conditions of memory load, people seem to encode mostly the "gist" of outcomes (Brainerd & Reyna, 1992; Reyna & Brainerd, 1991). Furthermore, people's relative preferences for the two gambles showed strong serial position as well as spatial order (top/bottom) effects, with a significant interaction between the two factors ($F(2, 24) = 15.46$; MSE = 2.40; $p<.00001$). As shown in Fig. 2, the median strength of preference across the 13 respondents for gamble G1 was clearly different across the six different information order conditions. G1 was more preferred when its outcomes were displayed first in the top portion of the display (choice proportion for G1 was .63 across those three order conditions) than when they were listed second in the bottom portion of the display (choice proportion was only .58), suggesting that the features that made G1 more attractive to people were more salient when displayed in the top of the display. More interestingly, there were strong serial position effects for the order in which the different outcomes for the two gambles were received, the nature of which depended on whether gamble G1 or G2 was listed first. The four small advantages of G1 over G2 had greatest impact when they occurred as a "run" (i.e., as the first four or the last four outcomes), and were less effective when the series was interrupted by large advantages of G2 over G1, again suggesting that people were encoding the gist of the stimuli. There was mild evidence for such a run effect when the majority of outcomes in the top display row were positive; that is, the preference for G1 = (+2.5, +2.5, −5, −5, +2.5, +2.5) when it was listed as the top gamble was somewhat greater when the four positive outcomes occurred as the first four outcomes (pair 6: choice proportion for G1 was .65) or the last four outcomes (pair 4; choice proportion for G1 was .65)

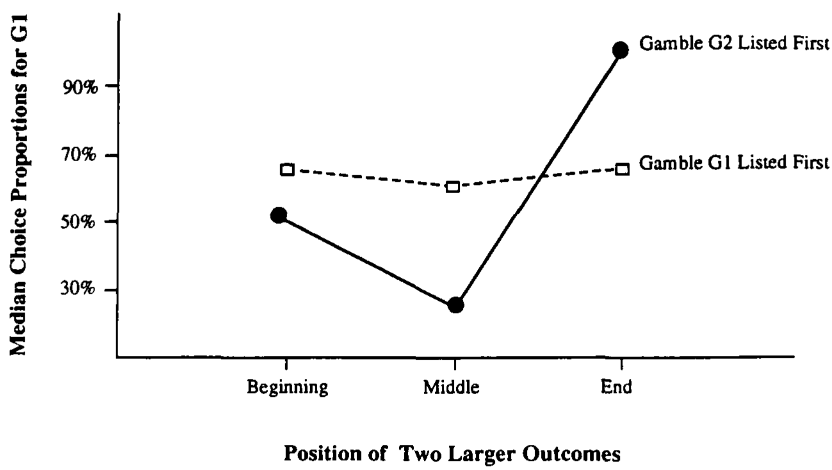

Fig. 2. Median choice proportions for gamble G1 = (+\$2.50, +\$2.50, −\$5, −\$5, +\$2.50, +\$2.50) over gamble G2 = (−\$2.50, −\$2.50, +\$5, +\$5, −\$2.50, −\$2.50) as a function of which gamble was listed first (i.e., in the top portion of the display screen) and as a function of the position of the two larger outcomes (+/−\$5, +/−\$5) in the series of outcome presentations.

than when the run was broken up by the two intervening negative outcomes (pair 1: choice proportion was .60). This run effect was greatly magnified when the majority of outcomes in the top display row were negative, accounting for the significant interaction between top and bottom position and serial order of outcomes. Preference for G2 = (−2.5, −2.5, +5, +5, −2.5, −2.5) when it was listed in the top display row was lower when the four negative outcomes were presented as the first four outcomes (pair 5: choice proportion for G2 was .00) or as the last four outcomes (pair 3: choice proportion for G2 was .50) than when they were interrupted by the two positive outcomes (pair 2: choice proportion was .75). This run effect suggests that under conditions that put a strain on limited working memory, such as sequential information presentation, massed presentation of positive and, in particular, negative information will have maximum impact.

In summary, Experiment 2 establishes that serial position effects exist not just in judgment tasks but also in preferential choice. The results show that the order in which information is received in a sequential presentation choice task can have a strong effect on people's preferences for different choice alternatives, leading in our case to preference reversals between pairs that differed only in the sequence in which the same outcome information was provided. These preference reversals did not necessitate any change of strategy explanation, but instead seemed to implicate simplifying encoding processes as the source of the effect.

3. *Information Elaboration and the Content of Memory*

Asking people for reasons for decisions and/or to elaborate on provided information provides evidence about the way information is encoded and incorporated into existing knowledge structures. Looking at differences in argumentation or reasons for choice provides converging evidence that differences in the encoding or representation of the same set of information can be responsible for differences in preference or choice. Hogarth and Kunreuther (1995) studied the reasoning processes and arguments involved in a consumer decision, holding information about probabilities and outcomes constant. They found that people who provided different arguments in a decision used different decision strategies and arrived at different answers. The role of reasons for judgments and decisions has also been studied by Curley, Browne, Smith, and Benson (1993) and Shafir and Tversky (1993).

Getting more directly at the role of information representation in determining both choice and reasons for choice, Levin and collaborators used an information elaboration task in two domains: in decisions about public health intervention programs that differed in the number of leukemia versus

AIDS patients saved (Levin & Chapman, 1993) and in decisions about cars that differed in the number of foreign versus domestic workers involved in their production (Levin, Jasper, Mittelstaedt, & Gaeth, 1993). Elaboration in the public health program domain involved the generation of reasons for contracting either leukemia or AIDS. The fewer "personal responsibility" reasons people generated for contracting AIDS, the more favorably they rated those programs that (*ceteris paribus*) saved a larger proportion of AIDS than leukemia patients. Similarly in the car domain, elaborations about the respective qualities of foreign versus domestic workers and other expressions of nationalism predicted people's preferences for cars better than their expressed perceptions of car quality. In other words, in both domains, people's preferences could be predicted from the way they elaborated on the respective decision outcomes when asked to do so at a different point in time.

Information elaboration thus has the potential to provide yet another piece of converging evidence about the nature of information representation and its role in predicting differences in judgment and choice. Given the recent interest in reason-based choice, further investigation is needed into the relationships between information representation and decision arguments, and between decision arguments and choice. It would be interesting, for example, to understand why different respondents in Hogarth and Kunreuther (1995) provided different arguments for their decisions and used different processing strategies even though everybody received the same information about the choice alternatives. An information elaboration task would be useful to determine whether differences in choice arguments are associated with differences in prior knowledge or in value structures, and thus in encoding and evaluation of new information. (For further discussion of the effect of prior knowledge on decision processes, see Goldstein & Weber, 1995).

C. Summary

In this section, we have tried to demonstrate the utility and even necessity of incorporating a more explicit consideration of memory structure and processes into models of judgment and choice. We argued that a new class of models about memory structure and processing should be considered by J/DM researchers. Experiment 1 demonstrated that the assumptions of distributed representation and parallel processing have the potential to change some basic conceptions about the relative effort of different processing strategies. We also argued that encoding differences, in addition to conventional framing effects, operate in J/DM tasks. Experiment 2 demonstrated that different serial presentation of the same informational input changed choices, most likely as the result of simplified encoding of outcomes resulting from memory limitations. Also, we argued that information elaboration tasks can help to reveal the organization of knowledge which is brought to bear on presented information. In summary, in this section we have made an argument for the integration of *memory concepts* into J/DM models. Section III tries to convince J/DM researchers that *memory techniques* are well suited (and probably underutilized) in testing J/DM models and their implicit encoding assumptions.

III. Use of Memory Techniques in J/DM

One postulate of behaviorism in psychology and logical positivism in economics and other social sciences has been that researchers should restrict themselves to studying observable phenomena. Differences in the way in which people encode information might seem as unobservable (and thus as metaphysical) to a behaviorist as claims about subatomic particles would be to an eighteenth century physicist. However, even though electrons, positrons, and neutrinos are not visible to the naked eye or even under a microscope, they can nevertheless be studied by means of the traces they leave: Nuclear physicists base much of their theories on photos of the trails left by particles as they traverse cloud chambers.

The trail that elementary particles leave in a cloud chamber can be taken as a metaphor for the trace that the cognitive processing of information leaves in memory. The basic notion underlying all memory techniques described in this section is that the encoding and utilization of information leaves a memorial residue. The nature of the trace or residue thus become evidence that information has been encoded or used in a particular way. For example, a basic question one can ask is whether information was encoded or utilized at all in a situation. As McClelland, Stewart, Judd, and Bourne (1987) point out, "if an attribute for an alternative is not processed, then it obviously cannot be remembered" (p. 238).

