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ABSTRACT

This paper considers the influence of information presentation form and frame on decision outcomes. A more thorough understanding of the interactions between presentation effects and decision outcome will enable systems designers to produce more bias free designs and control the biases which may be inherent in any system.

An experiment is presented which investigates the effects of framing in both tabular and graphic presentations. The experiment is a rough replication of an earlier study by McNeil, Pauker, Sox, and Tversky (1982) in which data describing historic outcomes of medical treatments were presented in mortality and survival frames. This previous study indicated that strong framing effects influenced the decision makers' choices. The current study presented similar data in a similar scenario, but utilized graphs and tables in place of textual presentations. Initial results indicate that framing effects are diminished by the presentation of information in tables and graphs. A number of possible explanations, drawing on various theoretical constructs, are presented to explain these results.

1. INTRODUCTION

The manner in which information is displayed to decision makers has been shown to influence the outcome of decisions based on that information. Framing and certainty effects have been widely demonstrated in both laboratory and field situations. For the most part, however, these demonstrations have been either highly stylized or of very specific application. The implication has been that the same effects would be found in real world interactions with *innocent* information, that is, information of arbitrary format.

The potential impact of this proposition on the design of information systems is quite far-reaching. When a manager makes a decision, it is conventionally assumed that the process is rational. That is, it contributes to the maximization of the objective function of the individual. If, in fact, the presentation of supporting information can influence the outcome of the decision process, the information presentation becomes as critical a design criterion as the content of the information itself.

The question of how the structure and form of information presentation can influence decision making is of interest to any profession or individual whose role it is to provide data to information users (Dickhaut 1976; Gafni and Torrance 1984; Wright 1980). A number of studies have been conducted which have investigated, in specific situations, how alternative forms of the presentation of information may lead to different decision outcomes. In each case, the same underlying information is available but the level of aggregation (daily, weekly, or monthly accumulations) or the structure (tables, graphs, or text) of the presentation differs. Information systems designers routinely compile great volumes of data into summary reports. The issue of how the graphic or tabular presentation of this distilled information can adequately reflect the underlying data has been investigated in the statistics literature. This same literature has looked at whether tables or graphs lead to better results in terms of speed or accuracy. Little attention has been paid to how presentation form influences decisions in realistic situations, the interaction form exhibits with frame, and how the presentation influences the cognition of the decision maker.

Work relating to the effect of presentation on decision making has been undertaken in a number of fields broadly including behavioral decision research and management information systems/decision support systems. This paper attempts to fuse the disparate fields into a unified explanation of framing effects in tabular and graphic presentations. An experiment is reported which investigates the effect of framing and presentation form on decision outcome.

2. LITERATURE REVIEW

The bulk of the literature relevant to this study has been drawn from two broad areas of research: behavioral decision research and presentation effects. The field of behavioral decision research provides a theory of human decision making which endeavors to explain objectively irrational choices on the part of decision makers. Much

of the behavioral decision research is conducted in application areas such as marketing (Thaler 1980) and accounting (Bell 1984; Einhorn 1976). The presentation effects literature comes generally from the information systems and human computer interaction fields. This area contains many studies of information effectiveness in terms of accuracy, speed, and decision maker performance. The presentation effects literature is empirical for the most part, with few theoretical foundations as yet, but its volume of experience is helpful in anticipating effects of information presentation.

2.1 Behavioral Decision Research

The heuristics and biases proposed by Kahneman and Tversky (1984) help explain many situations in which individuals appear to make irrational choices. Prospect theory (Kahneman and Tversky 1979) provides a rigorous base for much of this work. This theory proposes a two-stage decision process. In the first phase, acts, outcomes, and contingencies of the decision are framed (mapped into subject views of the decision maker with attendant subjective values and probabilities). The second phase is the evaluation of these framed alternatives. The act of framing can introduce a number of biases which are dealt with by the behavioral decision research literature.

2.2 Presentation Effects Literature

Much of the research on the effect of presentation manipulations in information systems displays has compared tabular with graphic presentations. A series of experiments were conducted in this vein at the University of Minnesota from 1970 to 1975 which set the tone for much of the work that has gone on in this area since then. Dickson, Senn and Chervany summarized this work in their 1977 *Management Science* article. Since this work was conducted in the early days of computerized information system use, much of it is preoccupied with comparing printed output with CRT displays. This work dealt almost exclusively with looking at the effectiveness of displays in terms of speed of problem solution and accuracy of response.

