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INFORMATION EVALUATION BEHAVIOR IN A COMPETITIVE ENVIRONMENT: CONTEXT AND TASK EFFECTS

ABSTRACT

This paper reports the results of an experiment in which subjects assuming the role of division managers in a decentralized firm made subjective information system evaluations. It extends existing subjective information evaluation research by: (1) incorporating a two-person competitive environment, (2) investigating the effects of context and task variables on information evaluation behavior, and (3) focusing on the actual choice of information system, rather than on judgment aspects of the task. Subjects' information system choices indicated misperception of information values, consistent with previous studies. This occured even though no complex calculations of information demand value were required in the experiment. Context did not have an aggregate effect on information evaluation behavior. However, the manner in which costs associated with information systems were presented had different effects on behavior across contexts. The findings of the study indicate that: (1) individuals ignore the strategic implications of private information, (2) overvaluation of information is a fairly pervasive phenomenon, and (3) problem context and system cost allocations may affect the evaluation and usage of information systems in organizational settings.

INFORMATION EVALUATION BEHAVIOR IN A COMPETITIVE ENVIRONMENT: CONTEXT AND TASK EFFECTS

One of the principal roles of accounting information is to help individuals resolve uncertainty in a problem prior to making a decision. This usage is commonly referred to as the "decision-facilitating" role of accounting information [Demski and Feltham 1976, p. 9]. Accountants often face the task of evaluating alternative systems for generating this type of information.

Accounting researchers have utilized the theory of information economics to develop criteria for the evaluation of management accounting systems. This theoretical framework assumes that individuals act consistently with the expected utility hypothesis. Experimental research has shown, however, that individuals' subjective evaluations of information systems are not always consistent with the values calculated using information economics [Hilton, Swieringa, and Hoskin, 1981; Hilton and Swieringa, 1981; Schepanski and Uecker, 1983; Uecker, Schepanski, and Shin, 1985].

This paper examines the task of choosing an information system in a multi-person scenario where individual objectives are in conflict. In doing so, it also investigates the effects of problem context and stated cost of information on individuals' information system choices. The paper reports an experiment in which subjects assumed the role of one of two division managers in a decentralized firm. The subjects interacted with a microcomputer, which played the role of the other manager.

This paper has four features which distinguish it from previous research. First, it addresses the problem of subjective information evaluation in a two-person environment with conflicting individual objectives. Within such an environment, a private information system may affect the actions of the person without access to the system. As a result, the value of information may differ from that in a single-person setting or in a multi-person setting where individual objectives are not in conflict [Baiman, 1975]. Current analytical models utilized in accounting research recognize this and generally assume a multi-person environment with conflicting objectives [Baiman, 1982; Demski and Kreps, 1982]. However, very little experimental work has been conducted within such an environment. In particular, it is not known whether individuals consider strategic implications when deciding whether or not to choose a given information system.

Second, this paper investigates the effect of context and task characteristics on information evaluation behavior. Existing subjective information evaluation research has only incorporated variables directly related to the economic demand value of information. However, the contexts in which information system evaluation problems are encountered often differ. Also, task effects, such as the manner in which the costs associated with a system are allocated, may vary. The findings of a number of recent studies of other decision problems involving uncertainty [Einhorn and Hogarth, 1981; Payne, 1982] suggest that subjective evaluations of information systems may be affected by context and task variables. These variables may affect the decision strategies used to evaluate an information system and, in turn, individuals' basic perceptions of the value of information. These effects may occur instead of, or in addition to, the effects of the variables that enter into the calculation of the demand value of information.

Third, the paper examines the problem of making a choice whether or not to utilize a given information system, rather than a judgment of its value. Existing studies have almost exclusively taken the latter approach, which tends to focus on the issue of whether subjects are good intuitive statisticians. In contrast, the choice approach focuses on individuals' basic perceptions of the value of information and the decisions made based on those perceptions. While models based on the expected utility hypothesis specify judgment as a prerequisite for choice, behavioral research has shown that decision makers do not always follow this process [Einhorn and Hogarth, 1981, pp. 73-74; Payne, 1982, p. 389]. Judgment may generally be an aid to choice, but it is neither necessary nor sufficient for choice. Therefore, the approach taken here is to investigate whether the decisions made by individuals are the same as those predicted by economic theories of information evaluation, given certain combinations of context and task variables.

Finally, the information systems evaluated by the subjects generated perfect information on the state outcome, rather than imperfect information. Computation of the demand value of an information system which generates imperfect information is a complex problem. Observed choices that are not consistent with economically optimal choices could occur because of the cognitive limitations of the subjects, context or task factors, or any combination of these. The use of perfect information avoids this potential confounding of effects. At the same time, the competitive setting keeps the problem of evaluating a perfect information system from becoming a trivial one.

The remainder of the paper is organized as follows. First, the relationship of context and task variables to the information evaluation problem is discussed. Second, the experimental method and hypotheses are described. The following section presents the experimental results. The final section of the paper discusses alternative explanations of the results and possible extensions of the present study.

Theoretical Development

Schepanski and Uecker [1983] and Uecker, Schepanski, and Shin [1985] found that individuals consistently ascribed positive value to information systems, even when the optimal economic value of these systems was zero. This research suggests that individuals may perceive the value of information as positive, even when it is not. However, other evidence on whether overvaluation is a general tendency is not clear. Hilton and Swieringa [1982] also found their subjects consistently overvalued information. On the other hand, Hilton, Swieringa, and Hoskin [1982] used a similar elicitation technique and reported that only a portion of their subjects overvalued information.

Inconsistencies between subjective valuations of information systems relative to their theoretical expected value may depend on context and/or task variables. Context effects in decision making research are synonymous with content, especially as it relates to the perceived values of the objects in a decision set under consideration [Payne, 1982, p. 386]. The specific context effect investigated here is differences in perceived information value arising from slight wording changes in an information evaluation problem. Task effects are associated with the structure of a decision problem. The task variable examined in this study is the presentation mode for information system costs, that is, whether the system costs are or are not allocated to the user.

Context Effects

Context effects arising from slight wording changes have been demonstrated in a number of problems involving decision making under uncertainty, such as gambles for money, medical decisions about saving lives, and decisions whether or not to purchase insurance [Kahneman and Tversky, 1979; Tversky and Kahneman, 1981; Hershey and Schoemaker, 1980; Slovic, Fischhoff, and Lichentenstein, 1982]. Since information evaluation is basically a decision to employ a system that will reduce or eliminate uncertainty, it may be subject to similar effects. There are two alternative premises tested in this study with respect to context.

