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# Constructive Processing of Representations for Choice

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## **Abstract**

Research on constructive processing in consumer choice has tended to focus on the construction of heuristics for choice, thus assuming that the information for the choice is in an appropriate format for heuristic construction and implementation. In many real-world decisions, however, consumers are often faced with information that is not in a suitable form for heuristic use. In this research, restructuring is proposed as a process by which consumers construct representations of information (e.g., brands), either as an alternative to, or in addition to, constructing heuristics. Issues of why, when, and how consumers might restructure are addressed. Hypotheses about restructuring and its effect on heuristic use are examined in a study. Subjects' generated external memories are used as a method for examining the nature of representations for choice and the types of restructuring operations used to construct each representation.



## CONSTRUCTIVE PROCESSING OF REPRESENTATIONS FOR CHOICE

Years of research into consumers' decision processes have led to the conclusion that consumers are not perfectly infallible information processors. We recognize that consumers are human, and that as a result they are possessed of limited processing capacity and often-faulty mechanisms for identifying and retrieving information from long term memory. It is not surprising, then, that numerous researchers have focused their attention on identifying and explaining how consumers function as decision makers in spite of, and because of, these constraints on their decision making abilities. One such area of research interest is constructive processing.

Constructive processing is a term used to describe behaviors that appear to be developed in an *ad hoc* fashion, in order to attain a particular goal (Payne, Bettman and Johnson 1992). For example, a consumer who must decide upon a brand in a product category for which he has little or no prior experience might construct a heuristic for evaluating the available brands. In a choice among microwave ovens, in which brands may be described by different features, the consumer might develop the heuristic, "Find a feature that is common to all of the brands, and choose the oven that has the best value on this feature." In this sense, constructive processing is a means to an end; it provides the consumer with a way to make a choice when the consumer cannot rely upon information stored in memory, such as a satisfactory prior purchase from the category, or an appropriate heuristic for evaluating the brands.

Previous research into constructive processing has tended to be focused on the construction of heuristics for making choices, as in the example of the microwave oven purchase (e.g., Bettman and Zins 1977). In this paper, constructive processes are considered in a very different manner; it is proposed that consumers may often carry out

constructive behaviors in order to create new representations of information. This process, termed 'restructuring', may occur in addition to, or even instead of, heuristic construction.

To illustrate the idea of restructuring, suppose that you are about to buy a car. The information upon which you will decide which cars should be considered, and which car you will choose, comes from many sources: advertisements, word-of-mouth, brochures, magazine articles, dealers, etc. You are faced with the task of determining what information you will pay attention to, and how that information will be integrated into your decision. Because the information is available in various formats and amounts from several sources, the nature of the set of alternatives (i.e., the representation) may need to be altered several times to reflect your current assessment of what information is relevant for making a choice. For example, if you notice that all of the cars have fuel injection systems, you can safely eliminate this feature from consideration; it is not diagnostic. If all the cars have similar warranties, but one car has no warranty, you might drop this car from further consideration. This example points out several aspects of restructuring: 1) it is a dynamic process for creating representations, 2) it can serve to increase processability and comparability of information, 3) it can be opportunistic, and 4) it may be done to facilitate use of a choice heuristic. In addition, restructuring can affect the actual choice, as it determines what information is available for evaluation.

This paper is organized as follows: a general description and review of constructive processing precedes a discussion of why and how consumers might restructure representations of information. To test hypotheses which stem from this discussion, a section on assessing constructive processing of representations describes a method developed to examine restructuring, which uses consumers' generated external memory, or notes. This method serves as the primary data collection technique employed in a study of restructuring behaviors. The results of the study are discussed, and conclusions are drawn about the nature of restructuring and its importance in consumer choice.

## CONSTRUCTIVE PROCESSING IN CHOICE

Past views of constructive processing have been focused on heuristic development: the process of creating a method for evaluating options. The basic idea is that a consumer constructs a heuristic because he doesn't have one that he can retrieve from long term memory and apply to the problem (Bettman and Zins 1977). Alternatively, a consumer may process constructively when perusal of the information suggests that there is a new and better way of making the decision. In this case, the consumer processes opportunistically, taking advantage of patterns or regularities in the information to guide the development of a heuristic (Hayes-Roth 1982, Hayes-Roth and Hayes-Roth 1979).

Why this focus on heuristic construction? Part of the answer may be due to the type of stimuli typically used to assess decision behavior. Previous research has been done primarily by using problems in which information is given to the subject in a form appropriate for heuristic use, like information display boards (Payne 1976), or computer-based displays of matrices (Klein and Yadav 1989; Payne, Bettman and Johnson 1988). These stimuli share the characteristics that the information is usually all available and comparable, and the information is easily processable. As a result, subjects may simply use the information 'as is' to make a choice; there is no need to restructure the initial representation of information.

In most real-world choices, however, information about brands isn't available to the consumer in such a well-structured format; it is often more difficult to process. For example, information may not all be available at one time, as when the consumer visits multiple stores. Some information may not be available at any time; some brands may have different attributes, or information about the value of an attribute may be unobtainable. Difficulty may also stem from the noncomparability of information, as when attribute values are given in different units, or from low processability, as when attributes are available in different orders for different brands. In addition, consumer characteristics, such as lack of familiarity with the product information or with an appropriate heuristic,

may make a choice problem difficult. One way that the consumer can cope with these sources of difficulty when evaluating brands is by creating a new representation of the information, restructuring the initial representation into a better, more usable, form. Given the frequency with which these sources of difficulty are encountered in everyday life, restructuring is an important component of the consumer choice process.

In the next section, an analysis of restructuring is presented which considers the nature of a representation, as well as the resources which can be used to alter the representation.

## CONSTRUCTION OF REPRESENTATIONS

### What Is A Representation?

Newell and Simon (1972) describe an individual making a complex decision as an 'information processing system'. The information processing system, henceforth described as a 'consumer', receives information from the task environment, which is an external representation of problem information. The task environment is analogous to the set of inputs (i.e., brands) provided by marketers.

From the external representation the consumer generates an initial internal representation. This initial representation contains marketing inputs perceived by the consumer. The internal representation may be a veridical copy of the external representation or it may be a transformed version. This part of the decision process is a structuring phase. Structuring describes the process by which the consumer constructs an initial representation of the decision (Gettys 1983; Keller 1987). Restructuring includes the initial representation and any subsequently constructed representations. The internal representation reflects the current situation for the consumer. It is contained in a problem space, along with all other possible states of knowledge. If the internal representation enables the consumer to select and apply a heuristic, which, when executed, will achieve a desired end, the consumer carries out the heuristic. If no heuristic is appropriate, the

consumer might either construct a new heuristic, or construct a new representation, restructuring the internal representation. Restructuring is defined as the application of one or more operations, such as eliminating redundant information or standardizing information, to a set of information which results in a new problem representation.

### **How Do Consumers Restructure?**

The resources for restructuring are of two basic types: 1) the means by which restructuring operations are carried out, and 2) the actual restructuring operations that are carried out.

Memory resources for restructuring information. Two memory resources can be used to restructure information: 1) internal memory, and 2) external memory. Consumers may restructure information by using the resources of internal memory to carry out desired operations: for example, computing and storing products of unit price transformations in working memory. One of the major drawbacks of working memory is that it has limited processing capacity; the consumer may not be able to maintain the amount of information in memory needed to complete the restructuring.

Internal processing capacity limitations affect the amount of effort or attention that a consumer can put into a decision; however, external memory is not subject to the same limitations. External memory is available to the consumer through, for example, ads, product displays, brochures, and self-generated notes. Consumers may generate external memory to restructure information, circumventing the difficulties caused by internal memory limitations. All forms of external memory can be used to aid restructuring.