Memory as a research tool has a history in social cognition and consumer research, both areas of J/DM research that have been more aware than other areas of the prevalence of memory-based judgment and choice and of the importance of encoding processes. Much of the research in social cognition revolves around the question of how prior beliefs influence the way in which people interpret and thus encode information. As a result, studies frequently employ techniques such as clustering in free recall and priming manipulations. The memory tasks reviewed in this section include recognition and free recall.

We first describe a study that draws inferences about the initial encoding of information using the *speed* with which forced choice recognition judgments are made. The basic notion underlying this technique is that if information is encoded or recoded in a particular way at the time of initial processing, then people should be faster to make old–new discrimination judgments when information is presented in this previously encoded form than when it is presented in a different form.

A. Experiment 3: Use of Forced Choice Recognition RT

Explanations based on encoding differences, for example, the evaluation of outcomes relative to different reference points as in Kahneman and Tversky's (1979) prospect theory, have successfully accounted for differences in judgments and choices made in different contexts or decision frames (Kahneman & Tversky, 1982). These differences are often well described by the shape of prospect theory's value function, both for risky decisions, the domain for which prospect theory was conceived, and for riskless decisions, the domain to which it was exported (e.g., Thaler, 1980, 1985). For decisions about gains, prospect theory's value function makes the same predictions as other theories, that is, expected utility with its predominant assumption of concave utility and Coombs and Avrunin's (1977) postulate that "good things satiate." Evidence has generally supported this common assumption. For decisions about losses, on the other hand, theories differ in their predictions. Prospect theory's value function is convex, making people risk-seeking for losses. Coombs and Avrunin (1977), however, assume a concave loss function and risk avoidance with their assertion that "bad things escalate." Here, the empirical evidence has been more equivocal. Schneider (1992) found people to be as frequently risk-averse as risk-seeking in the domain of losses. Linville and Fischer (1991) examined the predictions that an extension of prospect theory's value function would make about the aggregation versus segregation of (riskless) positive and negative events. They found that predictions held in the domain of gains (i.e., people preferred to segregate positive events), but failed to find the aggregation of losses that would follow from a convex value function in the domain of losses. Thaler and Johnson (1990) found that simple prospect theory predictions failed to describe people's risky choices after prior wins or losses and suggested additional assumptions about how people encode information in successive gambles.

If the encoding of information relative to some reference point has some psychophysical reality rather than just being a predictive as-if model (Arkes, 1991), then encoding differences should have consequences in addition to differences in the final judgment or choice. If the values of outcomes are encoded according to prospect theory's value function, which is steeper in the loss domain than in the gain domain, people should be able to discriminate differences between outcomes better in the loss domain than in the gain domain. The same objective difference in outcomes becomes a larger subjective difference when the outcomes are losses than when the outcomes are gains. With better discrimination, people should be more consistent when choosing between negatively framed prospects than between positively framed prospects, and they should also be faster. Consistency and speed of choices are, of course, affected by a variety of variables other than the psychophysical discriminability of the choice alternatives. Schneider (1992) found people to be less consistent in their choices across repeated trials when decision alternatives were negatively framed rather than positively framed, and attributed this result to the fact that emotional/motivational reasons for inconsistency (e.g., conflicting objectives) may overshadow and obscure the effects of psychophysical discriminability.

In the absence of such emotional/motivational reasons for inconsistency, however, consistency and RT measures may provide evidence not only about the difference in slope between the loss and gain functions, but also about the shape of the psychophysical discrimination function in the loss and gain domains. A concave, as opposed to convex, value function makes different predictions about the relative discriminability between members of different choice pairs, and thus about the relative consistency and speed of different choices. Experiment 3 was designed to test such psychophysical implications that follow from different assumptions about the shapes of people's value functions in the loss and gain domains. These results are described in Weber, Barlas, Wertenbrock, and Goldstein (1994). In summary, we found that RT and choice data were consistent with a value function that was steeper for losses than for gains. Evidence supported a concave value function in the gain domain, and, consistent with Coombsian predictions rather than with prospect theory predictions, also a concave value function for losses. In this chapter we describe another, related, objective of the study, namely to provide evidence for a specific information encoding, in particular for differences in encoding as the result of framing manipulations, by making use of the memorial residue of the initial encoding during a later task. We used RT measures for this purpose, in particular the time to respond to forced recognition memory questions.

As pointed out by Shanteau (1991), the use of RT as a dependent measure in decision research has been very limited, despite the fact that Donders (1868) used RT initially to analyze choice mechanisms. One notable exception is the work by Busemeyer, Forsyth, and Nozawa (1988) who showed that the use of RT allowed them to distinguish between Restle's (1961) suppression-of-aspects model and Tversky's (1972) elimination-by-aspects model, even though the two models make identical predictions about binary choice probability. Later in this chapter, we argue that RT measures should play a more important role in J/DM research, as they can help differentiate between different hypothesized processes that may lead to the same final decision or judgment.

1. Design and Instructions

In this microcomputer-administered experiment, respondents ($N = 384$) were asked to take the role of a salesperson in a large company and were told that management intended to change the current compensation system of its sales force. People in different groups received different expectations about the likely change in their salary and were asked to choose between pairs of compensation packages that differed in the amount of change in annual salary and in the number of vacation days. Precise scenario and task instructions that were designed to encourage people to use particular reference points when encoding the different salary offers are shown in Table III.

In a 2×2 between-subject design, we crossed whether the possible changes in compensation constituted an *actual* increase versus decrease in absolute salary level (real gain vs. real loss) with whether the changes constituted an increase versus a decrease in salary relative to respondents' *expectations*. Initial salary levels and possible choice alternatives were such that choices were comparable in the four different groups, in the sense that, for some choice pairs, the combination of starting salary and possible changes resulted in the same absolute levels of salary. Respondents in the real gain groups were told that their current salary was \$40,000. One half of them were led to expect a \$1,000 raise (for an absolute salary of \$41,000), and the other half expected a \$10,000 raise (for an absolute salary of \$50,000). Both real gain groups saw choice pairs that involved actual increases in salary that ranged from \$2,000 to \$8,500. For the gain group that had been led to expect a \$1,000 increase, all of these choice alternatives involved not only absolute gains but also gains relative to their expectation. For the gain group that had been led to expect a \$10,000 increase, however, these choice alternatives were absolute gains but also relative losses if evaluated relative to their expectation. Respondents in the real loss groups were told that their current salary was \$51,000. One half of them were led to expect a \$1,000 reduction (for an absolute salary of \$50,000), and the other half expected a \$10,000 reduction (for an absolute salary of \$41,000). Both real loss groups saw choice pairs that involved actual reductions in salary that ranged from \$2,000 to \$8,500. These choice pairs constituted both absolute and relative losses to the loss group that had been led to expect a \$1,000 reduction in salary. For the loss group that had been led to expect a \$10,000 reduction in salary, however, these choice alternatives

TABLE III

SCENARIO DESCRIPTION AND INSTRUCTIONS FOR CHOICE TASK IN EXPERIMENT 3

This part of the experiment asks you to evaluate and choose between different compensation packages that are offered to you by the company that you work for as a traveling salesman or saleswoman. Take a minute to imagine the following scenario and answer all questions as you would if you actually held that job under the conditions described below:

You have worked for the Acme Widget company as a salesperson for the last 3 years. Your territory includes all of the Midwest and Southwest of the United States. You visit major industrial manufacturing companies to sell a variety of widgets produced by Acme. This means that your job takes you away from home 3 to 4 days out of each week, usually overnight. You generally like your job because it is challenging and has a lot of potential for growth and promotions, but being away from home so much sometimes gets to be a bit stressful. Up until now you received a fixed salary of $40,000 which you considered fair even though it was just about average by industry standards. You also get 10 working days of paid vacation a year.

In a leveraged buyout, your company has recently been taken over by a much larger widget manufacturing concern. The new management wants to increase the market share of Acme, and has decided that it needs to motivate its sales force more with a new incentive system that is more performance based. You were initially quite concerned about the takeover and the new compensation system. You know that you cannot increase your volume of sales very much, even if you tried harder. What will the new system do to your income in an average year if you maintained your current volume of sales? Will your salary go up or down?

You went to talk to your supervisor about it last week. He wasn't quite sure himself about the details of the new incentive system. However, he assured you that management intended to RAISE average salaries to keep its salesforce content and motivated. He told you that even though the new incentive system would make part of the salary dependent on your volume of sales, he could virtually guarantee you that—with your current volume of sales—the net effect of the changes would be an INCREASE in your annual income of about $10,000.