The first premise is that individuals will overvalue information when presented with an explicit information purchase decision, but not when the problem is presented in more general terms, e.g., as an opportunity to reduce uncertainty. This prediction is based upon the context effects in insurance purchase decisions observed by Hershey and Schoemaker [1980] and further discussed by Slovic, et al. [1982]. In these studies, individuals responded differently when a problem was framed as a choice between a sure loss and a lottery with a loss component than when it was framed as a decision to pay an insurance premium to protect against loss. Given the same set of values in both problems, the majority of subjects chose the risky prospect in the gambling problem, while the majority decided to pay the premium in the insurance problem. One of the reasons Slovic, et al. [1982] gave for this result was that the insurance context may trigger social norms about prudent behavior that are not associated with the preference context. Individuals may operate with similar beliefs about the value of information. When presented with an information evaluation context, they may view information as a valuable good. However, they will not do this in a generalized uncertainty reduction context, where information is not explicitly labelled as such.

The alternative premise is that individuals will overvalue information, regardless of context. This is supported by the notion that persons are uncomfortable with uncertain outcomes, thus finding the reduction or omission of uncertainty a useful cognitive simplification mechanism [Hogarth, 1975, p.273]. Any mechanism that is thought to reduce uncertainty may be perceived as valuable, even though it may have no effect on final outcomes [Langer, 1977].

Task Effects

The subjective information evaluation research discussed at the beginning of this section focused upon elicitation of demand values. That is, experimenters determined the stated cost at which subjects would be indifferent between a given information system and no information. Within an organization, however, the stated cost of an information system to a user may or may not equal its expected value, or even the actual cost of implementing the system. For example, the costs of producing certain reports may be borne entirely by a data processing department within an organization. Alternatively, these costs may be allocated to individual corporate units.

Stated cost may affect the behavior of information evaluators in one of two ways. First, it may be used as an evaluation criterion within a simplified decision process, in lieu of expected value. Individuals following such an approach set an arbitrary stated cost cutoff point beyond which they will not utilize information, regardless of its expected value. In these cases, undervaluation of information, as well as overvaluation, may occur. A second possibility is that individuals may employ simplified decision strategies when information is costless or has low stated cost, and strategies consistent with economic theory beyond a given cost threshold. This prediction is derived from a cost-benefit framework for decision strategy selection [Beach and Mitchell, 1978] in that higher levels of stated cost are assumed to increase task demand, i.e., the perceived need to use analytic decision strategies.

The occurrence of either of these stated cost effects may depend on context. Individuals may employ stated cost as a sole decision cue in an information evaluation context and act according to economic theory in an uncertainty reduction context, regardless of stated cost. Alternatively, they may view the cost of information as a payment for obtaining a valuable good in the information evaluation context and as a loss in the uncertainty reduction context. This would result in consistent overvaluation of information in the first context and use of stated cost as a decision cue in the latter. This effect is consistent with a shift in reference point due to framing, where the reference point is the status quo in an uncertainty reduction context, while it is one's position after purchasing the information in the information evaluation context.

Method

Experimental Setting

The setting of the experiment is a firm which produces a single product. The firm has two divisions, each headed by a single manager (Manager A and Manager B). The firm's output and the payoffs to the managers depend jointly on the actions of the managers and the outcome of a random state of nature. Each manager has a choice of one of two actions and there are two possible states of nature. Both managers are aware of each other's payoffs and preferences. In one possible scenario, each manager might be responsible for one stage of the production process for a precision tool, with one in charge of the casting department and the other responsible for the machining department. The actions of the managers represent the level of effort expended by each, while the random parameter represents the quality of the raw materials used in the process.

Manager A has the opportunity to utilize an information system which generates perfect information on the state outcome (η^P). Alternatively, he may choose to act without an information system (i.e., "use" the null information system (η^o). Manager B knows Manager A's information system choice.

It can be shown that, depending on the payoff sets of both managers, that Manager A's private information can have zero, positive, or negative expected value (See Appendix A.). This is in contrast to a single-person or decision-theoretic setting, where the Fineness Corollary of Blackwell's Theorem states that the value of a finer information system is always greater than or equal to that of a coarser one. The result is counterintuitive, but the present example has a clear practical interpretation. First, assume the two actions available to each manager represent high and low levels of effort. When neither manager has private information, the best strategy for both is to expend a high level of effort. When Manager A has private information, he is able to adjust his effort level contingent on the state outcome. At the same time, the payoffs are such that it is no longer optimal for Manager B to expend a high effort level. This affects the firm's total output and, in turn, lowers Manager A's expected payoff.

Experimental Design

In the experiment, CONTEXT was a between-subjects variable with three levels and COST was a within-subjects variable with two levels. Additionally, the expected value of information (EV) was a within-subjects variable. Levels of COST were zero and positive (0 and 10 units) in the experimental cases. EV levels were negative, zero, and positive (–10, 0, and +10 units).[1] Each of the six resulting cases was repeated five times before the subject was presented with another case, resulting in a total of 30 experimental trials.

All cases with the same stated cost of information were presented together. Order of presentation with respect to stated cost (ORDER) was treated as a between-subjects variable and counterbalanced. The order of presentation with respect to expected value within each level of stated cost was randomized. Ten subjects were presented with each combination of CONTEXT and ORDER, resulting in a total of 60 subjects in the design. (See Figure 1.)

Insert Figure 1 about here.

Experimental Variables

<u>Dependent Variable</u>

The dependent variable in the experiment is the proportion of times over a set of game trials a subject chooses to act with private information for a given case. Since "Manager A" is the only individual in the experimental scenario able to make such choices, all subjects assumed this role. The role of "Manager B" was taken by the computer.[2]

Independent Variables: CONTEXT and COST

Two different contexts involving state uncertainty were used in the experiment. The first context was an information evaluation problem. The parameters (e.g., payoffs and probabilities) in the second context were exactly the same as in the first, except that the problem of information evaluation was presented as a choice between two production processes. One process allowed the manager to make decisions contingent on the observed state of nature, while the other did not. These two contexts will be referred to as the information evaluation and process choice contexts. In the first of these contexts, the stated cost of information (COST) was labelled as such. In the second, it was presented as an additional fixed cost associated with the process allowing contingent choices.

A setting without state uncertainty was also used in the experiment. In this setting, subjects chose a subgame (labelled a "production process") and an action to be taken within the subgame. Payoffs for each outcome in the subgames were the expected values of the outcomes for the settings with state uncertainty. The dependent variable for this setting is the proportion of times over a set of game trials a subject chooses the subgame corresponding to private information in the other settings. This setting will be referred to as the basic game.[3]

The basic game serves as a "baseline" against which the settings with state uncertainty can be compared. It is necessary to have such a baseline because observed misperceptions of information value could have one of two types of explanations. First, individuals may rely on simplified decision processes because of the complexity of the experimental problem. This explanation underlies the discussion of context and task effects presented above. Second, individual behavior in the game underlying the experimental settings may not conform to the noncooperative Nash solution presented in Appendix A. If subgame choices in the basic game setting do not correspond to the predictions of the model, this indicates the second explanation is the more appropriate one.