Lucas and Nielsen (1980) and Lucas (1981) reported on work investigating the influence of graphical displays on the quality of decisions. The first study did not find any significant results to indicate that graphs were preferable, while the second study did provide limited support. Both studies involved the playing of a management simulation game by a number of individuals. Bell (1984) and Zmud, Blocher and Molfie (1983) reported on experiments which have indicated that the preferred form of information display is task dependant. This conclusion follows smoothly from the early experimental results that tables are more accurate and graphs are faster and the premise that various tasks require different sorts of decisions.

Jarvenpaa, Dickson and DeSanctis (1985) report on three, more recent, University of Minnesota experiments and review much of the previous work. The article is somewhat of an indictment of the earlier studies. The lack of a guiding theory, proliferation of measurement instruments, inappropriate research designs and inconsistency in tasks are cited as contributors to the conflicting results and confusion in the field. Factorial designs are encouraged in order to enable the analytical consideration of interactions between factors. The use of established, validated scales and consistent task construction is necessary in order to facilitate the comparison of results across studies. Concern with internal validity, as opposed to external validity, is also encouraged as a step to developing more reliable experimental results. These recommendations were taken to heart in the development of the study reported here.

Huber (1980) has done virtually the only strong theoretical work to date looking at the decision process as the dependant variable, as opposed to the various dependant variables mentioned above. He proposed a contingency theory which related information form to decision strategy. Empirical work supports Huber's theory, but since his experiments dealt with verbal and numeric data, it is not directly applicable here.

Another approach adopted in prior work on the effects of information presentation on decision making has been founded on the idea of information processing overload. This research is generally more theory-based than the information form work. Much of this effort has been based on the early efforts by Newell and Simon (1972). This work proposes that the search strategy is chosen in a tradeoff between accuracy and effort (Johnson, Payne, and Bettman 1988). Johnson, Payne and Bettman looked at shifts in cognitive processes as the complexity of a task increased. By presenting data in simple fractions, more complex fractions and decimals, the experimenters were able to induce different frequencies of preference reversals in the participants. In addition, by using process tracing techniques, it was observed that the decision makers moved from alternative-based evaluation strategies to more attribute-based strategies. Alternative-based strategies are generally more accurate, but they require more cognitive effort.

The influence of the amount of information available in risk perception tasks has been investigated by Levin, et al. (1985). This study looked at the influence of the number of attributes of the stimulus on incidence of framing in three different tasks. Framing effects were seen across all conditions. Johnson and Tversky (1984) have looked at the influence of representation of risk on the relative ranking of risk. They found that the ranking of various risks differed according to the strategy utilized by the participants in the study. This study supported the idea that decision strategy influences the outcome of the decision process even when contingencies are materially the same.

The effect of grouping information on decision making was investigated by Behling, Gifford and Tolliver (1980). This study supported the idea that decision makers make decisions by the manipulation of categories rather than the explicit calculation of precise values.

McNeil, et al. (1982) conducted an experiment in the area of medical decision making in which treatment outcome information was presented in two frames: mortality and survival. A number of other conditions were also varied, but it is the framing manipulation which is most relevant to the current study. The participants in this study were asked to choose between two treatments based on the information presented.

The treatment outcomes differed in that surgery was characterized by a higher initial death rate during treatment and a lower five year probability of death than radiation therapy. The fact that a tradeoff was called for was obvious, but the final decision on the part of the participant was subject to the precise values attached to the tradeoff by individual preference per prospect theory. If no framing effect was operative, the frequency of choice for each treatment should have been consistent across presentation conditions. When the treatment was identified by name as well as when the identity was hidden, many more people chose surgery in the survival frame than in the mortality frame (42 percent versus 25 percent). The McNeil study suggested that this phenomenon occurred because the risk of death during treatment loomed larger when expressed in terms of mortality. A more recent work by Gafni and Torrance (1984) looked particularly at the interaction between time preferences and attitudes toward health risks. Gafni and Torrance found a clear interplay between these factors.