Operations for restructuring. Past research in decision making suggests several ways in which consumers might make changes to a representation. Kahneman and Tversky (1979) suggest six operations: 1) eliminating dominated alternatives, 2) coding, 3) combination, 4) cancellation, 5) segregation, and 6) rounding. The authors propose that decision makers use these operations whenever possible to simplify a representation and subsequent evaluation and choice. In addition, they demonstrate that the use of different sequences of operations may

result in the creation of different prospects for choice. Using one operation may preclude the use of another operation; therefore, the order in which operations are done may result in substantially different problem representations from decision maker to decision maker.

Research conducted by Klein and Yadav (1989) and by Ranyard (1989) provides empirical support for the use of two simplifying operations: elimination of dominated alternatives (Klein and Yadav) and rounding of values (Ranyard). Klein and Yadav present results which indicate that subjects use the knowledge of dominance to reduce the effort of making a choice. Although the authors do not explicitly consider the elimination of dominated alternatives as a process for restructuring, the findings suggest that subjects alter the decision representation to facilitate making a choice. Ranyard reports that subjects attempt to simplify decisions by rounding values and by combining information into ratios.

The operations described by Kahneman and Tversky represent only one facet of restructuring, that of simplifying a representation by reducing the amount of information. In describing his dominance model of decision making, Montgomery (1983) suggests a different type of process in which operations are used to transform the values of information without reducing problem size. Montgomery suggests that the decision maker will change information, transforming it to make it fit a desired dominance structure. Attributes may be emphasized or deemphasized, resulting in a transformation of attribute weights. The end goal of this process is to make one alternative clearly dominate the others.

Operations may also be done to transform information other than weights. Consumers may transform attribute values by ranking within an attribute, but across brands, from best to worst. The brands themselves may also be ranked to reflect a current evaluation of desirability.

Slovic and MacPhillamy (1974) report results of an experiment which provide support for the use of transforming operations, such as the operation described by Montgomery. Subjects were presented with stimuli in which some attributes were not commensurable for all alternatives. The authors found that subjects tended to place greater emphasis on the attributes which were commensurable. Although not intended as a study of restructuring, this study does

indicate that subjects transform information, such as attribute weights, to reflect evaluations of the decision formed in opportunistic, bottom-up information processing.

Based upon previous research into information processing for choice, a rough typology of restructuring operations can be developed. To construct a new representation, a consumer may simplify the initial representation by editing out information, or he might alter the problem representation by transforming or rearranging the presented information to make it more processable. In addition, a consumer may infer new attributes (Johnson 1984) or attribute values (Huber and McCann 1982). This suggests that restructuring can also be done to add new, not presented information to a problem representation. The table in Figure 1 presents the typology of operations, as well as examples of specific operations within each subgroup.

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Figure 1 about here.  
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Although many of the cognitive tools used to accomplish the processes of restructuring a representation and carrying out a heuristic may often be similar, the processes differ in terms of their primary goals and their output. The primary goal of restructuring is to create a new representation, whereas the primary goal of a heuristic is to select a single alternative. For example, the arithmetic operations used to generate unit prices and the intermediate products of a weighted adding heuristic are the same. The calculations of unit price, however, serve an immediate goal of creating a more easily processable representation, while the calculations of weighted adding products enable the consumer to make a choice. This distinction emphasizes the need to consider representation construction as a process that is often separate from, though related to, heuristic construction.

### **When Do Consumers Change Representations?**

Because processes for restructuring and processes for using a choice heuristic are closely linked, the discussion of when a consumer might opt for constructive processing of

a representation is developed based upon two cases of heuristic knowledge. In Case 1, the consumer does not know an appropriate heuristic. In Case 2, the consumer does know an appropriate heuristic for making a choice. The influence of each situation on restructuring behavior is considered below.

Case 1. The reasons why not knowing a heuristic may lead to restructuring are similar to those described by Bettman and Zins (1977), in their discussion of when consumers might construct heuristics for choice. They suggest that constructive processing of a heuristic may occur when: a) the consumer has little or no familiarity with the information, or b) the consumer is faced with a difficult choice. If a), the consumer may engage in constructive processing because he doesn't know what to choose or how to choose. If b), constructive processing may be undertaken because an appropriate heuristic is not obvious. For a theory of restructuring, these reasons for constructive processing also hold. For low familiarity, the consumer may construct a new representation to exploit patterns or regularities in the information, perhaps en route to developing a new heuristic. Restructuring of this sort might take the form of calculating unit prices, or eliminating information that is clearly nondiagnostic (e.g., redundant attributes, or attribute values of low variance). This type of constructive processing is opportunistic (Hayes-Roth and Hayes-Roth 1979).

A consumer might also restructure when faced with a difficult choice. For example, if the choice is difficult because the information is in a format that does not facilitate comparisons between attributes or alternatives, a consumer might restructure by completing obvious operations to a representation to 'fix it up', in the hope of recognizing or developing a heuristic that will lead to a satisfactory choice. Operations to this end might include standardizing attribute values presented in different units, hoping to detect a dominating alternative, or organizing information so that brands and their attributes can be more readily compared.

Case 2. In addition to the situations for constructive processing proposed by Bettman and Zins for heuristics, restructuring may occur when the consumer does know a heuristic. In this case, the consumer may decide to construct a new representation because the information currently available is not in an appropriate form for heuristic use. Kotovsky, Hayes and Simon (1985) report results of a study in which subjects trained in the use of a heuristic spent only 15% of the total time to solution implementing the heuristic. The majority of the time was spent examining the representation, presumably creating internal representations that were suitable for heuristic application. In a consumer setting, restructuring with knowledge of a heuristic might occur, for example, when the consumer must integrate and compare the contents of several brochures, as in choosing a health insurance policy. Even if the consumer knows that her heuristic is, "Choose the policy with the lowest deductible and the lowest monthly premium," the information may still need to be restructured to get it into a form that enables use of this conjunctive heuristic. Operations to rearrange information may be necessary, as well as operations to standardize information, such as converting all premiums into a per month format.

Despite the differing reasons for restructuring in these two cases, determination of how to restructure and how much to restructure can be explained in both cases with two accepted concepts in consumer decision making: contingent processing (McAllister, Beach and Mitchell 1979; Payne 1976; Payne 1982) and effort/accuracy tradeoffs (e.g., Christensen-Szalanski 1978).

McAllister, Beach and Mitchell (1979) summarize the contingent processing view, stating that, "...decision makers do different things in different ways when faced with different decision problems" (page 228). For a theory of restructuring, the contingent processing approach suggests that consumers will select and use different types and amounts of restructuring operations to facilitate choices among options in different information representations.

An effort-accuracy approach to decision restructuring characterizes a consumer as having limited cognitive resources and the need to trade off decision quality against processing costs. The tradeoffs may be assessed on both global and local levels (Payne, Bettman, Coupey and Johnson 1991). On a global level, more effort spent restructuring a problem may mean that fewer resources are required to process it later. In this way, the consumer can trade off effort to restructure and effort to use a heuristic. The consumer may restructure the decision by converting it into a familiar form, that is, one for which he has an accessible heuristic that can be applied to the information (Case 2). Alternatively, the structure the consumer imposes may be the result of patterns detected in the information, patterns which suggest a heuristic that can be retrieved, or constructed on the spot, and used to make the choice (Case 1). The consumer is still making effort/accuracy tradeoffs, but during this opportunistic processing, the tradeoffs may occur in a more local fashion; for example, they may reflect assessments of the tradeoffs involved in completing a restructuring operation, compared with the tradeoffs of using an alternative operation. Whether at a global or a local level, however, the effort/accuracy framework implies that the consumer attempts to strike an acceptable balance of the effort that must be invested to process the information and the decision quality that can be obtained for a given level of effort. The effort/accuracy approach is compatible with Newell and Simon's (1972) description of how decision makers economize cognitively by exploiting structure, and with the Hayes-Roth and Hayes-Roth (1979) view of opportunistic processing.