Dependent Variables: EV

EV was treated as a within-subjects variable, in order to have a basis for testing differences in choice proportions across different levels. Direct tests for over- or undervaluation of information pose certain problems, at least on an aggregate level. Since the dependent variable is a proportion, it is difficult to set a statistical criterion which indicates over- (for negative expected value cases) or under- (for positive expected value cases) valuation of information. As an alternative, it is possible to test the significance of differences in the choice proportions observed for different levels of expected value. These tests are an indication whether the subjects' perceived value of information differs at varying levels of expected value. Planned comparisons are employed to indicate if these differences (or lack of differences) are affected by context and stated cost.

Since the EV variable has three levels, a set of two orthogonal contrasts can be performed on it. The comparison of primary interest is that between observed values of the dependent variable for positive and negative EV levels. This comparison can be written as:

$$\mathfrak{a}_3 - \mathfrak{a}_1 \qquad (1)$$

where: $\mathfrak{a}_k$ denotes the proportion of times subjects choose to play the private information subgame for cases with EV k

and: k = 1, 2, and 3 denote negative, zero, and positive levels of EV.

As a main effect, this comparison indicates whether subjects perceive the value of information in the positive EV case to be greater than that in the negative EV case, or the same. Interactions between other independent variables and this comparison indicate whether or not these variables have an effect on perceived differences in information value.

The second possible contrast in this set is that between zero EV and the mean of positive and negative EV, or:

$$q_2 - (q_1 + q_3)/2 \quad (2)$$

Given that the value of the first contrast is significantly greater than zero, this contrast gives an indication whether the perceived differences between the three levels of information value are equal. If these differences are equal, then the value of the second contrast will not be significantly different from zero. If, however, the difference in choice proportions between zero and positive EV levels is smaller than that between zero and negative EV, the second contrast will be positive.

The contrasts specified by Equations 1 and 2 are a set of orthogonal polynomial contrasts. Therefore, contrasts of the type specified by Equation 1 will be referred to as 'linear' in the paper and those of the type specified by Equation 2 will be referred to as 'quadratic'. This does not indicate that precise mathematical relationships in these forms are expected between EV and information choice proportions. Instead, these terms will be used to facilitate further discussion.

Hypotheses

Let:

q_{ijk} = the proportion of times subjects in CONTEXT i choose to play the private information subgame (act with private information) for the case with COST j and EV k

and

i = 1, 2, and 3 denote the basic game, process choice, and information evaluation settings

j = 1 and 2 denote zero and positive levels of COST

k = 1, 2, and 3 denote negative, zero, and positive levels of EV.

The basic game setting is used in this study as a "baseline" against which results in the settings with state uncertainty are compared. Therefore, the hypotheses presented below are all based upon predicted interactions of CONTEXT with COST and EV. The hypotheses are grouped together by interaction term in the following discussion.

<u>CONTEXT x EV</u>

This interaction is an indicator whether misperceptions of information value have occurred in one or both settings with state uncertainty. Misperception of information value is said to have occurred if the contrast between negative and positive EV levels (the 'EV(linear)' contrast) for a setting with state uncertainty is significantly smaller than that for the basic game. The CONTEXT x EV(linear) interaction may take one of two forms, depending on which of the premises regarding the effect of problem wording presented above is true. If information evaluation behavior is affected by problem wording, then only the EV(linear) contrast for the information evaluation setting should be significantly smaller than that for the basic game. On the other hand, if information overvaluation occurs consistently, regardless of problem wording, the EV(linear) contrasts for both settings with state uncertainty should both be significantly smaller than for the basic game setting. H_{1A} is based on the first of the two premises, while H_{1B} is based on the second.

H_{1A}: $q_{1\bullet 3} - q_{1\bullet 1} = q_{2\bullet 3} - q_{2\bullet 1} > q_{3\bullet 3} - q_{3\bullet 1}$

H_{1B}: $q_{1\bullet 3} - q_{1\bullet 1} > q_{2\bullet 3} - q_{2\bullet 1} = q_{3\bullet 3} - q_{3\bullet 1}$

A similar set of effects may occur with respect to the relationship between the observed value of the dependent variable for zero and the other levels of EV. It is predicted that subjects in the basic game setting will not exhibit a clear preference for either subgame in the cases representing zero EV levels. This results in an EV(quadratic) contrast which is equal or nearly equal to zero. On the other hand, the subjects in either of the settings with state uncertainty may prefer to act with information when it has zero EV, even though in economic terms, they should be indifferent between information and no information at this point. This behavior results in a positive EV(quadratic) contrast, given the EV(linear) contrast is in the predicted direction. As with the overvaluation of information, this effect may occur only in the information evaluation setting (H_{1C}) or in both settings with state uncertainty (H_{1D}).

H_{1C}: $q_{1\bullet 2} - (q_{1\bullet 1} + q_{1\bullet 3})/2 = q_{2\bullet 2} - (q_{2\bullet 1} + q_{2\bullet 3})/2 < q_{3\bullet 2} - (q_{3\bullet 1} + q_{3\bullet 3})/2$

H_{1D}: $q_{1\bullet 2} - (q_{1\bullet 1} + q_{1\bullet 3})/2 < q_{2\bullet 2} - (q_{2\bullet 1} + q_{2\bullet 3})/2 = q_{3\bullet 2} - (q_{3\bullet 1} + q_{3\bullet 3})/2$

CONTEXT x COST

COST should only affect subjects' behavior in the settings with state uncertainty. It should have no effect in the basic game setting.

H_{2A}: $q_{11\bullet} = q_{12\bullet}$

H_{2B}: $q_{21\bullet} > q_{22\bullet}$

H_{2C}: $q_{31\bullet} > q_{32\bullet}$

CONTEXT x COST x EV

COST may affect the perceived differences between positive and negative levels of EV, causing them to be greater when information has positive stated cost than when the stated cost is zero. This would lead to a COST x EV(linear) interaction. However, this effect should not occur without a related CONTEXT x COST x EV(linear) interaction, since COST should not have an effect on perceived differences between levels of EV in the basic game setting. H_{3A} predicts such an effect will occur in both settings with state uncertainty. Alternatively, the COST x EV(linear) interaction may differ across state uncertainty contexts. As discussed earlier, subjects may view the cost of information as a loss in the process choice context, but as payment for a valuable good in the information evaluation context. If this occurs, the perceived difference between positive and negative levels of EV will be affected by cost only in the process choice context. H_{3B} is based on this prediction.

$$H_{3A}: (q_{123} - q_{121}) - (q_{113} - q_{111}) < (q_{223} - q_{221}) - (q_{213} - q_{211}) = (q_{323} - q_{321}) - (q_{313} - q_{311})$$

$$H_{3B}: (q_{123} - q_{121}) - (q_{113} - q_{111}) = (q_{323} - q_{321}) - (q_{313} - q_{311}) < (q_{223} - q_{221}) - (q_{213} - q_{211})$$