The results of the McNeil study were robust across patients, students and, perhaps surprisingly, physicians. If physicians are susceptible to the same biases layman are, the information we, as patients, receive is already skewed. The implications of this outcome are obvious and may persist across many professions. The current study seeks to roughly replicate the McNeil study using tabular and graphic presentations to complement McNeil's textual presentation. Tables and graphs are the most common form of data summary, the incidence of framing in these forms of display should be considered given the persistence of the framing bias in other forms. In addition, the interaction of framing effects and style of presentation should be investigated in order to better design human-computer interfaces.

3. RESEARCH QUESTION

The idea that differences in the frame of presentation of information will lead to preference reversals has been supported time and again in the behavioral decision research literature (Kahneman and Tversky 1984; Johnson, Payne and Bettman 1988). This study attempts to extend the current knowledge in the field by proposing and investigating the following hypothesis.

> **The frequency of preference reversals due to framing of information presentation varies with the form of presentation.**

This hypothesis is interesting in that it implicitly accepts the potential for differing decision processes given different forms of presentation. The effect being investigated in this study is made up of two parts, the framing effect and the presentation effect. It was anticipated that each of these would influence the outcome of the experiment being conducted, and an interaction effect would also be evident. In order to separate out the individual effects the two experimental treatments were manipulated in a 2x2 factorial design.

The frame manipulation is modelled after that in the McNeil, et al. (1982) study. The survival rates (or mortality rates) of two treatments for cancer are presented to the participants whose role it is choose between the two. One of the medical treatments is characterized by a higher initial probability of death and a lower long term probability of death (see Figure 1). A tradeoff clearly exists between the short and long run. The inherent value of this tradeoff will vary among individuals, but should be regularly distributed through the population as a whole. The precise underlying distribution is not critical as long as the experimental groups are randomly chosen. If the distribution of choices for treatment varies significantly between those groups presented information in different frames, the existence of a framing effect will be supported.

Percentage of Patients Expected to Die by the End of:

Treatment Period	Year 1	Year 2	Year 3	Year 4	Year 5
Treatment A	10	32	41	50	58	66
Treatment B	0	23	38	53	66	78

Percentage of Patients Expected to Survive until the End of:

Treatment Period	Year 1	Year 2	Year 3	Year 4	Year 5
Treatment A	90	68	59	50	42	34
Treatment B	100	77	62	47	34	22

Figure 1

The presentation effect is operationalized by presenting the data in tables and in graphs. The tabular data is numerical and expresses either cumulative mortality or remaining survivors at the end of each period (Figure 1). The graphs are vertical bars with each treatment represented by a single bar for each period (Figure 2). This graphical representation was considered to be the most

natural transformation of the tabular data. The graphs clearly indicate an increasing trend for the mortality frame and a decreasing trend for the survival frame.