## **ASSESSING RESTRUCTURING IN CONSUMER CHOICE**

A study was conducted to demonstrate constructive processing of representations as a function of the conditions suggested by Bettman and Zins (i.e., low familiarity and choice difficulty), and to demonstrate a method for studying restructuring: generated external memory.

## Generated External Memory

Generated external memory refers to the external memory created by a consumer in the course of making a choice. This external memory is important for two reasons:

1) because it may facilitate restructuring, and 2) because it provides a visible record of the operations used to construct a representation. Being able to generate external memory should make restructuring less effortful, because being able to write down information reduces the load on internal memory. As a result, the external memory consumers generate to make a choice may have the advantage not only of keeping information available at a lower cost (i.e., that of writing information down), but also of enabling changes to the information that would be too costly, or even impossible, in working memory.

Generated external memory can also enable observation of restructuring processes and comparison of decision making behaviors, such as the type of choice heuristic used. Incons-Peterson and Fournier (1986) examined recoding in external memory in the context of a recall task for a list of items. Although the authors were less interested in the nature of the observed recoding than in its effects on memory, their results do indicate that subjects use external memory to change information, and that these changes can be detected. As a result, generated external memory should provide a way to observe the type and amount of restructuring operations used to make brand choices.

One additional advantage of generated external memory is that it is a ubiquitous tool for decision making in many situations.<sup>1</sup> As a result, the note-making process is a natural one for subjects, thus reducing the likelihood that observed behaviors reflect influences of the method, rather than behaviors the subject might exhibit when making an actual brand choice.

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<sup>1</sup>Results of a survey taken of 66 shoppers at a mid-Atlantic mall indicate that 91% of the respondents reported using external memory in the form of notes to aid in making product choices.

## Task Analysis and Predictions

In this section, predictions based upon a theory of contingent processing are developed to describe when and how consumers will restructure information, as well as the effect of restructuring on heuristic use.

Research on heuristic selection in decision making has demonstrated that heuristic selection is contingent upon task and context factors (Payne 1982). Task factors describe general characteristics of the decision (e.g., time pressure, number of alternatives), and context factors reflect characteristics of the values of information (e.g., presence of dominated alternatives, comparability of attribute values). Because task and context factors often define the representation of decision information (e.g., whether the size of the representation is large or small), as well as indicate restructuring processes that can be done to make the choice manageable (e.g., eliminate information from a large representation), the presence of different factors should result in differential use of restructuring operations.

To facilitate the discussion of predictions about restructuring behavior, consider the following scenario. Suppose a consumer is faced with a decision that is difficult due to several task and context factors. The information seen by the consumer is poorly organized; that is, information about the brands' attributes is provided in a different order for each brand, and the values of an attribute are given in different units for each brand (e.g., warranty in months, weeks, or years). To further complicate the choice, there are many brands to evaluate, and the information is only available one brand at a time; the consumer must go to new store to get information about each additional brand. This sequential format makes interbrand comparisons difficult. In addition, the consumer has never purchased a brand in this product category before and has very little knowledge of the product's characteristics. What will the consumer do?

Will consumers invest the cognitive effort necessary to construct a new representation? Slovic (1972) has proposed a principle of "concreteness," stating that individuals tend to work with information in the form in which they receive it, due to cognitive constraints or cognitive

miserliness. Bettman, Johnson, and Payne (1990) provide support for the concreteness principle with a study in which subjects who make decisions with complex fractions make more preference reversals than subjects who make decisions without fractions. The common thread among the subjects who make reversals is that they generally do not carry out the operations necessary to simplify the fractions, perhaps due to constraints on cognitive capacity or ability.

Restructuring is the antithesis of the concreteness principle, because it requires that a consumer working under the same constraints of bounded rationality recognized by Simon will invest the cognitive effort needed to modify presented information. Moreover, restructuring to generate representations is proposed to be a dynamic process; multiple representations may be constructed prior to choice. For a task in which restructuring to construct a new representation can reduce the effort required to complete a heuristic, and for which consumers have the resources available for restructuring, changes to the representation may be completed. Therefore, it is expected that when restructuring can result in increased comparability and processability of brands, subjects will restructure presented displays of information more often than they will use them "as is". This tendency is expected to be more pronounced for decisions that are more difficult than for decisions that are less difficult. This expectation is formally stated as:

H1: Subjects will restructure presented sets of brand information more often than they will use them "as is." Higher frequencies of restructuring are expected for decisions of greater difficulty than for decisions of lesser difficulty.

Hypothesis 1 reflects the idea that consumers may make decisions about restructuring on a global level. That is, the consumer must decide whether to restructure the presented information, perhaps in search of a new or better heuristic, or to simply make do (as Slovic suggests they will), adjusting the current heuristic to the presented format.

Assuming that the consumer decides that restructuring is worthwhile, how can we characterize the process of operation selection? Consumers face many different choices, and these choices are made difficult in many different ways. The ability to make a satisfactory choice in any of these situations suggests that a consumer must either be very lucky, or that he must adapt his restructuring behavior to manage the source of difficulty. Successful difficulty management requires the consumer to recognize what the various sources of difficulty are, and to have knowledge of appropriate operations for reducing processing difficulty. Applied to restructuring, a theory of contingent processing suggests that consumers will select and apply restructuring operations contingent upon the characteristics of the decision which make choice difficult. Thus,

H2: Subjects will adapt restructuring behaviors to specific characteristics of the information display. More specifically, subjects will tend to complete:

- a. more standardizing operations for decisions with noncomparable attribute values than decisions with comparable attribute values,
- b. more rearranging for poorly organized problems than for better-organized problems, and
- c. more eliminations for larger problems than for smaller problems.

In contrast to Hypothesis 1, Hypothesis 2 implicitly reflects the local tradeoffs a consumer makes in deciding how to restructure. The consumer must decide, for example, whether he is willing to eliminate an attribute, thus reducing processing costs but running the risk that he has eliminated information that he might need later. Local tradeoffs may also take the form of deciding to complete one restructuring operation rather than a different operation, as with simplifying by eliminating a price or quantity attribute versus simplifying by calculating unit prices.

The third hypothesis addresses the effect of restructuring on a consumer's heuristic selection and use. Restructuring can enable the consumer to use a heuristic that requires fewer cognitive resources. For example, a consumer may compute unit prices to reduce processing effort. With a single 'unit price' attribute, the consumer can use a lexicographic heuristic to

compare brands. This is cognitively easier than balancing multiple attribute values in a compensatory heuristic. Restructuring may also enable a consumer to use a heuristic with less cognitive effort, rather than switching to a less cognitively effortful heuristic that may also be less accurate. For example, using a weighted adding rule in an appropriately structured problem is less difficult than using the same rule in an inappropriately structured problem, because the consumer doesn't have to search the representation for the appropriate attribute values for each arithmetic operation. By restructuring the representation into an appropriately structured form, the consumer can carry out the weighted adding rule with less effort. This suggests that consumers are able to carry out heuristics that are more normative when they restructure than when they do not. If consumers process information in a manner contingent upon perceived costs and benefits, then investing the cognitive effort to restructure should result in a tendency to use heuristics that they believe to be normative. Previous research indicates that heuristics which are alternative-based and compensatory tend to result in higher quality choices than heuristics which are attribute-based and noncompensatory (Payne, Bettman and Johnson 1988). Because subjects tend to be adaptive in the selection and use of heuristics, they are expected to recognize the value of the alternative-based, compensatory-type rules. Therefore, when restructuring is facilitated, subjects are expected to exhibit greater use of alternative-based heuristics than they do when restructuring is not facilitated.