The EV(quadratic) effect may also interact with CONTEXT and COST. Given two cases where information has zero EV, but different stated costs, individuals may prefer to act with information more often in the case where the stated cost is zero than when it is positive, even though the economic demand value of information in both cases is equal. If this is so, the EV(quadratic) effect will be smaller for positive than for zero cost cases. The COST x EV(quadratic) interaction may occur in both contexts with state uncertainty (H_{3C}). Alternatively, if subjects frame the stated cost of information differently across contexts, the interaction may only occur in the process choice context (H_{3D}).

$$H_{3C}: q_{112} - (q_{111} + q_{113})/2 - (q_{122} - (q_{121} + q_{123})/2) <$$
$$q_{212} - (q_{211} + q_{213})/2 - (q_{222} - (q_{221} + q_{223})/2) =$$
$$q_{312} - (q_{311} + q_{313})/2 - (q_{322} - (q_{321} + q_{323})/2)$$

$$H_{3D}: q_{112} - (q_{111} + q_{113})/2 - (q_{122} - (q_{121} + q_{123})/2) =$$
$$q_{312} - (q_{311} + q_{313})/2 - (q_{322} - (q_{321} + q_{323})/2) <$$
$$q_{212} - (q_{211} + q_{213})/2 - (q_{222} - (q_{221} + q_{223})/2)$$

Subjects and Procedure

The subjects were all students at the University of Texas at Austin. Twenty-one were fourth-year students in the Program in Professional Accounting (PPA), 34 were MBA students, and 5 were first-year accounting Ph.D. students. The experiment was run in a student computer lab at the University of Texas at Austin using IBM PCs with monochrome monitors. There were six separate experimental sessions, with from 6 to 16 subjects completing the experiment at any one time. Subjects participating in the same session were randomly assigned to different experimental treatments.

The experiment was conducted in four phases: (1) preliminary instructions, (2) a quiz on the instructions, (3) practice trials, and (4) the main part of the experiment. At the beginning of each experimental session, subjects were given a set of instructions consistent with their experimental condition and assigned to a computer. The computer displayed the game values and expected values (where appropriate) for the practice trials.[4] Subjects were instructed to read the instructions and examine the computer display, but not to proceed with the experiment.

When all subjects were set up at their computers, the experimenter gave them additional brief oral instructions on use of the IBM keyboard and on the conduct of the experiment. The subjects were informed they would be paid in cash at the end of the session and reminded they would be eligible for further prizes, based on their performance. They were instructed to ask any necessary questions during the quiz or practice trials, since no questions were allowed during the main part of the experiment. The subjects were then told to finish reading the instructions and proceed with the experiment when ready.

The quiz consisted of questions designed to test subjects' ability to correctly read the payoff matrices. Each subject completed five practice trials. The values for the practice trials were the same for all subjects. After the practice trials, the subjects' point endowment was reset to 100 points and they played the thirty actual trials.

During each trial, the computer prompted the subject for two responses: (1) an information (in the information evaluation setting) or process choice (in the basic game and process choice settings) and (2) an action or production plan choice.[5] In the basic game setting, the computer's ("Manager B's") action and the payoffs to the subject and computer were revealed after the subject's response. In the other settings, a random number representing the state outcome was drawn and revealed to the subject immediately if he chose to act with information.[6] The computer's action and the payoffs to the subject and computer were then revealed. In cases where the subject chose to act without information, the computer's action was revealed first, then the random number, and finally the payoffs. A message on the computer screen notified the subject when payoffs or the stated cost of information were to change on the next trial. After all the experimental trials were completed, the experimenter verified the subjects' point totals and paid them in cash.

Subject payoffs for each trial were stated in points. The conversion rate from points to cash was 1 point = 1 cent.[7] Subjects began the experiment with an initial endowment of 100 points, and accumulated further payoffs on each of the 30 experimental trials. The expected value (or in the basic game setting, the payoff) from making the optimal subgame and action choices for all 30 trials was $16.00.

Combined with the initial endowment, this made the expected value for the entire experiment \$17.00.[8]

Results

Main Effects

Table 1 is a summary of the proportions with which the subjects chose the private information subgame, broken down by the four independent variables. Table 2 presents the results of the repeated measures MANOVA of the data.[9, 10] The only significant main effects are those for COST ($p < 0.004$) and EV ($p < 0.001$). The dependent variable proportion for the zero COST level is greater for that for positive COST ($q_{\bullet 1 \bullet} = 0.75$; $q_{\bullet 2 \bullet} = 0.67$). The EV(linear) effect is significantly greater than zero ($q_{\bullet\bullet 3} - q_{\bullet\bullet 1} = 0.86 - 0.50 = 0.36$; $p < 0.001$), as is the EV(quadratic) effect ($q_{\bullet\bullet 2} - (q_{\bullet\bullet 1} + q_{\bullet\bullet 3}) / 2 = 0.08$; $p < 0.01$).

Insert Tables 1 and 2 about here.

Hypothesized Interactions

The CONTEXT x COST, CONTEXT x EV, and CONTEXT x COST x EV interactions were all statistically significant ($p < 0.06$, $p < 0.001$, and $p < 0.03$, respectively). Table 3 displays the results of tests of individual hypotheses. All these tests were performed using Dunn's multiple comparison procedure [Kirk, 1982, pp. 106-109; Dayton and Schaefer, 1973].

Insert Table 3 about here.

<u>CONTEXT x EV</u>: Only the EV(linear) component of this interaction is statistically significant ($p < 0.001$). Values of the EV(linear) contrast are 0.71, 0.16, and 0.22, for the basic game, process choice, and information evaluation settings, respectively. The comparisons between CONTEXTs shown in Table 3 are consistent with the predictions of H_{1A} (See Figure 2.). The absence of a CONTEXT

x EV(quadratic) interaction indicates the EV(quadratic) effect occurred consistently across contexts, including the basic game setting.

Insert Figure 2 about here.

CONTEXT x COST: The effect of COST in the basic game and information evaluation settings is as predicted (not significant for H_{4A} and $p < 0.01$ for H_{4C}). However, no significant effect was found in the process choice setting (H_{4B}) (See Figure 2.).

Insert Figure 3 about here.

CONTEXT x COST x EV: Values of the COST x EV(linear) contrasts are 0.10, –0.25, and 0.08 for the basic game, process choice, and information evaluation settings, respectively. Note that the value for the process choice setting is negative, contrary to predictions. As a result, the difference in contrasts between the process choice and basic game settings is significant ($p < 0.05$), but opposite the predicted direction. The difference between the information evaluation and process choice settings is significant ($p < 0.05$) and in the predicted direction, but it also occurs because the value of the process choice contrast is negative. This pattern of results is consistent with neither H_{3A} nor H_{3B}.