Today, management revealed their new compensation plans. Somewhat unexpectedly, they decided to combine FINANCIAL INCENTIVES that are tied to your volume of sales with ADDITIONAL VACATION TIME also tied to your volume of sales.

Because management is uncertain about the preferences of their sales force for additional money versus additional vacation days, they are passing out a questionnaire that asks you for your preferences between packages that differ in the relative amounts of money versus vacation days. Based on your answers and those of your colleagues, they will make a final decision on the composition of the new incentive system in a couple of weeks.

To help you make your decision, they customized the effect that each package would have on your annual income, given your current volume of sales. That is, they calculated how your income this past year would have been different under each of the new packages available to you now.

When you get the questionnaire containing the different compensation package options, you notice that all of the options actually increase your salary CONSIDERABLY LESS than the $10,000 that your supervisor had "virtually guaranteed" you last week. You had already

(Continues)

TABLE III (*Continued*)

made some plans about how to use the additional $10,000—just about the price of that new sailboat you have had your eyes on for a while. Needless to say, you are quite upset about getting less than expected.

Now please help management in their incentive system allocation by indicating for each pair of incentive packages shown to you which one you would prefer. Remember that your current annual salary is $40,000, with a total of 10 working days of paid vacation. Take your time and consider each pair of options carefully.

Instead of the promised $10,000 raise,

Package 1 will give you	Package 2 will give you
only a $5,000 raise	only a $6,000 raise
and	and
a total of 14 vacation days	a total of 10 vacation days

Would you prefer to get Package 1 or Package 2?

were absolute losses but also relative gains if evaluated relative to prior expectation. The computer recorded people's choices and measured their response latencies.

After having made their 18 pairwise choices between the different compensation packages, participants were given a surprise recognition-memory test. Presented with the description of two annual salaries, they had to decide as quickly as possible which of the two salaries they had previously seen during the pairwise choice task. For four recognition pairs, the "old" and "new" salaries were described in exactly the same way as they were described during the choice task (e.g., a $4,000 raise). For another four pairs, both salaries were expressed in terms of absolute salary (e.g., a raise that changed your annual salary to $44,000). For yet another set of four pairs, both salaries were expressed as deviations from people's prior expectations (e.g., a raise that was $6,000 less than a $10,000 raise). The 12 forced-choice recognition pairs were presented in random order. Respondents were encouraged to identify the previously seen salary level in each pair as quickly as possible while still being sure of their answer. Precise task instructions and an example of each of the three different formats in which the salary pairs were described are shown in Table IV. Again, people's responses as well as response latencies were recorded.

2. *Results for Recognition Task*

Figure 3 shows mean RT (top panel) and accuracy (bottom panel) for the forced-choice recognition judgments as a function of the initial framing condition (real gain groups vs. real loss groups, a between-subject variable)

TABLE IV

INSTRUCTIONS AND STIMULI FOR RECOGNITION-MEMORY TASK IN EXPERIMENT 3

We are interested in the impression that different compensation packages have made on you. To that end, we will ask you a variety of different questions that test your memory of these packages.

As in all other parts of this experiment, the computer times your responses. For this part in particular, it is important that you answer as quickly as possible while still being sure of your answer.

Each question will describe two packages, one that actually appeared on the questionnaire with all the different compensation packages you just saw and another one that did not. It is your task to indicate which of the two packages is the one that appeared on the questionnaire.

The packages will be described only in terms of the money component (i.e., annual income), leaving out the vacation days component. As you will see, the money component of the two packages will be described in different ways. Some of these ways may strike you as odd. You may have to do some simple calculations in addition to recalling what the packages were that you saw before. However, try to do your best to pick out the correct alternative as quickly as you can. Remember that your previous annual salary was $40,000 and that you expected to get a $10,000 raise. Now tell us which of the packages described below was actually offered to you as choice alternatives on the questionnaire.

Which of the following two packages appeared above as an option on the questionnaire?

"As-Shown" Item Format

(1) A package that gave you a $5,000 raise in your annual salary?
(2) A package that gave you a $2,000 raise in your annual salary?

"Absolute Salary" Item Format

(1) A package that changed your annual salary to $44,000?
(2) A package that changed your annual salary to $48,000?

"Deviation from Expectation" Item Format

(1) A package that gave you a raise that was $3,000 less than a $10,000 raise?
(2) A package that gave you a raise that was $1,000 less than a $10,000 raise?

and presentation format of the items to be discriminated (as shown, absolute salary, deviation from expectation; a within-subject variable). The results for the two gain and the two loss groups are not shown separately for the two prior-expectation levels (i.e., for relative gain vs. relative loss), as there was no (main nor interaction) effect of expectation level either on discrimination RT or accuracy.

The overall interaction between framing condition and item format was significant for accuracy ($z = 2.97$, $p < .005$) and marginally significant for RT ($F(2, 220) = 2.64$, $p < .07$). The as shown condition served as a baseline for the speed and accuracy with which people could make old–new discriminations between salaries that were shown to them in exactly the same format in which they had appeared before (i.e., on the basis of visual recognition). As shown in Fig. 3, people made their recognition judgments

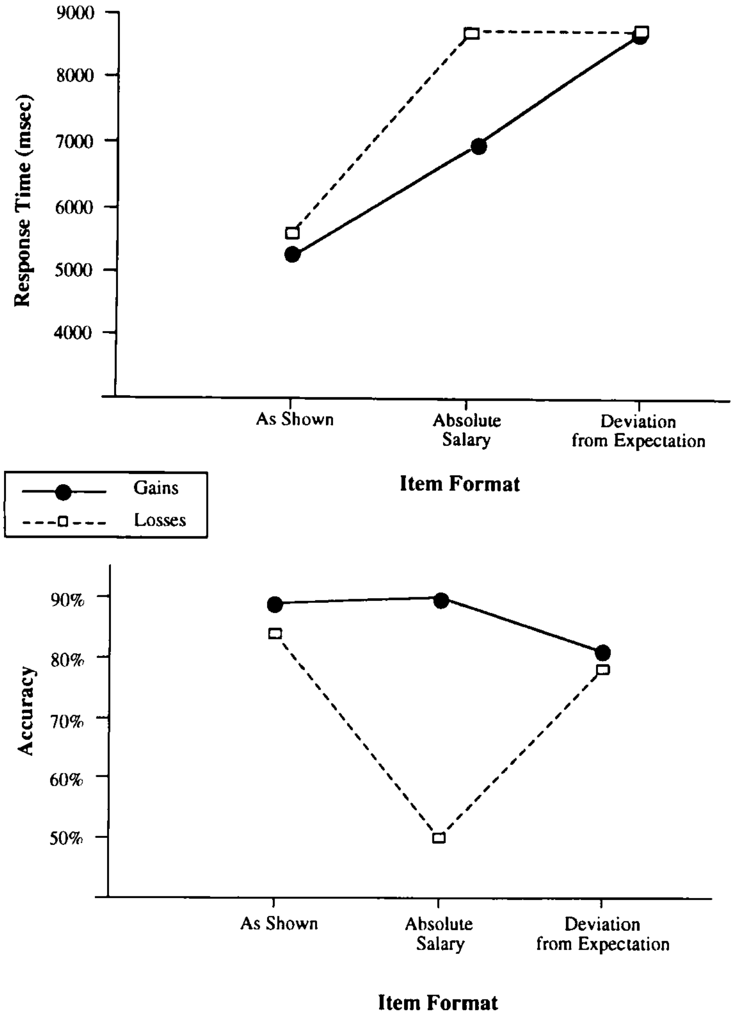

Fig. 3. Response time (top panel) and accuracy (bottom panel) for forced-choice recognition judgments for salary losses and salary gains as a function of the format in which items were presented (as shown during the previous judgment task vs. recoded in terms of absolute annual salary vs. recoded as deviation from prior expectation about salary change).

(including reading time) in the "as shown" condition in less than 6 sec (top panel), with an accuracy of close to 90% (bottom panel). Although judgments were somewhat slower and less accurate in the Real Loss than in the Real Gain groups, these differences were not significant.