H3: Subjects will tend to use alternative-based heuristics more often when restructuring is less effortful than when it is more effortful.

It should be noted, however, that some types of restructuring may result in the use of compensatory heuristics which appear normative, but which may not result in a choice quality as optimal as that which could be achieved with a simpler, attribute-based heuristic. Paese and Sniezak (1991) demonstrate that increased effort, as with an alternative-based heuristic rather than an attribute-based heuristic, may simply lead to over-confidence, and not to improved performance.

## Method

*Design and Subjects.* Three between-subjects factors were manipulated in a study to test the hypotheses about restructuring behavior: 1) organization (better-organized or poorly organized), 2) format (simultaneous or sequential), and 3) opportunity to generate external memory (yes or no). One within-subjects factor was also manipulated: number of attributes (four, five, or six). Subjects were recruited with an ad in a university newspaper. Each subject received approximately eight dollars for participating in the study, which took one hour to complete, on average. Forty-eight subjects were randomly assigned to the eight treatment conditions. Because the restructuring operations recorded in external memory were the phenomena of primary interest, thirty-two subjects were allocated among the four treatment conditions in which subjects had the opportunity to generate external memory. Due to equipment failure, one subject's data was eliminated. Sixteen subjects were allocated among the treatment conditions without the opportunity to generate external memory.

*General Procedure.* Every subject completed a practice decision and five test decisions. The order of problem presentation was counterbalanced across subjects. Stimuli were presented on personal computers with Mouselab (Johnson, Payne, Schkade, and Bettman 1989). The Mouselab program is designed to gather detailed data about the processes used by a subject to make a decision. The subject moves the cursor in and out of boxes which comprise the decision matrix on the computer screen. The Mouselab program records the number of boxes "opened," time spent in each box and between boxes, and the sequence of box acquisitions.<sup>2</sup>

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<sup>2</sup>Forcing subjects to open Mouselab boxes may result in increasing the effort required to generate external memory. Subjects may simply copy down the initial representation. This does not introduce a bias into the data, however, as merely copying information is not counted as restructuring. In addition, as all subjects are faced with closed boxes, the added effort is required equally of all subjects.

Subjects took the study on an individual basis. Each subject was greeted and seated alone in a room. The experimenter explained how to acquire information within a screen and how to move from screen to screen using the computer mouse. All subjects were asked to provide verbal protocols to be videotaped and audiotaped by speaking aloud as they worked through the decisions.

*Stimuli.* The stimuli were five sets of brands. Each set contained five alternatives, and each set of brands was from a different product category. Every brand in a set was described by the same attributes, and information was available for all attributes. The products were: 1) knitting machines, 2) humidifiers, 3) air cleaners, 4) water purifiers, and 5) storage sheds. These products were selected for use based upon pretest data from a similar subject population which indicated that subjects were not very familiar with the attributes of these products. Unfamiliarity was desirable for two reasons. First, Bettman and Zins (1977) describe unfamiliarity as one possible instigator of constructive processing of heuristics. It was expected that unfamiliarity would also influence constructive processing of representations. Second, unfamiliarity also lessened the likelihood that subjects would use subjective preferences in making their recommendations.

*Independent variables.* Difficulty was manipulated with three factors: 1) the organization of information in the representation, 2) the presentation format, and 3) the amount of information. These factors were used for two reasons: 1) past research has shown that they are of theoretical interest (e.g., Bettman and Kakkar 1977; Jarvenpaa 1989; Payne 1976), and 2) they are frequently characteristics of everyday purchase situations (e.g., choosing a health insurance policy by telephoning several agents or by considering multiple brochures in varying formats).

The first factor, organization, had two levels. A better organized decision was one in which information was presented in brand/attribute matrix form, with all information

presented simultaneously. A less organized decision was one in which information was not organized in matrix form, that is, attribute information was presented in different orders for each brand. In addition, within an attribute, information was presented in different units (e.g., warranty in weeks, months, or years). Figure 2 contains a sample display of a less organized problem in which the subject must choose among storage buildings. It should be noted that although the information is not as well-organized in the poorly organized condition, it is still better organized than the information available to consumers in many typical purchase decisions. As a result, conclusions about the extent of restructuring that can be drawn from data obtained with these stimuli may be conservative.

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Insert Figure 2 here.  
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The second task factor manipulated in the information representations was the format of the information. Information was presented either simultaneously, with all brands available at one time of the computer screen, or sequentially, one brand at a time. In the sequential condition, subjects had the same acquisition options as subjects in the simultaneous condition; they could look at all or some of the brands or attributes, and they could reacquire pieces of information. The only difference in presentation was that in the sequential condition, only one brand and its attributes appeared on the screen at a time.

Two additional factors were manipulated to assess restructuring behavior: the amount of information and the opportunity to generate external memory. Amount of information, a within-subjects factor, was manipulated by the number of attributes presented for the five brands in each decision. All subjects made choices among brand sets with four, five and six attributes.

The third between-subjects factor was the opportunity to generate external memory. Caution was exercised in the manipulation of generated external memory to insure that the use of external memory was not merely a demand artifact: that subjects felt motivated to do

something that appeared intelligent that they would not have done in a different context. To reduce the risk of demand bias, a pile of computer print-out paper was left on the desk next to the printer. The experimenter casually mentioned that the subject could use the "scratch paper" if he or she desired. A trash can was placed near the desk. No subject voluntarily handed over the notes made on the scratch paper. Most of the paper was retrieved from the trash can or the desk. In addition, subjects were asked after the study whether they had suspected that the notes were of interest to the experimenter. Only one subject said that she had thought they might be, but that she had not altered her behavior.

*Dependent variables.* Three types of dependent measures were used to test the hypotheses: 1) a variable to reflect the presence and amount of restructuring observed in generated external memory, 2) measures of specific restructuring operations observed in generated external memory, and 3) a variable to reflect the type of heuristic used to make a choice. The dependent variables were developed using three types of data: audio- and videotaped protocols, computer-based process tracing data, and external memory generated by subjects.

*Coding data from notes.* The data used for analyzing hypotheses about the presence of restructuring and the types of restructuring operations used were obtained from the external memories subjects generated while making choices. Restructuring was deemed to have occurred only when the generated external memory reflected a problem representation that differed from the originally presented representation.

It is important to recognize that generation of external memory is not an absolute indicator of restructuring. That is, consumers who do not make notes are not necessarily incapable of restructuring. External memories form the base of a method for looking at the types of restructuring used, and as a gauge for the relative amounts of restructuring exhibited in a decision. As such, external memory may show more restructuring versus less restructuring, rather than some versus none. Two examples of internal restructuring

are contained in Appendix A. The presence of internal restructuring in verbal protocols suggests that the analyses of restructuring behaviors will tend to underestimate the extent to which consumers restructure.

Individual operations to restructure were coded from subjects' generated external memories. Specific operations were only coded if the actual procedure was evident in the external memory. For example, presence of a brand/attribute matrix in an external memory which contained only four of five brands presented in the Mouselab display did not mean that a brand elimination was coded. Although the subject had most likely restructured the initial representation by eliminating the brand, this behavior could not be determined unequivocally; the subject might have simply forgotten or ignored a brand. Therefore, as noted above, the conclusions drawn from the study about the extent of restructuring are probably conservative, because restructuring operations completed internally were not counted.