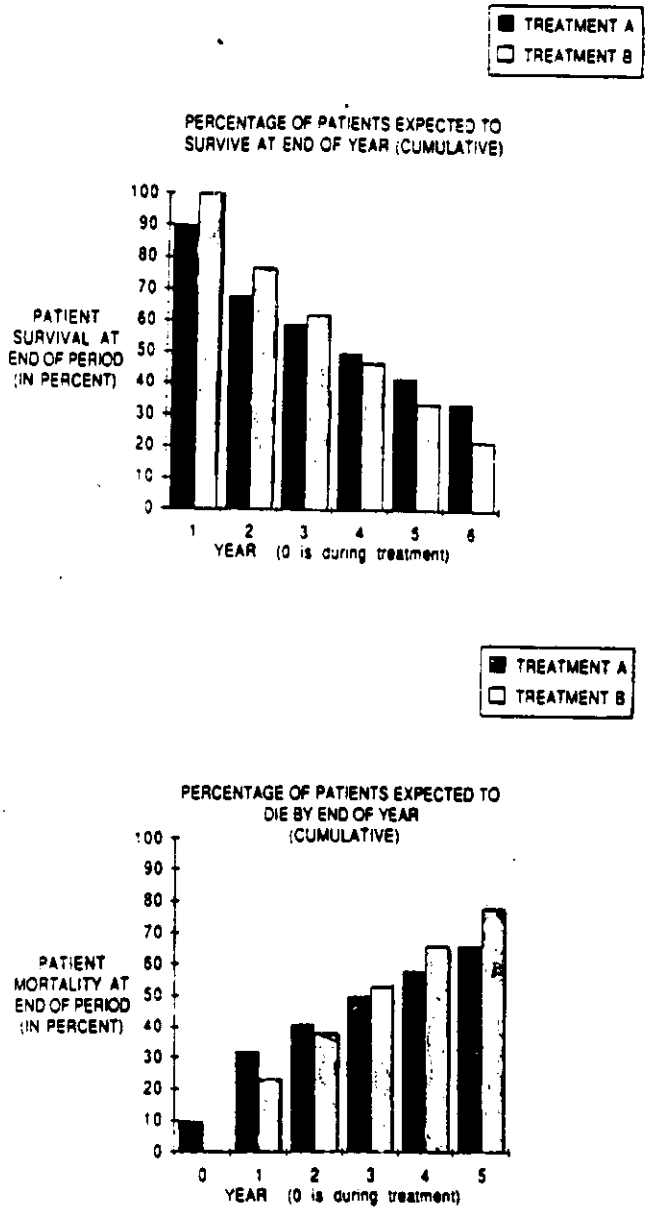

Figure 2

In addition, treatment A in the mortality frame shows a peak in the "during treatment" period which is not matched by treatment B.

4. EXPERIMENTAL METHOD

The participant pool for this study consisted of students in the first year of the Masters of Science in Industrial Administration program at Carnegie Mellon University's Graduate School of Industrial Administration. Questionnaires were administered in class to a total of 275 students, of which 267 were returned.

The experimental task was to choose the preferred medical treatment of two alternatives. The two alternatives were referred to only as "Treatment A" and "Treatment B" to prevent any results relating to idiosyncratic biases associated with the name of the treatments. This is equivalent to McNeil's "unidentified treatment" manipulation.

The treatment materials consisted of three pages: a title page with a short introduction, the treatment page with the scenario, data, the choice question and one open question requesting a retrospective explanation of the choice, and a final page with two open questions and several personal data questions. The first and third pages were identical across all questionnaires, only the second page varied across the four conditions.

The participant was assigned the role of a cancer unit director who was charged with choosing one treatment for his unit to support. The data summarizing the survival (or mortality) rate associated with each treatment was presented, and the participant instructed to choose between the two treatments. Following the decision task, the participant was asked to express why they made that choice.

5. RESULTS AND ANALYSIS

The results of this experiment differed substantially from those observed in the McNeil study (Table 1). The proportions of individuals choosing treatment A in all treatment groups, except for the graphic/mortality (GM) group, were not significantly different from .5. The corresponding proportion in GM was .38. This figure was significantly different from each of the other three at the $p < .1$ level using the Z test for difference between proportions.

Table 1. Proportion of Participants Choosing Treatment A (cell size in parentheses)

		FRAME	
		Mortality (M)	Survival (S)
FORM	Graph (G)	.38 (66)	.49 (67)
	Table (T)	.47 (68)	.48 (64)
	*Test	.47	.73

*From McNeil, et al. (1982) for similar conditions, i.e., cumulative probability, unidentified treatment, students.

in order to examine the contribution of the various possible interactions to the outcome of the decision, a logit regression was run in which each of the interactions were separated out in the following way:

$$\text{Choice} = B_0 \times TM + B_1 \times GS + B_2 \times TS + B_3 \times GM$$

In this model each treatment group is seen as a separate contributor to the decision outcome. The results follow.

	Coefficient	T-Statistic
B_0	.12	.483
B_1	.02	.085
B_2	.03	.126
B_3	.47	1.842

The coefficients for the first three groups are very small and not statistically significant. The coefficient for GM is .47 and the coefficient is significant at the $p < .1$ level. That is to say that the particular interaction of graphical presentation and mortality frame appear to produce an effect which is significant and is different from the other three conditions.