The COST x EV(quadratic) contrasts are –0.11, 0.19, and 0.07 for the basic game, process choice, and information evaluation settings. This pattern of effects is also different than predicted. Only the contrasts for the basic game and process choice settings are significantly different from each other ($p < 0.05$).

Inspection of Figure 4 shows that COST apparently has a negligible effect on the dependent variable for all levels of EV in the basic game and a consistent effect for all levels of EV in the information evaluation setting. In the process choice setting, the EV (linear) contrast is greater for zero than for positive cost cases, which is inconsistent with the predicted form of the COST x EV interaction.

Insert Figure 4 about here.

Interactions with ORDER

In addition to the predicted interactions, two interactions involving the ORDER variable were significant, ORDER x COST ($p < 0.03$) and ORDER x CONTEXT x COST x EV ($p < 0.03$). The significant ($p < 0.01$) EV(linear) component of the second of these interactions indicates learning effects may have occurred. If learning is taking place in the experiment, the perceived difference in information value between negative and positive EV cases should be greater in the second half of the experiment than in the first, regardless of ORDER. This leads to an interaction between COST, ORDER, and the linear component of EV. Further investigation of this interaction showed that the difference in choice proportions between negative and positive EV cases was greater in the second half of the experiment than in the first in the basic game and information evaluation settings, but not in the process choice setting. The difference from the first to the last half of the experiment was statistically significant ($p < 0.01$) only in the basic game setting.

Individual Choice Patterns

An analysis was made of individual choice patterns in order to determine whether they were consistent with the CONTEXT x EV interaction found in the aggregate data. This analysis is broken down by CONTEXT and COST (See Table 4.).[11] Payoff maximization was the most common pattern in the basic game setting. On the other hand, consistently acting with information was the most common pattern in the settings with state uncertainty.[12] When behavior across both COST levels is considered, no subjects in the process choice setting consistently acted as expected payoff maximizers through the entire experiment, and only one subject did so in the information evaluation setting. In contrast, seven subjects in the basic game consistently made choices consistent with payoff maximization throughout the entire experiment.

Insert Table 4 about here.

To further investigate the CONTEXT x COST x EV interaction, an analysis of individual shifts in choice proportions across COST levels was also made. This was done by performing a separate Wilcoxon matched-pairs signed-ranks test for each level of EV within each CONTEXT, using response proportions for each COST level as the dependent variable. None of the comparisons for the basic game or process choice settings were statistically significant. However, the comparisons for all levels of EV within the information evaluation setting were all statistically significant in the expected direction for negative, zero, and positive EV levels ($p = 0.04$, $p = 0.01$, $p = 0.02$).

Summary, Discussion, and Extensions

Summary of Key Results

The choices of subjects in both settings with state uncertainty were relatively unaffected by information EV, compared to the "benchmark" of subjects playing under conditions of certainty. This effect occurred primarily because of overvaluation of information with negative EV in both settings with state uncertainty. Some undervaluation of information with positive EV also occurred, but to a lesser extent than overvaluation. Analysis of individual choice data confirmed that overvaluation of information occurred at the individual level in both settings with state uncertainty.

However, the effects of COST on information evaluation differed in the two settings with state uncertainty. Within the information evaluation setting, the effects of COST were in the predicted direction and consistent across EV levels. This was further supported by the analysis of individual data. It therefore appears that subjects in the information evaluation setting tended to focus on COST as a decision cue within a simplified decision process.

The aggregate effects of COST in the process choice setting, however, were contrary to predictions. There was virtually no difference in information choice proportions across EV levels for positive COST cases, and the difference between EV levels for these cases was less than that for zero COST cases. Examination of Figure 4 suggests a kind of "reversal" may have occurred at the negative EV level between the process choice and information evaluation settings. That is, the observed choice proportion for zero cost cases in the process choice setting is approximately equal to that for positive cost cases in the information evaluation setting, and vice versa. However, while analysis of individual choice patterns at the negative EV level showed a greater tendency to prefer information with zero than with positive COST in the information evaluation setting, the opposite was not true for the process choice setting.

Discussion of Results

One possible explanation for the observed misperceptions of information value is that the basic structure of payoffs in the decision problem examined here caused individual behavior to deviate from the Nash noncooperative solution. Decisions consistent with the Nash solution concept in the experimental task consist of two stages: (1) evaluating the payoff associated with the optimal action <u>within</u> each subgame (i.e., evaluating the optimal payoffs for acting with and without information) and (2) choosing an optimal <u>subgame</u> (i.e., information system choice) based on that evaluation. The results presented above indicate: (1) the majority of subgame choices in the basic game setting were consistent with this decision process and (2) the introduction of an uncertain component into the task caused subjects to apply alternate decision strategies. However, the results presented thus far do not indicate at <u>which</u> stage of the optimal decision process these deviations occurred. A possible explanation for non-optimal subgame choices in the settings with state uncertainty is that subjects might not have made the optimal evaluation of actions within each subgame. However, dominant actions were chosen 95% of the time in the entire experiment, regardless of subgame choice. Therefore, subjects in the settings with state uncertainty acted consistently with the Nash solution concept concerning action choices. However, they appeared to ignore strategic considerations when making information system choices.

A second possible explanation is that the level of task demand in the experiment was not sufficiently high for subjects to select decision strategies consistent with payoff maximization in the settings with state uncertainty. That is, subjects consciously decided the costs of implementing complex decision strategies outweighed the benefits to be gained from their use. Two elements in particular determined the level of task demand in the experiment. The first was the stated cost of information. The stated cost effects on task demand discussed earlier in the paper may not have occurred because the positive stated cost level was not sufficiently high to trigger the use of analytic strategies. The second principal task demand element is the opportunity cost associated with making a non-optimal decision. The opportunity costs in the experiment were relatively low, since the expected loss from making a non-optimal decision was only 10 units for cases with positive and negative information EV. These may not have been sufficiently high to justify the cognitive effort associated with making optimal decisions.

The cost-benefit approach assumes that the decision maker follows a conscious, deliberate approach to the selection of decision strategies [Christensen-Szalanski, 1978, 1980]. However, the experimental results indicate inconsistencies with such an approach. Task demand should have been invariant across contextual settings, but the pattern of observed results was not. While one could argue that the familiarity of the task to subjects might have been affected by context, a stronger counterargument lies in the fact that the relatively abstract task should have been unfamiliar to the subjects, regardless of context. Also, the order effects observed in the process choice setting appeared inconsistent with conscious strategy selection.

A third possible explanation is that acting with information is a metarule or metaheuristic, which is used to generate lower-level strategies. Kleinmuntz and Thomas [1987] propose that decision makers may employ metaheuristics as an alternative to calculative rationality in choosing strategies for specific tasks. They describe the use of an infer-then-act metarule, which is used to generate lower level strategies. This metarule is consistent with the use of uncertainty avoidance mechanisms discussed in the second section of the paper. The individual results show that a number of subjects in the experiment exhibited this type of behavior pattern.