The individual operations used to develop dependent measures were transforming operations (e.g., putting all attribute information in the same units), rearranging operations (e.g., placing attribute values in the same order across brands or organizing within an attribute, as by ranking from best to worst), and eliminating operations (e.g., deleting brands or attributes from the representation). Selection of these operations as dependent measures was dictated by the manipulations of problem difficulty; transforming and rearranging operations were expected to be used to manage difficulty engendered by poor organization of information, while eliminations were expected to be used to manage problem size, if the hypothesis of contingent processing is supported. The dependent measure is a frequency count of the operation within each problem for each subject. Figure 3 illustrates the processes for restructuring observed in one subject's notes.

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Figure 3 here  
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A measure of the presence and amount of restructuring overall for each problem was constructed by summing the counts of observed individual operations described above for each subject. A value of zero indicates that no restructuring was observed, based upon the information contained in the subject's generated external memory.

*Reliability of measures developed from notes.* A coder from outside the university was given a page of definitions of restructuring operations, and a brief explanation of the stimuli, including the manipulated factors. In addition, the coder received Xerox copies of the actual notes made by subjects, with no additional clarifying marks or information.<sup>3</sup> A Pearson product-moment correlation on the counts of operations by operation type recorded by the coder with counts by type coded by the experimenter provided a coefficient of .978, demonstrating a significant correlation between counts ( $p < .0001$ ,  $n = 16$ ). Analyses of correlation within categories of restructuring operations were also completed. The results indicate a level of correlation for each operation significant at  $p < .0001$ . These results demonstrate that the definitions of operations were sufficiently clear and comprehensive to capture the range of restructuring processes observed in the external memories.

*Variable of heuristic type.* Although numerous heuristics have been observed in decision research, the dependent measure used in this study is based upon a division of heuristics into one of two types: evaluative processing that is primarily brand-based, such as using a weighted adding rule, and evaluative processing that is primarily attribute-based, such as using a lexicographic heuristic.

Heuristic type was assessed with information from verbal protocols and Mouselab process data. Heuristic assessment was made for all subjects using the verbal protocols generated during the choice process. Although the protocols from some subjects were sketchy in some choices, in general the processes were clear. Of the 235 problems,

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<sup>3</sup>Because the behavior of a subject on one problem was expected to be correlated with behavior on other problems, the coder coded one problem, arbitrarily selected, from each subject.

heuristic determination could not be made for twenty-seven choices. Alternative-based choice processes were coded as a 1, while attribute-based choice processes were coded as a 0.<sup>4</sup>

To minimize the risk of subjective biases in coding heuristic type from verbal protocols, Mouselab data about processing patterns were tested against the heuristic type assessments based on protocols for subjects who could not generate external memories. The Mouselab process tracing data was used to create a measure of the subject's overall tendency to process by alternative or by attribute for each decision. For example, a subject could move within an attribute, scanning the values of several brands on one attribute, or within a brand, looking at all the the different attribute values on one particular brand. The measure was calculated as the number of alternative transitions minus the number of attribute transitions, divided by the sum of both types of transitions (Payne 1976). This index is bounded by 1, which indicates entirely alternative-based processing, and -1, which indicates purely attribute-based processing.

Two analyses were conducted to assess the reliability of the protocol assignments. First, for subjects without the opportunity to generate external memory, a logistic regression was done to determine how well the Mouselab-derived measure would predict protocol assignments.<sup>5</sup> The regression revealed a significant relationship between the Mouselab-derived measure and the protocol assignments ( $X^2_{(1, 72)} = 15.79, p < .0001$ ). Second, because each subject completed five problems, a more stringent test of the protocol

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<sup>4</sup>A choice was coded as the result of an alternative-based process if the majority of statements in the protocol were transitions from one piece of information about the features of a brand to another piece of information about the same brand (e.g., "Brand A has a pretty good good efficiency rating and a terrific price, even though it only has a short warranty.") A choice was coded as the result of an attribute-based process if the majority of statements reflected transitions among the values of attributes, across brands (e.g., "Brand A is higher than B on efficiency, but not as good as C or D. On price, A is much better than B or C or D.") This method is similar to the method described by Payne (1976).

<sup>5</sup>Only subjects without the opportunity to generate external memory were included in this analysis because it was felt that the Mouselab data of subjects who could generate external memory would reflect primarily acquisition sequences, and not processing/evaluative patterns.

assignments was done in which the Mouselab measure was used as the dependent measure. The protocol assignments and the repeated measure, problem, were used as independent variables. The same subjects were used as in the first analysis. If the Mouselab measure and the protocol assignments were in agreement, there should have been a significant effect of the protocol assignments, such that attribute-based assignments should have indicated Mouselab measures of less than zero, and alternative-based assignments should have indicated Mouselab measures greater than zero. This is exactly what was observed; the effect was significant ( $F_{(1, 15)} = 103.74, p < .0001$ ), and the means were in the predicted directions (for protocol assignments of attribute-based processing, Mouselab mean =  $-.02$ ; for protocol assignments of alternative-based processing, Mouselab mean =  $.74$ ). Thus, it was concluded that the heuristic assessments from verbal protocols were acceptable.

## Results

Subjects restructure decision information in order to make choices. Eighty-four percent of subjects generated external memory to restructure on all problems, and ninety-four percent of subjects used external memory to restructure the representation on some problems. Subjects transformed, rearranged and eliminated information to create better-organized representations in external memory. Subjects were sensitive to the way information was initially presented, and they restructured differently depending upon the amount of organization in the initial representation. Finally, restructuring affected the heuristics subjects used. Once the initial representation was restructured, subjects did eliminations and more transformations to facilitate use of alternative-based heuristics.

### *Tests of hypotheses.*

*Test of H1.* Hypothesis 1 pitted the theory of restructuring against Slovic's concreteness principle, stating that subjects would restructure more often than they would

use information 'as is'. Of the 31 subjects who had the opportunity to generate external memory, 29 subjects made notes to restructure on some problems.

It was also expected that subjects would tend to restructure more difficult problems more often than less difficult problems. Inspection of subjects' external memories indicates that of the thirteen problems (spread over five subjects) in which restructuring was not done, eleven of the problems were in the lower difficulty conditions (simultaneous format, better-organized information). The remaining two problems were in sequential format and less organized.

An analysis of variance examined the effect of problem difficulty on the extent to which subjects restructured. As predicted, subjects completed significantly more restructuring operations when the problem was poorly organized than when it was better organized ( $F_{(1, 26)} = 50.35, p < .0001$ ). The means were 26.04 for poorly organized problems, and 15.95 for better organized problems.

There was also a significant interaction of organization and format ( $F_{(1, 26)} = 58.39, p < .0001$ ). These results indicated that although subjects completed the most operations when information was poorly organized and sequentially formatted, they did the second greatest amount of restructuring when information was better organized and simultaneously presented. The least amount of restructuring was completed in the better organized, sequentially formatted condition. These results are examined in greater detail in the analyses of individual operations to test H2.

Test of H2. The second hypothesis addressed whether restructuring could be characterized as a process contingent upon the nature of the initial representation. Three dependent measures were used to examine the hypothesis: operations to transform information, operations to rearrange information, and operations to eliminate information.

Transforming operations.

The effect of problem difficulty on subjects' tendency to restructure by transforming the representation was assessed with analysis of variance. As predicted, subjects completed significantly more transforming operations when information was poorly organized than when it was better-organized ( $F_{(1, 26)}=4.4$ ,  $p < .05$ ), with means of 19.79 and 13.49, respectively.