Figure 3 also shows RT and accuracy of the discrimination judgments when item pairs were recoded to absolute salaries and to deviations from expectations. We assumed that people who recoded salaries during the choice task into absolute salary levels (i.e., recoded a $4,000 raise on a $40,000 salary as a new absolute salary of $44,000) would be faster and/or more accurate in detecting the "old" (i.e., previously seen) salary level during the discrimination task than people who did not do such recoding. In other words, we assumed that there would be some "saving" from the original recoding during the choice task. If people spontaneously recoded salary changes into absolute salaries during the choice task, this recoding should have left a memorial residue, and they should be able to do the old–new discrimination task by "recognition" based on their memory of the recoded information. On the other hand, people who did not spontaneously recode salary changes into absolute salaries during the choice task would have to do some recoding during the discrimination task, namely recoding absolute salary levels into changes in salary, in order to make the discrimination. Such recoding would presumably make their RT longer and/or their discrimination accuracy lower. The results in Fig. 3 show that respondents in the gain groups were both faster and more accurate in detecting the "old" item than respondents in the loss groups when salaries were presented in terms of absolute levels. Thus differences in RT between the two groups were *not* the result of any speed–accuracy trade-off. For respondents in the gain groups, accuracy was just as high for absolute salary discriminations as for as shown discriminations, and RT increased by less than 2 sec. For respondents in the loss groups, on the other hand, accuracy for absolute salary discriminations dropped to 50% (from a 90% baseline level), whereas RT increased by almost 4 sec.[1]

These results suggest that people in the gain groups were much more likely to recode salary changes into absolute salary levels during the initial choice task than people in the loss groups.[2] Calculating one's absolute salary

[1] These differences in difference between the as shown and absolute salary conditions were statistically significant for both RT and accuracy.

[2] An alternative explanation could be tested if we had included some additional control groups. One might argue that people in both the gain and loss groups recoded salary changes into absolute salary levels at the time of the recognition test and not during the initial choice task, and that the superior speed and accuracy observed for the gain groups resulted from the operation of addition (for the gain groups) being easier than the operation of subtraction (for the loss groups). Benchmarks to test this hypothesis could be obtained by including groups whose initial task, instead of preferential choice, had *required* them to perform recodings of the sort in question (e.g., addition and subtraction tasks). It would support our interpretation if respondents in our gain groups were as fast and accurate as people who had earlier performed the additions, and respondents in our loss groups were slower and less accurate than people who had earlier performed the subtractions. Additional benchmarks could be obtained by including groups whose initial tasks *prevented* them from performing the recodings in question. Although we don't have the data to draw definitive conclusions in this case, our main point is that the speed and accuracy of a surprise recognition test, compared with appropriate benchmarks, can be used to gather evidence concerning covert codings and recodings of information.

level for the different choice alternatives is, presumably, an emotionally much more rewarding task when all salary levels are larger than the status quo (in the gain groups) than when the absolute salary levels of all options are lower than one's current level (in the loss groups). The assumption that people try to maximize their hedonic experience of outcomes would predict the observed result of absolute salary recoding for the gain groups but not for the loss groups. Although this interpretation is post hoc, it is at least consistent with the hypothesis that the recoding of changes in outcomes into absolute outcome levels is under strategic control.

The same argument about savings of initial spontaneous recoding of information during the choice task can be made for the deviation from expectation condition of the discrimination task. We had hypothesized that, to maximize their hedonic experience of the choice alternatives, respondents in the loss group that expected a large $10,000 reduction in salary would recode subsequent smaller losses seen during the choice task as gains relative to their initial expectations. Respondents in the other loss group, who were led to expect a small $1,000 reduction in salary, however, should not recode subsequent larger losses seen during the choice task as losses relative to their initial expectations, as such recoding would lead to a double loss experience (i.e., an absolute as well as a relative loss). Similarly, we hypothesized that respondents in the gain group that were led to expect a large $10,000 salary increase would be unlikely to recode subsequent smaller gains as relative losses, but that respondents in the gain group with the small $1,000 salary increase expectation would be more likely to recode subsequent larger increases as relative gains. In summary, we predicted that recoding of outcomes as deviation from an expectation would occur when the recoding made the experience of the outcomes more positive, but not when it would make the experience more negative. As mentioned earlier, we did not find any significant main or interaction effects for the two prior expectation levels. Mean accuracy for the deviations-from-expectation condition was lower for the loss group, for whom recoding as deviation from expectation would have resulted in a relative loss, than for the other three groups, but this difference was not significant, especially when speed–accuracy trade-offs are taken into consideration. As shown in Fig. 3, the two gain and the two loss groups had very similar (long) RT and (lower) accuracy rates for the deviations-from-expectation condition. This absence of any significant difference in performance was contrary to our predictions, suggesting that our manipulation to get people to frame outcomes relative to their prior expectations failed. Although one could generate a range of post hoc explanations for this failure, the point that is important for the purposes of this chapter is not the absence of a framing effect, but our ability to diagnose this absence by means of people's performances on our surprise recognition memory test.

3. *Discussion*

The technique illustrated in Experiment 3, namely the speed of forced-choice recognition, is a useful tool if one wants to distinguish between decision or judgment models that predict the same final outcome but postulate different encoding and combination processes that lead up to that decision. There is an indeterminacy between models that postulate differences at the information encoding stage vs. differences at the information integration stage as being responsible for differences in final judgments or choices. Hogarth and Einhorn (1992), for example, show that certain characteristics of the way in which people update their beliefs that are usually attributed to different integration functions (i.e., additive vs. averaging functions) can be explained equally well by assuming different encoding strategies (encoding relative to a constant standard vs. encoding relative to a variable standard). The memory techniques discussed in this section are designed to provide "cloud-chamber evidence" for differences in encoding, and thus will help to discriminate between alternative explanations that cannot be discriminated by choice data alone. Similar indeterminacies exist among risky choice theories, for example, between change-of-process (i.e., integration rule) explanations of preference reversals (Mellers, Ordóñez, & Birnbaum, 1992), change-of-outcome-encoding explanations (Luce, Mellers, & Chang, 1993), and change-of-reporting explanations (Goldstein & Einhorn, 1987).

B. Recognition Tasks to Infer Information Representation

In Experiment 3, the *speed* with which people were able to give recognition judgments served as evidence about the previous encoding and representation of information. Pennington and Hastie (1988) also used a surprise recognition-memory task to draw inferences about the representations that underlie people's judgments and choices. However, instead of looking at the *speed* with which people were able to give recognition judgments, they used the *pattern of false recognitions* to draw inferences about encoding and representation. Pennington and Hastie's goal was to provide evidence for their hypothesis that people spontaneously construct causal stories when hearing legal evidence. As discussed more extensively in Goldstein and Weber (1995), representation of information by fitting it into a "story" or some other schema has the property that information that has not been presented but that is a part of the story or schema may be inferred spontaneously by people, leading to "false" recognitions. Similar to hindsight, when people are unable to distinguish between elements of their knowledge structures that predate the revelation of the actual outcome and those that postdate it, Pennington and Hastie (1988) found that people were unable to distinguish between pieces of evidence that had actually been presented in testimony and pieces of evidence they had inferred as consistent with the case story. The recent legal controversy about whether memories of childhood sexual abuse that emerge late in life are false versus previously repressed revolves around the possibility that apparent recollections may not be recollections but constructions. Unfortunately, in real life the truth–value of recollections or recognitions is often undeterminable.

C. Recall Tasks to Infer Strategy Use

Higgins and Bargh (1987) draw a theoretical distinction between the availability and accessibility of information. *Availability* refers to whether information is stored in memory; *accessibility* refers to the ease with which stored information can be retrieved. In order to use memory information in judgments or decisions, it must not only be available, but also be accessible. Higgins and Bargh (1987) argue that recognition tests are sensitive indicators of what is stored in memory, that is, of availability, whereas free recall tests are better indicators of what can easily be retrieved, that is, of accessibility. If one is interested in showing the *existence* of some information in memory (e.g., the existence of a particular encoding), the use of recognition measures is appropriate. If, on the other hand, one is interested in demonstrating the *use* of some information from memory in a decision or judgment, recall measures may be more appropriate because recently used information is more accessible.

Hastie and Park (1986) based their distinction between on-line and memory-based processing in impression formation on evidence from a free recall task. In particular, they looked at the correlation between the favorability of information about a target that people recalled from memory and the favorability of their impression about the target. The absence of any significant correlation was shown to be characteristic of on-line processing, and the presence of a positive correlation was shown to be characteristic of memory-based processing. McGraw, Lodge, and Stroh (1990) argued that these two conclusions have different inferential strength; whereas the absence of a correlation between memory and judgment measures strongly suggests on-line processing, the presence of a positive correlation may not necessarily be the result of memory-based processing. In an experiment in which people were forewarned about a judgment task (promoting on-line impression formation), but not about a subsequent memory task, McGraw et al. found that the *type* of recall task influenced the magnitude of the correlation observed. In particular, cued recall of evidence (e.g., "recall as many of the pieces of evidence that you *liked,*" followed by "recall as many of the pieces of evidence that you *disliked*") led to a stronger recall–impression relationship than standard free recall instructions (e.g., "recall as many of the pieces of evidence as you can"). As there was no difference in processing goals for the two conditions (memory task instructions were issued *after* the initial impression formation task), there was no reason why the evidence should have been encoded differently, an assumption that was confirmed by the absence of any difference in a subsequent recognition memory test. Thus, McGraw et al. argued that the positive memory-judgment correlation observed for the cued-recall group was an artifact of the cued-recall procedure (with favorability of the evidence acting as a retrieval cue), rather than evidence of memory-based processing. Their results suggest that researchers should stick to free recall tasks when assessing the accessibility of information.