Other metarules not yet identified may have been used by subjects who did not exhibit consistent choice patterns. It is not yet known which factors affect the use of metaheuristics. They may be "hard-wired", that is, individuals may have a repertoire of metarules which are automatically called upon when facing certain task situations. Otherwise, their use may be subject to a simplified choice process, in which the input includes decision cues such as context.

Extensions of the Study

These competing explanations suggest two extensions of this study. The first extension would further investigate the effects of task demand on subjective information evaluation. It would consist of an experiment similar to the present one in which differing levels of stated information cost and information expected value are presented to the subjects.

The second extension would entail gathering verbal reports (e.g., concurrent protocols) from subjects as they complete the task. The protocols would indicate not only if subjects are using simplified decision strategies, but also if they are consciously aware they are selecting such strategies [Payne, 1982, p. 397]. These data would also provide evidence as to subjects' awareness of the importance of the other player's actions in determining their own payoffs.

Conclusions

Misperceptions of information value occurred extensively in this study, consistent with the findings of other subjective information evaluation studies. The present results occurred even though complex calculations were not required to determine the demand value of information in the experiment, as in previous studies. It appears that a number of subjects used simplified decision strategies which did not take the strategic implications of information system choice into account.

Misperceptions of information value, especially information overvaluation, occurred consistently across different contexts. However, the effects of the stated information cost task variable were not consistent across contexts. These effects indicate that researchers need to consider context and task variables when designing information evaluation experiments, since the results obtained with one set of variables may not be readily generalizable to others. These effects also have potential implications for those who design and implement information systems for use in organizations. The manner in which a given system and the costs associated with it are presented may cause individuals' subjective evaluations of the system to vary.

This study also is the beginning of a process of determining why individuals misperceive the value of information, rather than merely describing how they misperceive it. It was shown that the results are consistent with current theories of decision strategy selection in some ways, but inconsistent with them in others. Extensions of the present work will provide a means of further investigating the information evaluation problem within the current theoretical framework of decision making research.

APPENDIX A

The experimental setting can be characterized as a game of imperfect, but complete information with an uncertain parameter. Imperfect information indicates the players are unable to observe each others' action choices. Complete information indicates the players are aware of all the rules of the game, including each others' payoffs and preferences [Schotter and Schwödiauer, 1980]. The game can also be thought of as a reformulation of a game of incomplete information, which is a game characterized by uncertainty about one or more game parameters [Harsanyi, 1967, 1968].

In the following discussion, Action 1 is denoted a_1 for Manager A and b_1 for Manager B; Action 2 is denoted a_2 for Manager A and b_2 for Manager B. The two possible states of nature are denoted s_1 and s_2. Figure A2 shows the extensive form of the game facing the two managers, based on the parameters in Figure A1. The game can be decomposed into two subgames, labelled "informed" and "not informed" in Figure A2. Manager A's decision problem on his first move is to determine which of the two subgames will yield him a higher payoff.

Insert Figure A1 and A2 about here.

The game can be more easily analyzed by examination of its strategic form (See Figure A3.). Examination of the no information subgame shows that a_1 is a dominant strategy for Manager A, since $50 > 25$ and $36 > -50$. A similar analysis shows that b_1 is a dominant strategy for Manager B. The strategy pair (a_1, b_1) is thus a Nash equilibrium (NE); that is, a pair of strategies such that no player, assuming the other is committed to his strategy, can increase his payoff by unilaterally changing strategies [Shubik, 1982, p.240].

Insert Figure A3 about here.

The strategic form of the private information subgame shows that Manager A has a choice of one of four decision rules. For a decision rule a_{ij}, the subscript i indicates Player 1's actions when s_1 occurs; j indicates his actions when s_2 occurs. For example, a_{12} means "choose a_1 when s_1 occurs; choose a_2 when s_2 occurs". The decision rule a_{12} dominates all of Manager A's other decision rules. Manager B still must choose between one of two actions as in the no information case. Manager B's best response to a_{12} is b_2, which makes (a_{12}, b_2) a NE.

The expected value of private information to an individual is his expected payoff in the private information case, minus his expected payoff in the no information case. In the present example, the value of private information to the informed manager is 40 – 50, or –10. Information also has zero value to the uninformed manager here. The negative value of private information for the informed manager is in contrast to a single-person or decision-theoretic setting where the Fineness Corollary of Blackwell's Theorem states that the value of a finer information system is always greater than or equal to that of a coarser one.

This analysis presumes that the game is only played once. In the experiment, the game was played repeatedly over multiple trials. The outcome of a repeated game may differ from that of a single play game under certain circumstances [Luce and Raiffa, 1957]. Specifically, if the NE point in single plays is not Pareto-optimal, the players can achieve gains through cooperation in repeated plays. However, the games used in the experiment were designed so that the single-play optimal solutions were also optimal for both players in repeated plays.

Footnotes

[1]The payoffs for the case with EV of –10 and zero COST are shown in Appendix A (See Figures A1 and A3). Other levels of EV were obtained by changing Manager A's payoff for the outcome (a_2, b_2) in State 2. For positive COST cases, 10 units were subtracted from all of Manager A's payoffs in the private information subgame.

[2]A secondary reason this was done was to minimize the possibility that subjects playing non-Nash strategies might confound the results. The computer was programmed to play its NE strategies in each subgame.

[3]The term CONTEXT will be used in the remainder of the paper to refer to both the settings with uncertainty and that without.

[4]Expected values were displayed in the settings with state uncertainty to control for the fact that deviations from the expected utility model might be due to the subjects' limited calculation ability. Calculating expected values for the subjects in no way trivializes the task. Instead, it allows them to focus upon the tasks of subgame and action selection, which relate directly to the key issues examined in this study.

[5]The subjects always chose actions in the basic game setting and when they were acting without information in the other settings. When they chose to act with information in the settings with state uncertainty, they were told to choose a production plan, which is the same as the decision rules discussed in Appendix A.

[6]The random numbers ranged from 1 to 100. Random numbers from 1 to 60 indicated the occurrence of State 1, while numbers from 61 to 100 indicated State 2 had occurred.

[7]Differences in individual risk preferences were controlled for by designing the experiment so that the ordinal relationship of the expected values for each strategy combination is maintained under a wide variety of positive monotonic transformations of the matrix values. (A proof is available from the author.) The results can only be affected by risk attitude in the case where subjects are extremely risk-averse or risk-seeking. Such risk attitudes are unlikely to occur, given the range of payoffs from the experiment. Not only do the predictions of the game theory model hold under a wide range of preferences for both players, but they will also hold under a variety of individual beliefs about those preferences.

[8]Additionally, the top and second place subjects in each CONTEXT treatment group were awarded prizes of $100 and $25.