In addition, problem format interacted with organization to exert a significant influence of the use of transforming behaviors ( $F_{(1, 26)}=8.13$ ,  $p < .008$ ). Means and standard errors for this and all subsequent analyses are found in the table in Figure 5. The crossover interaction indicated that subjects tended to complete most transforming operations when information was more poorly organized and sequentially formatted (mean = 23.89). An unexpected result was the relatively high number of transforming operations completed when information was better organized and simultaneously formatted (mean = 18.71). Perusal of subjects' external memories suggested that transforming operations could be subdivided into two types: 1) operations to standardize information, such as putting information within an attribute into the same units for comparison (completed more often for poorly organized displays), and 2) operations to relabel information, such as ranking values of an attribute from best to worst (perhaps undertaken primarily on better organized displays). To examine these findings further, standardizing and relabeling operations were coded in notes, and the analyses of variance completed for each dependent measure.

*Exploratory analyses of standardizing and relabeling transformations.* As expected, an ANOVA conducted on the counts of standardizing operations revealed a significant effect of organization on restructuring ( $F_{(1,26)}=90.65$ ,  $p < .0001$ ). Subjects completed an average of 8.08 standardizing operations when information was poorly organized, compared with 3.08 when information was better organized.

More interestingly, the ANOVA on relabeling operations revealed a significant crossover interaction of organization and format on restructuring ( $F_{(1, 26)}=63.24$ ,  $p <$

.0001). Subjects completed the most relabeling operations when information was better organized and simultaneously presented (mean = 15.34). The second highest number of relabeling transformations was observed when information was poorly organized and sequentially presented (mean = 14.35). An average of 8.05 relabeling transformations was observed when information was poorly organized but simultaneously presented, followed by an average of 4.94 such operations when the display was better organized but sequentially presented. In addition, there was a significant effect of format ( $F_{(1, 26)}=3.80$ ,  $p < .05$ ). Subjects did more relabeling transformations when information was simultaneously presented than when it was sequentially presented (11.83, on average, versus 9.70). These results underscore the dynamic nature of restructuring; subjects who were presented with poorly organized, sequential displays generated external memory to restructure the initial display with standardizing operations into a better organized display, and then used relabeling operations to construct another representation in which brands were ranked by the goodness of their attribute values. An example of this latter form of restructuring is shown in figure 4.

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 Figure 4 about here.  
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#### Rearranging operations.

An ANOVA was also conducted on the contingent use of operations to rearrange information. The tendency to rearrange information was examined as a function of difficulty due to poor organization. As predicted, subjects completed significantly more rearranging operations when information was poorly organized than when it was better organized ( $F_{(1, 26)}=386.62$ ,  $p < .0001$ ). In addition, there was a significant interaction of organization and format, such that although more rearranging operations were always done when information was poorly organized, the number of rearranging operations for poorly structured problems drops when information is simultaneously presented, but the

number of rearranging operations increases from sequential to simultaneous format when the information is better organized ( $F_{(1, 26)} = 102.73, p < .0001$ ).

In order to assess subjects' tendency to restructure by rearranging within brand versus within attribute as a function of organization, another dependent measure was constructed. An index of rearranging behavior was created by taking the number of rearranges within brand minus the number of rearranges within attribute. Higher index values indicate a greater degree of restructuring within brand, while lower number indicate more restructuring within attribute. An ANOVA revealed a significant effect of organization ( $F_{(1, 26)}=26.34, p < .0001$ ), such that subjects presented with poorly organized displays did more rearranging within brands, while subjects presented with better organized displays did more restructuring within attributes (means were 3.31 and -1.29, respectively). There was also a significant effect of format ( $F_{(1, 26)}=21.17, p < .0001$ ), which indicated that subjects did more within-brand rearranging when information was presented sequentially than simultaneously. A significant interaction of organization and format was also detected ( $F_{(1, 26)}=18.93, p < .0001$ ). Subjects tended to rearrange within-brand when information was poorly organized and sequentially formatted, and within-attribute when information was better organized and simultaneously formatted.

#### Eliminating operations.

How do subjects know how much to eliminate, and when do they decide to stop eliminating information from a restructured representation? In H2c it was proposed that consumers are sensitive to decision difficulty caused by the sheer amount of available information; therefore, the more information in a decision, the more eliminations of all types of information consumers will make. The hypothesis was tested with an ANOVA to examine the effects of increasing the number of attributes on eliminations. The dependent measure was the total number of brand and attribute eliminations. The simple main effect of size was significant ( $F_{(2, 26)}=4.48, p < .01$ ). Subjects eliminated an average of .86 pieces of information in four-attribute problems, compared with .90 pieces in five-attribute

problems and 1.46 pieces in six-attribute problems. The data indicate that as problem size increases, so do the numbers of eliminations. This suggests that subjects adapt to difficulty caused by number of attributes by restructuring to decrease the size of the problem.

In addition, inspection of the data indicate that reduction is accomplished by eliminating brands, rather than attributes, from consideration. Subjects never eliminated an attribute from the restructured representation. This finding suggests that eliminating brands is a more expedient way to reduce effort while retaining the possibility of making a good decision.

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 Figure 5 about here.  
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Effects of restructuring on heuristic type: Test of H3. The effects of restructuring on the selection and use of heuristics were also examined. Recall that in H3, consumers for whom restructuring was less effortful, due to external memory, were expected to use alternative-based heuristics more often than consumers for whom restructuring was more effortful.

The analysis for H3 was done with a categorical modeling procedure which used log-likelihood estimates to evaluate the effects of external memory on the binary dependent variable, TYPE. The effect of external memory on heuristic use was significant ( $X^2_{(26)}=13.70, p < .0002$ ). Subjects who generated external memory used alternative-based heuristics more often than subjects without the opportunity to generate external memory. Ninety-four percent of subjects who could generate external memory used an alternative-based heuristic, compared with forty percent of subjects who could not generate external memory.

## SUMMARY AND DISCUSSION

*What is restructuring?* Restructuring is a component of decision processing carried out in order to change a representation, presumably into a form suitable for evaluation and choice. The results of the study demonstrate the prevalence of the restructuring component. Subjects did restructure choice problems by transforming initial, poorly organized representations into better-organized representations.

*How is restructuring accomplished?* The restructuring operations observed in subjects' generated external memories support the typology of operations which described how restructuring can be done. When problems were poorly organized, subjects rearranged information within brands to create a brand/attribute matrix, and they made transformations to standardize information within attributes. Relabeling operations were also used to transform the representation; for example, attribute weights and attribute value information were often converted into rank-order data. Subjects also eliminated information, such as dominated alternatives, to reduce the size of the decision.

*When is restructuring done?* Support for a contingent processing approach to when consumers restructure was observed in subjects' selective use of operations to restructure decision representations. Restructuring was a response to specific facets of problem difficulty: in this study, poor organization and sequential presentation. Subjects did not waste effort doing unnecessary or redundant operations. More restructuring was done for poorly organized and/or sequential decisions than for better-organized and/or simultaneous decisions.

Subjects used a variety of operations to reformat the representation. These operations were used contingent upon perceived factors of difficulty. For example, subjects rearranged a poorly organized display to create a brand/attribute display which facilitated making comparisons in choice processing. When information was given as a brand/attribute matrix, however, subjects often restructured by creating a matrix of ranked brands. In addition, subjects coped with the amount of information by eliminating some of

the information. Brand information was discarded rather than attribute information (only one subject eliminated an attribute), suggesting that trading off potential accuracy by eliminating brands to save effort is perceived as more efficient than trading off accuracy by eliminating attribute information.