McClelland et al. (1987) gave people a surprise memory task after a multiattribute choice task. Respondents had to choose either one or three cars from a set of 15 alternatives, with each alternative being described on three major and eight minor attributes. McClelland et al. used people's performances on a memory task described as cued recall, but perhaps closer to recognition (i.e., people had to decide whether each of the eight minor features had been present or absent in each car of the choice set), to infer what strategy they had used to make their multiattribute choices. In particular, McClelland et al. hypothesized that people used a lexicographic strategy that would allow them to winnow the full set of alternatives to a smaller set, using major attributes first and considering minor attributes only when necessary. This hypothesis predicted that minor attributes would be used more often when decisions were more difficult and consequently should be remembered better under those conditions. As predicted, memory for the minor car features was better in both conditions that made choice more difficult (in the choose-one vs. choose-three condition, and in a condition that had a dense set of good alternatives). Johnson and Russo (1984) used a free recall task to infer strategy use in judgments and choice. Free recall performance provided evidence for an elimination-based (i.e., noncompensatory) processing strategy used by people when making choices between automobiles that were described on multiple attributes but for more compensatory processing when making judgments of the desirability of individual cars. In particular, a much larger percentage of recalled attributes referred to the most preferred automobile in the choice task (35% belonged to the chosen car) than in the judgment task (18% belonged to the car with the highest desirability rating). These studies suggest that performance on free recall memory tasks may provide evidence about strategy use during judgment or choice tasks that is far easier to collect and analyze than other evidence, such as verbal protocols. Also, because memory tasks are administered as a surprise, after the judgment or choice task, there is no possibility that the diagnostic task can interfere with the task it is designed to diagnose.

In addition to using free recall to diagnose processing strategies, Johnson and Russo (1984) used people's free recall of product attributes to analyze their *organization of knowledge* about consumer products. Free recall does not guide or constrain people to generate previously seen items in any particular order. As a result, the way in which recalled information is clustered is diagnostic of the way the information is organized in memory. By analyzing clustering in free recall, Russo and Johnson (1980), for example, found clear evidence for brand-based rather than attribute-based organization of knowledge about consumer products. Johnson and Russo (1984) also found that brand-based organization became even more pronounced with increasing product familiarity.

D. Summary

This section provided an overview and a demonstration of different ways in which memory tasks can be used to test the encoding and processing assumptions that are explicitly or implicitly made by J/DM models. Lynch and Srull (1982) lamented the mismatch between the proliferation of theoretical assumptions about cognitive processes in consumer research and the paucity of methodologies capable of diagnosing such processes. They advised researchers to adopt methods from cognitive psychology (in particular methods capitalizing on attention and memory processes) to supplement simple outcome measures (judgments or choices) as well as commonly used but difficult to analyze process-tracing methods. We offer our review of the recognition and free recall methods in that spirit. It is also noteworthy that all studies reviewed in this section at least implicitly acknowledge the strategic or goal-directed nature of information encoding and information usage by making the various memory tests used to diagnose encoding or strategy use a surprise task for their respondents.

IV. Conclusions

In this chapter, we considered the two main metatheoretical frameworks of J/DM research, that is, strategy selection and the perceptual framework (Payne et al., 1992), and for each one we discussed the potential contributions of memory research. With respect to strategy selection, we demonstrated that recent models of memory representation and memory processes have the potential to enlarge the set of explanatory constructs that J/DM researchers have available to account for information integration. Although information integration is usually thought to be accomplished by an effortful decision strategy, the formation of overall impressions may instead be the relatively effortless by-product of memory representations and storage operations (i.e., the superposition of distributed item representations). We also discussed the theoretical and methodological implications of distinctions based on the *content* of memory (i.e., episodic vs. semantic vs. procedural memory).

With respect to the perceptual framework, we showed strong effects of the order in which outcome information was serially received in a choice task, suggesting simplified "gist" encoding of information as the result of short-term memory limitations (see also, Brainerd & Reyna, 1992; Reyna & Brainerd, 1991). We also discussed the influence of prior events and experiences on the encoding of information and the use of information elaboration tasks to reveal the knowledge base that people use in encoding information. In addition, we also showed that memory tasks, such as free recall or forced-choice recognition, can provide innovative diagnostic tools to shed light on otherwise "invisible" cognitive processes. The speed and accuracy of performance on memory tasks can reveal the traces of prior mental representations and uses of information analogous to the way vapor trails in a cloud chamber reveal the passage of subatomic particles. As we show elsewhere (Goldstein & Weber, 1995), the representation of the information on which a decision is based is related to the content of the decision and can influence the process as well as the outcome of the decision.

What are the lessons and implications of the suggestions and demonstrations of this chapter? Beyond the use of memory techniques as a tool capable of diagnosing a particular form of information encoding and/or processing, our intention was to encourage decision theorists to show greater concern for the details of memory representation and processes in their models of judgment and decision making. As argued at various points of the chapter, most judgment and decision tasks involve elements of memory retrieval. Memory-based judgments and decisions and mixed tasks that involve the integration of retrieved information with information that is physically present are the norm rather than the exception in most domains, from consumer choice to medical diagnosis to social judgments. This chapter summarized much of the empirical evidence documenting the need to address memory-based processes.

In the course of this chapter, we touched on several directions for theory development that integrate memory processes and judgment or decision processes in different ways and at different levels of analysis. A prime example of one important direction is the work by Kahneman and associates on the way in which memories of past experiences are integrated to form preferences for events that extend and change over time (e.g., Kahneman et al., 1993). Models at this level of analysis consider selective encoding, storage, and retrieval of the substantive information, possibly providing psychological explanations and boundary conditions for the existence of any memory effects (e.g., neglect of the duration of aversive experiences in retrospective evaluations, or strong sequence effects). Another direction for theory extension at a more abstract level is exemplified by the work of Busemeyer and Townsend (1993). Their decision field theory attempts to describe, among other things, the dynamic process by which the anticipated consequences of different choice alternatives, assumed to be retrieved over time by associative memory processes, are integrated until preference for one alternative emerges strong enough to result in choice. Their stochastic–dynamic theory predicts the choice probability of different alternatives as a function of variables such as available information about past and present preferences, attentional manipulations, and length of deliberation time. Decision field theory models the results of the deliberation process over time, but makes no assumptions about the representation of information or structure of memory. A third direction for theory extension, namely consideration of specific microlevel assumptions about information representation and associated information storage and retrieval processes is exemplified by the work of Weber et al. (1991) and Kashima and Kerekes (1994), described earlier. Theory extensions for judgment and choice models that address memory phenomena and processes at all of these levels of analysis will be necessary to predict real-world decisions and judgments that involve the evaluation and combination of new information, often obtained over time, in light of preexisting knowledge.

Researchers in other areas of cognitive psychology routinely acknowledge interconnections among different cognitive processes. Memory researchers, for example, have long incorporated attentional and decision processes into their models (e.g., Atkinson & Juola, 1973; Bernbach, 1967; Hockley, 1984; Hockley & Murdock, 1987; Ratcliff, 1978; Wickelgren & Norman, 1966). As reviewed by Elstein, Shulman, and Sprafka (1990), research in reasoning and, in particular, medical reasoning has in recent years addressed issues of memory organization, problem representation, and the structure of knowledge. We would like to reiterate the suggestion by Estes (1980) in Wallsten's (1980) predecessor to this volume that decision researchers can profit from following these examples. Explicit assumptions about the structure, processes, and content of memory ought to be incorporated more into J/DM models. We believe that a broader range of theoretical constructs and dependent measures than traditionally used in decision research—but with a history in other branches of cognitive psychology—can make important theoretical contributions.

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References

Adelson, B. (1984). When novices surpass experts: The difficulty of a task may increase with experience. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 10,* 483–495.

Anderson, J. A. (1972). A simple neural network generating an interactive memory. *Mathematical Biosciences, 14,* 197–220.