6. DISCUSSION

The experimental results and ensuing analyses enable us to state with some certainty that those participants who were presented information in the Mortality frame and Graphic form made a substantively different decision than those in the other groups. This outcome differs from that originally anticipated and those observed in previous studies. During the development of this study, we anticipated that framing effects would be observed in both forms of presentation but that the strength of effect would vary according to some interaction between the manipulations. Had main effects occurred, and if the effects had been symmetric, this study would not have as much potential for shedding new light on the framing process and its interaction with form of presentation. The framing phenomenon has proven to be quite robust over a number of studies, and this study roughly replicated a study in which framing was quite evident.

The reader should bear in mind that an alternative to any explanation is that the manipulation did not have an effect for any or all treatments other than the GM treatment. The 50:50 split in preferences could be due to either a lack of an effect or an effect away from some natural bias. The lack of an effect could be due to a poorly designed experiment or a real, theoretically explainable, phenomenon. Even though the results are statistically reliable, the experimental validity needs to be ratified. A plan to verify the results of the experiment, that is, to show that the manipulation did influence the decision process, is proposed in Section 7 of this paper.

A possible explanation for the absence of preference reversals between the two tabular groups draws on work by Johnson and Payne (1985). Johnson and Payne found that, when confronted with more complex information, decision makers shift their strategies to reduce the cognitive effort required to make a decision. It may be that the problem representation was sufficiently complex in the tabular form that the participants were led to some alternative decision strategy which differed from that pursued in the graphic presentation. Bear in mind that the McNeil study indicated that the framing effect was operative by revealing significant preference reversal in a very similar scenario. This use of the strategy-shifting argument differs somewhat from that proposed by Johnson and Payne (1985) and pursued in Johnson, Payne and Bettman (1988). In these studies, decision makers moved from alternative-based strategies to attribute-based strategies in multiattribute decisions, presumably to reduce the cognitive cost of processing the information. The scenario in the current study employed a single attribute, so the next simplest strategy may have been to choose randomly. It might be suggested that the participants were not sufficiently motivated to invest a great deal of effort in the decision and so changed strategy quickly. However, since few participants completed the questionnaire in less than ten minutes and most wrote several lines in response to the open-ended questions, it did appear that the participants were adequately motivated.

The above explanation explains the discrepancy with the McNeil study in addition to explaining the lack of reversals between two frames in the tabular form. It is worth noting that the McNeil study provided the participants with only three data points: the perioperative, one year, and five year survival/mortality rates. This decreased cognitive load could have been sufficiently light to not cause the participants to shift strategies.

The results observed in the graphic groups suggest that representing the information graphically simplified the cognitive task sufficiently to enable heuristic processing. Instead of having to deal with numbers, calculating and comparing differences, the decision makers were able to directly compare the relative heights of columns. Simkin and Hastie (1987) laid out several mechanisms for the cognitive processing of graphs. They suggested that the comparison of heights is a very basic operation. By presenting the data in graphical form, it may be more accessible for heuristic processing.

Johnson, Payne and Bettman (1988) suggested that, by simplifying information presentation, the incidence of preference reversals may be reduced. The results of the current study indicate that certain simplifications may actually lead to more preference reversals.

7. CONCLUSION AND FUTURE RESEARCH

The results of the current study have shown that framing effects may act differentially according to the form in which they are presented. Graphic presentations are more apt to induce framing than tabular presentations. The implications of this discovery for information system designers are far reaching. The generalizability of the results of this study are limited, however, and their verity may be questionable. Further work is required to establish the conditions within which the phenomenon observed operates and to verify the current results.

It may be possible to begin to verify the current work with data already collected. The responses to the open-ended questions may enable us to see if the participants in different cells went through different decision processes. It is not necessary at this point to determine what the processes were, only that varying the information display induced varied processes. This work will help establish that the treatment did take.

Future work should include demonstrating the limits of the current study. How complex does the problem have to be before the process changes? How does the strategy-shifting process work differentially in graphic versus tabular forms? Previous work has demonstrated the phenomenon in very limited conditions; this study has expanded the explored realm somewhat. It may be possible to use process tracing to elicit information regarding the actual cognitive process.

The behavioral decision research and presentation literatures hold, separately, a great deal of information relevant to the information system designer. When brought together, the areas provide a synergy which creates a whole new wave information. This paper has tapped some of that potential and has shown a few new directions. Future work will investigate the area more fully.

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