Additional support for the contingent processing approach is also noted in that restructuring influenced the type of heuristic subjects used. Subjects who could generate external memory to carry out desired restructuring tended to use alternative-based heuristics. Subjects who could not generate external memory to restructure tended to rely upon attribute-based heuristics. This finding suggests that subjects are aware of the effort costs of carrying out operations to restructure, and are willing to restructure because of the potential benefits, such as cost savings, of being able to use an alternative-based, compensatory strategy with less effort.

Taken as a whole, the results of the study provide support for the conceptual description of restructuring presented in this paper. Three main points should be noted. Firstly, restructuring does occur often, particularly when decisions are in less-than-optimal form for evaluation. Secondly, several types of operations can be used to effect restructuring; the use of these operations conforms to a contingent processing approach. Thirdly, restructuring has a significant effect on the selection and use of heuristics. These three points indicate that restructuring is a frequent and profound influence upon decision making behavior.

Restructuring is depicted as a dynamic process, in which the operations to construct a representation at one point in time can have significant effects on the operations and heuristics that may be carried out on subsequent representations, and on the construction or retrieval of heuristics for choice. This model conceptually extends previous research, which typically has addressed the use and effects of information displays in only one slice of time.

Generated external memory, or consumer notes, was demonstrated to be a viable method for studying a subset of restructuring operations. External memory generated by

subjects provided a visible record of restructuring to construct a representation; notes served as a window onto otherwise inaccessible restructuring operations.

## **Implications**

*Theoretical implications of restructuring.* The results of this research indicate that restructuring should be included as a component in general models of decision making. Past research has focused on heuristic selection as one method for managing effort demands in choice problems. Restructuring is another way that consumers can manage effort. Restructuring may enable the consumer to retrieve and apply a less effortful heuristic or to use a heuristic with less effort than could be done without restructuring.

Incorporating restructuring into decision making models may provide explain many observed switches in heuristic use in the course of a decision. The switches may reflect the decision maker's use of restructuring operations to opportunistically create a new problem representation, one that requires a change in heuristics. Restructuring may even suggest the construction of an entirely new heuristic. By recognizing that restructuring is an integral part of decision making, insights into the largely unstudied area of bottom-up, or constructive, processing can be gained.

The use of notes as an experimental method has several implications for further research on restructuring. Firstly, the processes by which decision makers spontaneously construct external problem representations, and how they use the representations in making choices, are largely unstudied. The research reported in this paper demonstrates that examining the external memory generated by a subject can provide insights into the broader question of how people restructure decisions. Secondly, by studying how a decision maker uses external memory to restructure a problem, it is possible to look beyond information use in the moment. Traditional process monitoring methods, such as information display boards, only provide the researcher with details about information use at the time of acquisition. Whether that information is forgotten immediately, or rehearsed

and used later in the decision process is largely a matter of inference. By tracking the order in which the subject enters information into an external memory, the researcher can trace what happens to pieces of information after the initial acquisition. Information that is noticed and stored in external memory during an initial perusal of the decision can be reused by the decision maker once he has decided what to do with it. The way information is manipulated in external memory later in the decision may reveal restructuring processes for reorganizing or simplifying information.

*Managerial implications of restructuring.* Previous research in constructive processing has focused on how heuristics are constructed (Bettman and Zins 1977). Other research has considered the effect of display format on heuristic selection and use (Bettman and Kakkar 1977; Jarvenpaa 1989). Work in both of these streams of research adheres to Slovic's (1972) concreteness principle: that consumers will use information in the form in which it is provided. The research described in this paper demonstrates an alternative behavior: that consumers often alter the initially presented display. In addition, this research demonstrates that constructive processing of a representation can also influence the type of choice heuristic used. As a result, marketers should not restrict themselves to consideration of how the display format will affect consumers' heuristic processing. They should also consider how consumers might change the displayed information, and how the resulting new representations may influence choice processing.

Predicting the ways in which product information displays might be altered by consumers, and how the changes will affect choice processing might seem impossible. This research, however, indicates that there are systematic restructuring tendencies that can be predicted to occur, contingent upon recognizable characteristics of the information display. In addition, consumers for whom restructuring is made less effortful, as by the ability to generate external memory, tend to use alternative-based choice heuristics.

The role of generated external memory in consumer decision making is also important for marketers. These external memories do not serve merely as vehicles for storing information as it is received; they are also the means for making changes to the initial information display that might not be possible in working memory. As a result, the ability to store and restructure information externally may have a profound influence on the choice a consumer makes.

Consumers' tendency to generate external memory may be determined by several factors. Because there is an effort cost involved in the generation of external memory, it is expected that consumers will spontaneously tend to make notes only when the potential benefits, such as making a good quality choice, override the costs. For example, a purchase that is very important to the consumer, such as buying a house, might engender high involvement. This high involvement may make the consumer more likely to invest the effort needed to generate external memory, perhaps in order to restructure acquired information, than for a lower involvement purchase. In addition, consumers may tend to generate external memory for decisions that are difficult, as demonstrated in this research. Finally, although it may seem obvious, consumers will only generate external memories when the means (i.e., paper and pencil) are available. Therefore, a marketer who wishes to influence the choice process by stimulating restructuring would do well to insure that the consumer not only sees a need to restructure, but also has the necessary tools for doing so.

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Figure 1

## A TYPOLOGY OF RESTRUCTURING OPERATIONS\*

EDITING	TRANSFORMING	INFERRING
Round values	Standardize attribute values	Infer attributes
Eliminate redundant attribute information	Relabel attribute weights or values (e.g., by ranking or coding)	Infer attribute values
Eliminate non-diagnostic information	Combine information (e.g., group similar options)	
	Segregate information (e.g., good options and bad options)	
	Rearrange (e.g., to create a brand/attribute matrix)	

\* Note that in general, editing operations reduce problem size, transforming operations maintain size, and inferring operations increase size. However, operations to infer may often reduce size, as in the case of inferring an abstract attribute on which to compare two originally noncomparable alternatives (Johnson 1984). Reduction occurs if the decision maker eliminates the original, noncomparable features from a subsequent representation.

Figure 2

**MANIPULATIONS OF ORGANIZATION:  
A SAMPLE DECISION**

**Storage Buildings**

Panel A

**POORLY ORGANIZED PRESENTATION**

Brand A	Total price: \$1500	Size 15l x 10w	Difficulty to build: avg. (5 pt scale)	Durability 6 years
Brand B	Price per square foot \$14	Durability 50 months	Size 12l x 14w	Difficulty to build: 4 out of 10 (0=easy)
Brand C	Total price: \$1700	Size 10lx10w	Difficulty to build: easy (5 pt. scale)	Durability 4.5 years
Brand D	Total price: \$769.50	Durability 72 months	Difficulty to build: 8 out of 10 (0=easy)	Size 9l x 9w
Brand E	Price per square foot \$28	Difficulty to build: 29 (100 pt. scale, 0 = easy)	Size 12l sq ft	Durability 10 years
Brand F	Total price: \$1568	Size 16l x 8w	Durability 64 months	Difficulty to build: some- what difficult (5 pt. scale)

**BETTER ORGANIZED PRESENTATION**

Brand	Price	Size (in square feet)	Durability (in months)	Difficulty to build (0=easy, 5=very hard)
Brand A	\$1500	150	72	3
Brand B	\$2352	168	50	2
Brand C	\$1700	100	54	2
Brand D	\$769.50	81	72	4
Brand E	\$3388	121	120	1.5
Brand F	\$1568	128	64	4

Panel B

Figure 3

SAMPLE CODING FROM A SUBJECT'S NOTES

Choice Among Five Storage Buildings: Attributes are Ease to Build, % Preassembled, Quality of Materials, Price, Size, Length of Warranty