[9]The proportions were transformed before analysis using an arcsin transformation (Neter and Wasserman, 1974, p.507) in order to avoid the problem of unequal variances across different levels of the dependent variable.

[10]The data meet the compound symmetry assumptions required for a univariate repeated measures ANOVA, however, the multivariate approach was used here to facilitate tests of the interaction hypotheses. With repeated measures MANOVA, the set of orthogonal contrasts on EV is treated as a vector of dependent variables. For each effect involving EV which MANOVA indicates to be significant, separate ANOVAs are done on each individual contrast [Bock, 1975, Ch. 7; La Tour and Miniard, 1983]. The multivariate approach is generally less powerful than the univariate. As a check, univariate tests were run on the data. No differences were found between the two approaches as to the significance of main effects or interactions .

[11]The classifications for each level of cost were defined according to private information subgame choice proportions as follows: payoff maximization--0.2 or 0.0 on the negative EV case, 0.8 or 1.0 on the positive EV case, and any proportion on the zero EV case; always preferring information--0.8 or 1.0 on all cases. No meaningful subclassifications could be drawn within the "other" category, except for the three subjects who consistently acted without information (two acted as such only when stated cost was positive and one did so for both levels of stated cost--all were in settings with state uncertainty).

[12]The differences across contexts in relative proportions of choice patterns are statistically significant for both zero stated cost ($\chi^2_{(4)} = 8.75$; $p = 0.07$) and positive stated cost ($\chi^2_{(4)} = 29.78$; $p < 0.0001$).

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Table 1
Proportion of Choices–Private Information Subgame

Breakdown by Cells

Zero Cost

Order	Context	Negative EV	Zero EV	Positive EV
Zero	Basic Game	0.54	0.80	1.00
Cost	Process Choice	0.50	0.88	0.94
First	Info. Evaluation	0.80	0.94	0.88
	Mean	0.61	0.87	0.94
Positive	Basic Game	0.14	0.72	1.00
Cost	Process Choice	0.58	0.82	0.70
First	Info. Evaluation	0.58	0.76	0.86
	Mean	0.43	0.77	0.85
Mean	Basic Game	0.34	0.76	1.00
Values	Process Choice	0.54	0.85	0.82
for Contexts	Info. Evaluation	0.69	0.85	0.87
Overall Mean		0.52	0.82	0.90

Positive Cost

Order	Context	Negative EV	Zero EV	Positive EV
Zero	Basic Game	0.08	0.78	0.94
Cost	Process Choice	0.78	0.68	0.80
First	Info. Evaluation	0.46	0.66	0.74
	Mean	0.44	0.71	0.83
Positive	Basic Game	0.32	0.78	0.98
Cost	Process Choice	0.66	0.76	0.70
First	Info. Evaluation	0.52	0.58	0.76
	Mean	0.50	0.71	0.81
Mean	Basic Game	0.20	0.78	0.96
Values	Process Choice	0.72	0.72	0.75
for Contexts	Info. Evaluation	0.49	0.62	0.75
Overall Mean		0.47	0.71	0.82

(Table continues.)

Table 1, continued

Averaged Across EV and COST

Means across EV levels

Order	Context	Negative EV	Zero EV	Positive EV
Zero	Basic Game	0.31	0.79	0.97
Cost	Process Choice	0.64	0.78	0.87
First	Info. Evaluation	0.63	0.80	0.81
	Mean	0.53	0.79	0.88
Positive	Basic Game	0.23	0.75	0.99
Cost	Process Choice	0.62	0.79	0.70
First	Info. Evaluation	0.55	0.67	0.81
	Mean	0.47	0.74	0.83
Mean	Basic Game	0.27	0.77	0.98
Values	Process Choice	0.63	0.79	0.79
for Contexts	Info. Evaluation	0.59	0.74	0.81
Overall Mean		0.50	0.76	0.86

Means across COST levels

Order	Context	Zero Cost	Pos. Cost
Zero	Basic Game	0.78	0.60
Cost	Process Choice	0.77	0.75
First	Info. Evaluation	0.87	0.62
	Mean	0.81	0.66
Positive	Basic Game	0.62	0.69
Cost	Process Choice	0.70	0.71
First	Info. Evaluation	0.73	0.62
	Mean	0.68	0.67
Mean	Basic Game	0.70	0.65
Values	Process Choice	0.74	0.73
for Contexts	Info. Evaluation	0.80	0.62
Overall Mean		0.75	0.67

Averaged Across All Cases

Order	Context	Mean Choice Proportion
Zero	Basic Game	0.69
Cost	Process Choice	0.76
First	Info. Evaluation	0.75
	Mean	0.73
Positive	Basic Game	0.66
Cost	Process Choice	0.70
First	Info. Evaluation	0.68
	Mean	0.68
Mean	Basic Game	0.67
Values	Process Choice	0.73
for Contexts	Info. Evaluation	0.71
Overall Mean		0.71

Table 2
Multivariate Analysis of Variance of Proportions of Private Information Subgame Choices

Source of Variation	Wilks Lambda	F or approx. F	p
CONTEXT		0.20	0.82
ORDER		0.80	0.38
ORDER x CONTEXT		0.05	0.94
COST		9.06	0.00
CONTEXT x COST		2.95	0.06
ORDER x COST		5.23	0.03
CONTEXT x ORDER x COST		1.34	0.27
EV	0.33	53.05	0.00
Linear		106.46	0.00
Quadratic		6.40	0.01
CONTEXT x EV	0.50	10.97	0.00
Context x Linear		26.40	0.00
Context x Quadratic		1.11	0.34
ORDER x EV	1.00	0.02	0.98
Order x Linear		0.03	0.87
Order x Quadratic		0.01	0.94
CONTEXT x ORDER x EV	0.92	1.16	0.33
Context x Order x Linear		1.19	0.31
Context x Order x Quadratic		0.94	0.40
COST x EV	0.98	0.50	0.61
Cost x Linear		0.25	0.62
Cost x Quadratic		0.96	0.33
CONTEXT x COST x EV	0.82	2.74	0.03
Context x Cost x Linear		3.66	0.03
Context x Cost x Quadratic		3.26	0.05
ORDER x COST x EV	0.95	1.31	0.28
Order x Cost x Linear		2.67	0.11
Order x Cost x Quadratic		0.29	0.60
ORDER x CONTEXT x COST x EV	0.82	2.86	0.03
Order x Context x Cost x Linear		5.53	0.01
Order x Context x Cost x Quadratic		1.90	0.16

Table 3
Analysis of Predicted Interaction Contrasts

Interaction	C	t	p
CONTEXT x COST			
Context (1)	0.05	1.25	N.S.
Context (2)	0.01	0.32	N.S.
Context (3)	0.18	3.65	0.01
CONTEXT x EV(Linear)			
Context (1) - Context (2)	0.56	6.53	0.01
Context (2) - Context (3)	-0.07	-0.50	N.S.
Context (1) - Context (3)	0.49	6.03	0.01
CONTEXT x COST x EV(Linear)			
Context (2) - Context (1)	-0.35	-2.45	0.05*
Context (3) - Context (2)	0.33	2.22	0.05
Context (3) - Context (1)	-0.02	-0.22	N.S.
CONTEXT x COST x EV(Quadratic)			
Context (2) - Context (1)	0.30	2.53	0.05
Context (3) - Context (2)	-0.12	-0.98	N.S.
Context (3) - Context (1)	0.18	1.55	N.S.