Anderson, J. A., Silverstein, J. W., Ritz, S. A., & Jones, R. S. (1977). Distinctive features, categorical perception, and probability learning: Some applications of a neural model. *Psychological Review, 84,* 413–451.

Anderson, J. R. (1976). *Language, Memory, and Thought.* Hillsdale, NJ: Erlbaum.

Anderson, N. H. (1981). *Foundations of information integration theory.* New York: Academic Press.

Anderson, N. H., & Hubert, S. (1963). Effects of concomitant verbal recall on order effects in personality impression formation. *Journal of Verbal Learning and Verbal Behavior, 2,* 379–391.

Arkes, H. (1991). Costs and benefits of judgment errors: Implications for debiasing. *Psychological Bulletin, 110,* 486–498.

Atkinson, R. C., & Juola, J. F. (1973). Factors influencing speed and accuracy of word recognition. In S. Kornblum (Ed.), *Attention and performance IV.* New York: Academic Press.

Bargh, J. A. (1989). Conditional automaticity: Varieties of automatic influence in social perception and cognition. In J. S. Uleman & J. A. Bargh (Eds.), *Unintended thought* (pp. 3–51). New York: Guilford Press.

Barsalou, L. W. (1990). On the indistinguishability of exemplar memory and abstraction in category representation. In T. K. Srull & R. S. Wyer (Eds.), *Advances in social cognition* (Vol. 3, pp. 61–88). Hillsdale, NJ: Erlbaum.

Barsalou, L. W., & Ross, B. H. (1986). The role of automatic and strategic processing in sensitivity to superordinate and property frequency. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 12,* 116–134.

Beach, L. R. (1993). Broadening the definition of decision making: The role of prechoice screening of options. *Psychological Science, 4,* 215–220.

Ben Zur, H., & Bresnitz, S. J. (1981). The effect of time pressure on risky choice behavior. *Acta Psychologica, 47,* 89–104.

Bernbach, H. (1967). Decision processes in memory. *Psychological Review, 74,* 462–480.

Böckenholt, U., & Kroeger, K. (1993). The effect of time pressure in multiattribute binary choice tasks. In O. Svenson & A. J. Maule (Eds.), *Time pressure and stress in human judgment and decision making* (pp. 195–214). New York: Plenum Press.

Bornstein, R. F. (1989). Exposure and affect: Overview and meta-analysis of research, 1968–1987. *Psychological Bulletin, 106,* 265–289.

Brainerd, C. J., & Reyna, V. F. (1992). Explaining "memory-free" reasoning. *Psychological Science, 3,* 332–339.

Brehmer, B. (1980). In one word: Not from experience. *Acta Psychologica, 45,* 223–241.

Brooks, L. R. (1978). Non-analytic concept formation and memory for instance. In E. Rosch and B. Lloyd (Eds.), *Cognition and categorization* (pp. 169–211). Hillsdale, NJ: Erlbaum.

Brooks, L. R., Norman, G. R., & Allen, S. W. (1991). Role of specific similarity in a medical diagnostic task. *Journal of Experimental Psychology: General, 120,* 278–287.

Bruce, D., Hockley, W. W., & Craik, F. I. M. (1991). Availability and category-frequency estimation. *Memory and Cognition, 19,* 301–312.

Busemeyer, J. R. (1985). Decision making under uncertainty: A comparison of simple scalability, fixed-sample, and sequential-sampling models. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 11,* 538–564.

Busemeyer, J. R., Forsyth, B., & Nozawa, G. (1988). Comparisons of elimination-by-aspects and suppression of aspects choice models based on choice response time. *Journal of Mathematical Psychology, 32,* 341–349.

Busemeyer, J. R., & Townsend, J. T. (1993). Decision field theory: A dynamic-cognitive approach to decision making in an uncertain environment. *Psychological Review, 100,* 432–459.

Chandler, C. C. (1991). How memory for an event is influenced by related events: Interference in modified recognition tests. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 17,* 115–125.

Chase, W. G., & Simon, H. A. (1973). Perception in chess. *Cognitive Psychology, 4,* 55–81.

Cohen, N. J. (1984). Preserved learning capacity in amnesia: Evidence for multiple memory systems. In L. R. Squire & N. Butters (Eds.), *The neuropsychology of memory* (pp. 419–432). New York: Guilford Press.

Coombs, C. H., & Avrunin, G. S (1977). Single-peaked functions and the theory of preference. *Psychological Review, 84,* 216–230.

Curley, S. P., Browne, G. J., Smith, G. F., & Benson, P. G. (1993). *Arguments in the practical reasoning underlying constructive probability responses.* Unpublished manuscript. University of Minnesota.

DeGroot, A. D. (1965). *Thought and choice in chess.* The Hague: Mouton.

Donders, F. C. (1868). Die Schnelligkeit psychischer Prozesse. *Archiv fuer Anatomie und Physiologie und Wissenschaftliche Medizin,* pp. 657–681.

Dreben, E. K., Fiske, S. T., & Hastie, R. (1979). The independence of evaluative and item information: Impression and recall order effects in behavior-based impression formation. *Journal of Personality and Social Psychology, 37,* 1758–1768.

Eddy, D. M. (1982). Probabilistic reasoning in clinical medicine: Problems and opportunities. In D. Kahneman, P. Slovic, & A. Tversky (Eds.), *Judgment under uncertainty: Heuristics and biases.* Cambridge, UK: Cambridge University Press.

Einhorn, H. J., & Hogarth, R. M. (1978). Confidence in judgment: The illusion of validity. *Psychological Review, 85,* 395–416.

Elstein, A. S., & Bordage, G. (1979). Psychology of clinical reasoning. In G. Stone, F. Cohen, & N. Adler (Eds.), *Health psychology: A handbook.* San Francisco: Jossey-Bass.

Elstein, A. S., Shulman, L. S., & Sprafka, S. A. (1990). Medical problem solving: A ten-year retrospective. *Evaluation and the Health Professions, 13,* 5–36.

Elster, J., & Loewenstein, G. (1992). Utility from memory and anticipation. In G. Loewenstein & J. Elster (Eds.), *Choice over time* (pp. 213–234). New York: Russell Sage Foundation.

Estes, W. K. (1980). Comments on directions and limitations of current efforts toward theories of decision making. In T. S. Wallsten (Ed.), *Cognitive processes in choice and decision behavior* (pp. 263–274). Hillsdale, NJ: Erlbaum.

Fischhoff, B. (1975). Hindsight ≠ foresight: The effect of outcome knowledge on judgment uncertainty. *Journal of Experimental Psychology: Human Perception and Performance, 1,* 288–299.

Fiske, S. T., & Neuberg, S. L. (1990). A continuum model of impression formation, from category-based to individuating processes: Influence of information and motivation on attention and interpretation. In M. P. Zanna (Ed.), *Advances in Experimental Social Psychology* (Vol. 23), (pp. 1–74). San Diego: Academic Press.

Fiske, S. T., & Taylor, S. E. (1991). *Social cognition* (2nd ed.). New York: McGraw-Hill.

Fox, J. (1980). Making decisions under the influence of memory. *Psychological Review, 87,* 190–211.

Friedrich, J. (1993). Primary error detection and minimization (PEDMIN) strategies in social cognition: A reinterpretation of confirmation bias phenomena. *Psychological Review, 100,* 298–319.

Frisch, D. (1993). Reasons for framing effects. *Organizational Behavior and Human Decision Processes, 54,* 399–429.

Frisch, D., & Clemen, R. T. (1994). Beyond expected utility: Rethinking behavioral decision research. *Psychological Bulletin, 116,* 46–54.

Gigerenzer, G., Hell, W., & Blank, H. (1988). Presentation and content: The use of base rates as a continuous variable. *Journal of Experimental Psychology: Human Perception and Performance, 14,* 513–525.

Goldstein, W. M., & Einhorn, H. J. (1987). Expression theory and the preference reversal phenomena. *Psychological Review, 94,* 236–254.

Goldstein, W. M., & Mitzel, H. C. (1992). The relative importance of relative importance: Inferring other people's preferences from relative importance ratings and previous decisions. *Organizational Behavior and Human Decision Processes, 52,* 382–415.

Goldstein, W. M., & Weber, E. U. (1995). Content and discontent: Indications and implications of domain specificity in preferential decision making. In J. R. Busemeyer, R. Hastie, D. L. Medin (Eds.), *The Psychology of Learning and Motivation, 32,* San Diego: Academic Press.

Hastie, R. (1988). A computer simulation model of person memory. *Journal of Experimental Social Psychology, 24,* 423–447.