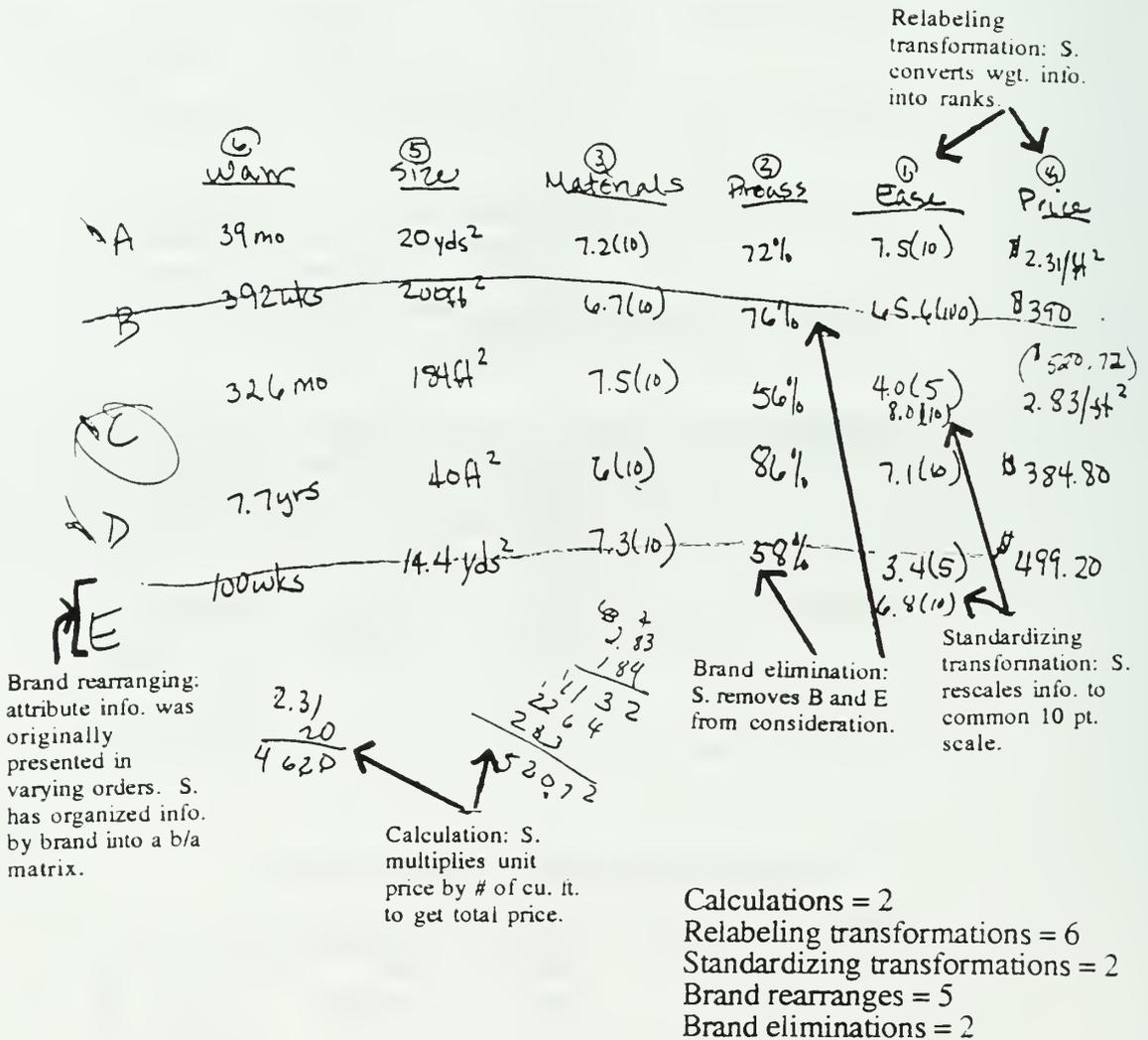


Figure 4

EXAMPLE OF REARRANGING WITHIN ATTRIBUTE

wks	5-scale	price	100	gallons
276	(4)	215	45	5.5
247	2.8	171	54	2.4
232	3.4	180	72	(6)
261	3	(140)	48	5.6
(290)	2.6	220	(90)	3

A	2	1	4	5	3
B	4	4	2	3	5
C	5	2	3	2	1
D	3	3	1	4	2
E	1	5	5	1	4

7	15
10	13
7	13
11	16

Figure 5

MEANS FOR DEPENDENT MEASURES (H2)  
(Standard errors are given in parentheses.)

OPERATION	ORGANIZATION			
	<u>Well</u>		<u>Poor</u>	
	<u>Simultaneous</u>	<u>Sequential</u>	<u>Simultaneous</u>	<u>Sequential</u>
TOTAL RES. OPS.	23.89 (1.90)	9.6 (1.38)	21.1 (1.29)	31.23 (1.34)
TRANS.	18.72 (4.12)	7.83 (3.00)	16.23 (2.80)	23.89 (2.92)
STAN. TRANS.	3.38 (.76)	2.89 (.55)	8.18 (.52)	9.54 (.54)
RELABEL TRANS.	17.25 (1.33)	4.94 (.97)	8.05 (.91)	14.08 (.94)
REARR.	2.57 (.27)	.26 (.20)	4.25 (.19)	6.63 (.19)
REARR INDEX	-2.57 (.27)	-.257 (.20)	3.25 (.19)	3.37 (.19)
ELIM.	.75 (.44)	1.51 (.35)	.63 (.32)	1.05 (.32)

## APPENDIX A

### SAMPLE PROTOCOLS WITH INTERNAL RESTRUCTURING

In the following excerpt from a verbal protocol, the subject is deciding which of five brands of humidifiers he would recommend. Each brand is described by four attributes: price, length of warranty, energy efficiency, and water capacity. The subject cannot make notes and relies on internal restructuring.

...The decision is between C and D. Okay, C -- let's look at the price. 58.77 a gallon. That times 4.8 gallons... Five -- five eighty-seven in half is 250, 290, 294. 294 for C (subject rehearses value). D is 49.17 versus 58.77, so D wins on price. C wins efficiency. C has 195 weeks in warranty and D has 70 months. 70 times 4 is 280, so the winner is D. C won efficiency, D wins price and warranty, and D is 5.8 gallons and C has 4.8 gallons -- so D won the last three categories or something. D won the last three, but the first was pretty important, but I'm going to recommend D.

The following protocol illustrates restructuring by eliminating information. In this example of internal restructuring the subject is choosing one of five air cleaners to recommend. The attributes are price, number of speeds, cleaning capacity in cubic feet per hour, number of pollutants removed, and a noise rating. The subject considers only two of five brands on more than one attribute, eliminating brands without comparable information on the most important attribute, and eliminating a brand that is dominated. In addition, the subject eliminates information on the least important attribute.

Okay, well, cubic feet per hour is the most important thing here. Let's see -- cubic yards. Brand A is 262 cubic yards. B is 437 -- that's better. C is -- ah -- this one's in feet. Let's see if there's another in yards. The reason I'd like to eliminate these on...that one's lower, D is lower, so it's out. This one is another one in yards -- feet. So far, let's see -- how do I convert these? Ten is...uh -- okay -- it's going to be B or C as far as cubic feet. Hmm, well, it seems I have no paper to do any sort of conversions with this -- even if I felt so inclined. Let's see, I guess, um, yards sound better than feet anyway, so I'll go to noise. Least important thing. Skip that. Go to number of pollutants removed. Let's see what that is one B -- 53. That's kind of low, isn't it? But it's higher than C. Speeds, 2 and 4. C's good, but I'm going to go with B.







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