Hastie, R., & Park, B. (1986). The relationship between memory and judgment depends on whether the judgment task is memory-based or on-line. *Psychological Review, 93,* 258–268.

Hawkins, S. A., & Hastie, R. (1990). Hindsight: Biased judgments of past events after the outcomes are known. *Psychological Bulletin, 107,* 311–327.

Hawkins, S. A., & Hoch, S. J. (1992). Low-involvement learning: Memory without evaluation. *Journal of Consumer Research, 19,* 212–225.

Higgins, E. T., & Bargh, J. A. (1987). Social cognition and social perception. *Annual Review of Psychology, 38,* 369–425.

Hockley, W. E. (1984). Analysis of response time distributions in the study of cognitive processes. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 10,* 598–615.

Hockley, W. E., & Lewandowsky, S. (Eds.). (1991). *Relating theory and data: Essays on human memory in honor of Bennet B. Murdock.* Hillsdale, NJ: Erlbaum.

Hockley, W. E., & Murdock, B. B. (1987). A decision model for accuracy and response latency in recognition memory. *Psychological Review, 94,* 341–358.

Hogarth, R. M., & Einhorn, H. J. (1992). Order effects in belief updating: The belief-adjustment model. *Cognitive Psychology, 24,* 1–55.

Hogarth, R. M., & Kunreuther, H. (1995). Decision making under ignorance: Arguing with yourself. *Journal of Risk and Uncertainty, 10,* 15–36.

Holbrook, M. B. (1987). What is consumer research? *Journal of Consumer Research, 14,* 128–132.

Hsee, C. K., Abelson, R. P., & Salovey, P. (1991). The relative weighting of position and velocity in satisfaction. *Psychological Science, 2,* 263–266.

Huber, O. (1980). The influence of some task variables on cognitive operations in an information processing decision model. *Acta Psychologica, 45,* 187–196.

Humphreys, M. S., Bain, J. S., & Pike, A. R. (1989). Different ways to cue a coherent memory system: A theory for episodic, semantic, and procedural tasks. *Psychological Review, 96,* 208–233.

Jacoby, L. L., Lindsay, D. S., & Toth, J. P. (1992). Unconscious influences revealed: Attention, awareness, and control. *American Psychologist, 47,* 802–809.

Jacoby, L. L., Toth, J. P., & Yonelinas, A. P. (1993). Separating conscious and unconscious influences of memory: Measuring recollection. *Journal of Experimental Psychology: General, 122,* 139–154.

Johnson, E. J., & Russo, J. E. (1984). Product familiarity and learning new information. *Journal of Consumer Research, 11,* 542–550.

Joseph, G.-M., & Patel, V. L. (1990). Domain knowledge and hypothesis generation in diagnostic reasoning. *Medical Decision Making, 10,* 31–46.

Kahneman, D., Fredrickson, B. L., Schreiber, C. A., & Redelmeier, D. A. (1993). When more pain is preferred to less: Adding a better end. *Psychological Science, 4,* 401–405.

Kahneman, D., Slovic, A., & Tversky, A. (1982). *Judgment under uncertainty: Heuristics and biases.* Cambridge, UK: Cambridge University Press.

Kahneman, D., & Snell, J. (1992). Predicting a changing taste: Do people know what they will like? *Journal of Behavioral Decision Making, 5,* 187–200.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrika, 47,* 263–291.

Kahneman, D., & Tversky, A. (1982). The psychology of preference. *Scientific American, 246,* 163–169.

Kashima, Y., & Kerekes, A. R. Z. (1994). A distributed memory model of averaging phenomena in person impression formation. *Journal of Experimental Social Psychology, 30,* 407–455.

Klayman, J., & Ha, Y.-W. (1987). Confirmation, disconfirmation, and information in hypothesis testing. *Psychological Review, 94,* 211–228.

Kleinmuntz, B. (1968). The processing of clinical information by man and machine. In B. Kleinmuntz (Ed.), *Formal representation of human judgment* (pp. 149–186). New York: Wiley.

Kolodner, J. L., Simpson, R. L., & Sycara-Cyranski, K. (1985). A process model of case-based reasoning in problem solving. *Proceedings of the Ninth International Joint Conference on Artificial Intelligence.* Los Angeles, CA.

Kruschke, J. K. (1992). ALCOVE: An exemplar-based connectionist model of category learning. *Psychological Review, 99,* 22–44.

Levin, I. P., & Chapman, D. P. (1993). Risky decision making and allocation of resources for leukemia and AIDS programs. *Health Psychology, 12,* 110–117.

Levin, I. P., Jasper, J. D., Mittelstaedt, J. D., & Gaeth, G. J. (1993). Attitudes toward "buy American first" and preferences for American and Japanese cars: A different role for country-of-origin information. In L. McAlister & M. L. Rothschild (Eds.), *Advances in Consumer Research* (Vol. 20, pp. 625–629). Provo, UT: Association for Consumer Research.

Lewin, K., Dembo, T., Festinger, L., & Sears, P. S. (1944). Level of aspiration. In J. McV. Hunt (Ed.), *Personality and the behavior disorders: A handbook based on experimental and clinical research* (Vol. 1, pp. 333–378). New York: Ronald Press.

Libby, R., & Frederick, D. M. (1990). Experience and the ability to explain audit findings. *Journal of Accounting Research, 28,* 348–367.

Lichtenstein, S., Fischhoff, B., & Phillips, L. D. (1982). Calibration of probabilities: The state of the art to 1980. In D. Kahneman, P. Slovic, & A. Tversky (Eds.), *Judgment under uncertainty: Heuristics and biases.* Cambridge, UK: Cambridge University Press.

Lichtenstein, S., & Slovic, P. (1971). Reversal of preference between bids and choices in gambling decisions. *Journal of Experimental Psychology, 89,* 46–55.

Lingle, J. H., & Ostrom, T. M. (1979). Retrieval selectivity in memory-based impression judgments. *Journal of Personality and Social Psychology, 37,* 180–194.

Linville, P. W., & Fischer, G. W. (1991). Preferences for separating or combining events. *Journal of Personality and Social Psychology, 60,* 5–23.

Logan, G. D. (1988). Toward an instance theory of automatization. *Psychological Review, 95,* 492–527.

Lopes, L. (1994). Psychology and economics: Perspectives on risk, cooperation, and the marketplace. *Annual Review of Psychology, 45,* 197–227.

Luce, R. D., Mellers, B. A., & Chang, S. (1993). Is choice the correct primitive? On using certainty equivalents and reference levels to predict choices among gambles. *Journal of Risk and Uncertainty, 6,* 115–144.

Lynch, J. G., & Srull, T. K. (1982). Memory and attentional factors in consumer choice. *Journal of Consumer Research, 9,* 18–37.

Markowitz, H. (1959). *Portfolio selection: Efficient diversification of investment.* New York: Wiley.

McClelland, G. H., Stewart, B. E., Judd, C. M., & Bourne, L. E. (1987). Effects of choice task on attribute memory. *Organizational Behavior and Human Decision Processes, 40,* 235–254.

McGraw, K., Lodge, M., & Stroh, P. (1990). *Processes of candidate evaluation: On-line or memory based?* Unpublished manuscript, SUNY at Stonybrook.

Means, B., & Loftus, E. F. (1991). When personal history repeats itself: Decomposing memory for recurring events. *Applied Cognitive Psychology, 5,* 297–318.

Medin, D. L., & Edelson, S. (1988). Problem structure and the use of base-rate information from experience. *Journal of Experimental Psychology: General, 117,* 68–85.

Medin, D. L., & Schaffer, M. M. (1978). Context theory of classification learning. *Psychological Review, 85,* 207–238.

Mellers, B. A., Ordóñez, L., & Birnbaum, M. H. (1992). A change-of-process theory for contextual effects and preference reversals in risky decision making. *Organizational Behavior and Human Decision Processes, 52,* 331–369.

Melton, A. W., & Martin, E. (Eds.). (1972). *Coding processes in human memory.* Washington, DC: Winston.

Metcalfe Eich, J. (1982). A composite holographic associate recall model. *Psychological Review, 89,* 627–661.

Metcalfe, J. (1990). Composite holographic associate recall model (CHARM) and blended memories in eyewitness testimony. *Journal of Experimental Psychology: General, 119,* 145–160.

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review, 63,* 81–96.

Montgomery, H. (1983). Decision rules and the search for a dominance structure: Toward a process model of decision making. In P. Humphreys, O. Svenson, & A. Vari (Eds.), *Analysing and aiding decision processes* (pp. 343–369). Amsterdam: North-Holland.

Morton, J. (1970). A functional model of memory. In D. A. Norman (Ed.), *Models of human memory* (pp. 203–260). San Diego: Academic Press.

Murdock, B. B., Jr. (1982). A theory for the storage and retrieval of item and associative information. *Psychological Review, 89,* 609–626.

Murdock, B. B., Jr. (1983). A distributed memory model for serial-order information. *Psychological Review, 90,* 316–338.

Murdock, B. B., Jr. (1989). Learning in a distributed memory model. In C. Izawa (Ed.), *Current issues in Cognitive Processes: The Tulane Floweree Symposium on Cognition* (pp. 69–106). Hillsdale, NJ: Erlbaum.

Murdock, B. B., Jr. (1993). TODAM2: A model for the storage and retrieval of item, associative, and serial-order information. *Psychological Review, 100,* 183–203.

Newell, A., & Simon, H. A. (1972). *Human problem solving.* Englewood Cliffs, NJ: Prentice-Hall.

Nisbett, R. E. (Ed.). (1993). *Rules for reasoning.* Hillsdale, NJ: Erlbaum.

Nosofsky, R. M. (1992). Exemplars, prototypes, and similarity rules. In A. F. Healy, S. M. Kosslyn, & R. M. Shiffrin (Eds.), *From learning theory to connectionist theory: Essays in honor of William K. Estes* (Vol. 1, pp. 149–167). Hillsdale, NJ: Erlbaum.

Payne, J. W. (1982). Contingent decision behavior. *Psychological Bulletin, 92,* 382–402.

Payne, J. W., Bettman, J. R., and Johnson, E. J. (1988). Adaptive strategy selection in decision making. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 14,* 534–552.

Payne, J. W., Bettman, J. R., and Johnson, E. J. (1990). The adaptive decision maker: Effort and accuracy in choice. In R. M. Hogarth (Ed.), *Insights in decision making: A tribute to Hillel J. Einhorn.* Chicago: University of Chicago Press.

Payne, J. W., Bettman, J. R., and Johnson, E. J. (1992). Behavioral decision research: A constructive processing perspective. *Annual Review of Psychology, 43,* 87–131. Cambridge, UK: Cambridge University Press.

Payne, J. W., Bettman, J. R., and Johnson, E. J. (1993). *The adaptive decision maker.* Cambridge: Cambridge University Press.

Pennington, N., & Hastie, R. (1988). Explanation-based decision making: The effects of memory structure on judgment. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 14,* 521–533.

Posner, M. I., & Keele, S. W. (1968). On the genesis of abstract ideas. *Journal of Experimental Psychology, 77,* 353–363.

Ratcliff, R. (1978). A theory of memory retrieval. *Psychological Review, 85,* 59–108.

Restle, F. (1961). *Psychology of judgment and choice.* New York: Wiley.

Reyna, V. F., & Brainerd, C. J. (1991). Fuzzy-trace and framing effects in choice: Gist extraction, truncation, and conversion. *Journal of Behavioral Decision Making, 4,* 249–262.

Roediger, H. L. (1990). Implicit memory: Retention without remembering. *American Psychologist, 45,* 341–357.

Rumelhart, D. E., & McClelland, J. L. (Eds.). (1986). *Parallel distributed processing: Explorations in the microstructure of cognition* (two volumes). Cambridge, MA: MIT Press.

Russo, J. E., & Johnson, E. J. (1980). What do consumers know about familiar products? In J. Olson (Ed.), *Advances in Consumer Research* (Vol. 7, pp. 417–423). Ann Arbor, MI: Association for Consumer Research.

Schneider, S. L. (1992). Framing and conflict: Aspiration level contingency, the status quo, and current theories of risky choice. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18,* 1040–1057.

Schneider, W., & Shiffrin, R. M. (1977). Controlled and automatic human information processing: I. Detection, search, and attention. *Psychological Review, 1984,* 1–66.

Shafir, E., & Tversky, A. (1992). Thinking through uncertainty: Nonconsequential reasoning and choice. *Cognitive Psychology, 24,* 449–474.

Shanteau, J. (1991). A functional measurement analysis of reaction times in problem solving. In N. H. Anderson (Ed.), *Contributions to integration theory* (Vol. 1). New York: Academic Press.

Simon, H. A. (1955). A behavioral model of rational choice. *Quarterly Journal of Economics, 59,* 99–118.

Simon, H. A. (1956). Rational choice and the structure of the environment. *Psychological Review, 63,* 129–138.

Slovic, P., Fischhoff, B., & Lichtenstein, S. (1982). Response mode, framing, and information-processing effects in risk assessment. In R. Hogarth (Ed.), *New directions for methodology of social and behavioral sciences: Question framing and response mode.* San Francisco: Jossey-Bass.

Smith, E. R. (1990). Content and process specificity in the effects of prior experience. In T. K. Srull & R. S. Wyer (Eds.), *Advances in Social Cognition* (Vol. 3, pp. 1–61). Hillsdale, NJ: Erlbaum.

Smith, J. F., Mitchell, T. R., Beach, L. R. (1982). A cost–benefit mechanism for selecting problem-solving strategies: Some extensions and empirical tests. *Organizational Behavior and Human Performance, 29,* 370–396.

Staw, B. (1976). Knee-deep in the big muddy: A study of escalating commitment to a chosen course of action. *Organizational Behavior and Human Performance, 16,* 27–44.

Thaler, R. (1980). Toward a positive theory of consumer choice. *Journal of Economic Behavior and Organization, 1,* 39–60.

Thaler, R. (1985). Mental accounting and consumer choice. *Marketing Science, 4,* 199–214.

Thaler, R., & Johnson, E. H. (1990). Gambling with the house money and trying to break even: The effects of prior outcomes on risky choice. *Management Science, 36,* 643–660.

Townsend, J. T. (1990). Serial versus parallel processing: Sometimes they look like tweedledum and tweddledee but they can (and should) be distinguished. *Psychological Science, 1,* 46–54.

Tubbs, R. M., Gaeth, G. J., Levin, I. P., & van Osdol, L. A. (1993). Order effects in belief updating with consistent and inconsistent evidence. *Journal of Behavioral Decision Making, 6,* 257–269.

Tulving, E. (1972). Episodic and semantic memory. In E. Tulving and W. Donaldson (Eds.), *Organization of Memory* (pp. 381–403). New York: Academic Press.

Tversky, A. (1972). Elimination by aspects: A theory of choice. *Psychological Review, 79,* 281–299.

Tversky, A., & Kahneman, D. (1973). Availability: A heuristic for judging frequency and probability. *Cognitive Psychology, 5,* 207–232.

Tversky, A., & Kahneman, D. (1981). The framing of decisions and the psychology of choice. *Science, 211,* 453–458.

Tversky, A., & Kahneman, D. (1986). Rational choice and the framing of decisions. *Journal of Business, 59,* S251–S278.

Tversky, A. Sattath, S., & Slovic, P. (1988). Contingent weighting in judgment and choice. *Psychological Review, 95,* 371–384.

Wallsten, T. S. (Ed.). (1980). *Cognitive Processes in choice and decision behavior* (pp. 263–274). Hillsdale, NJ: Erlbaum.

Wallsten, T. S. (1981). Physician and medical student bias in evaluating diagnostic information. *Medical Decision Making, 1,* 145–164.

Weber, E. U., Barlas, S., Wertenbrock, K., & Goldstein, W. M. (1994). The psychophysics of value functions. Unpublished manuscript. Center for Decision Research, University of Chicago.

Weber, E. U., Böckenholt, U., Hilton, D. J., & Wallace, B. (1993). Determinants of diagnostic hypothesis generation: Effects of information, base rates, and experience. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19,* 1151–1164.

Weber, E. U., Goldstein, W. M., Barlas, S., & Busemeyer, J. R. (1994). Memory representation and cognitive effort. Unpublished manuscript. Center for Decision Research. University of Chicago.

Weber, E. U., Goldstein, W. M., & Busemeyer, J. R. (1991). Beyond strategies: Implications of memory representation and memory processes for models of judgment and decision making. In W. E. Hockley & S. Lewandowsky (Eds.), *Relating theory and data: Essays on human memory in honor of Bennet B. Murdock.* Hillsdale, NJ: Erlbaum.

Whittlesea, B. W. A., Brooks, L. R., & Westcott, C. (1994). After the learning is over: Factors controlling the selective application of general and particular knowledge. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20,* 259–274.

Wickelgren, W., & Norman, D. (1966). Strength models and serial position in short-term recognition memory. *Journal of Mathematical Psychology, 3,* 316–347.

Young, A. W., & DeHaan, E. H. F. (1990). Impairment of visual awareness. *Mind and Language, 5,* 29–48.