Context (1): Basic Game Setting
Context (2): Process Choice Setting
Context (3): Informaton Evaluation Setting

* denotes two-tailed test. All other tests are one-tailed.

Table 4
Tabulation of Subject Choice Patterns by CONTEXT and COST

	Basic Game Setting	Process Choice Setting	Information Evaluation Setting	Totals
Zero Stated Cost				
Payoff Maximizing	10	5	4	19
Always Preferring Pvt. Info. Subgame	2	8	10	20
Other	8	7	6	21
Positive Stated Cost				
Payoff Maximizing	15	1	3	19
Always Preferring Pvt. Info. Subgame	1	12	7	20
Other	4	7	10	21

Figure 1
Experimental Design

Between-Subjects Variables: Order	Between-Subjects Variables: Context	Subjects	Within-Subjects Variables (Case Characteristics) — Stated information cost: Zero; Expected value of information: Negative	Zero; Zero	Zero; Positive	Stated information cost: Positive; Expected value of information: Negative	Positive; Zero	Positive; Positive
Zero cost first, then positive cost	Basic Game	1 . . 10						
	Uncertainty Reduction	11 . . 20						
	Information Evaluation	21 . . 30						
Positive cost first, then zero cost	Basic Game	31 : . 40						
	Uncertainty Reduction	41 . . 50						
	Information Evaluation	51 . . 60						

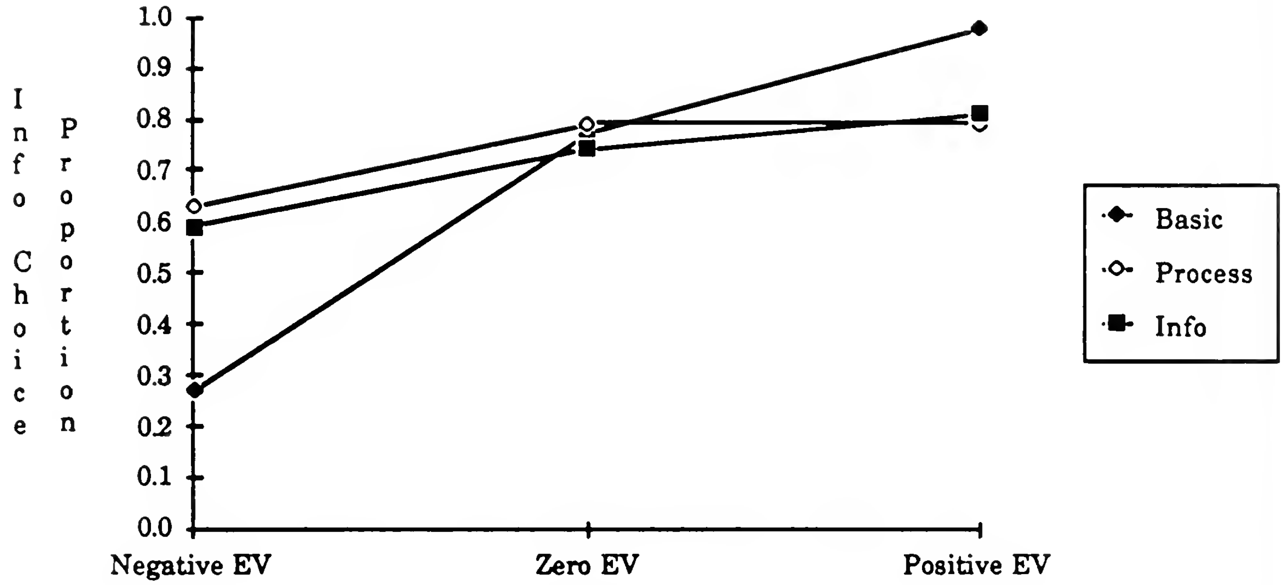


Figure 2
CONTEXT x EV Interaction

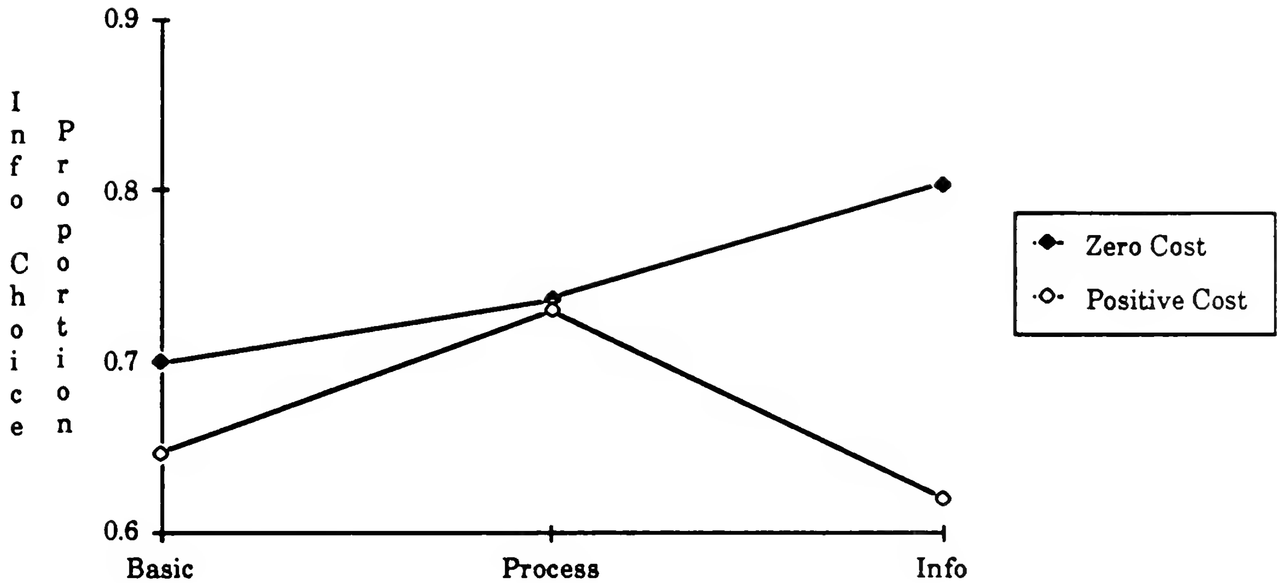


Figure 3
CONTEXT x COST Interaction

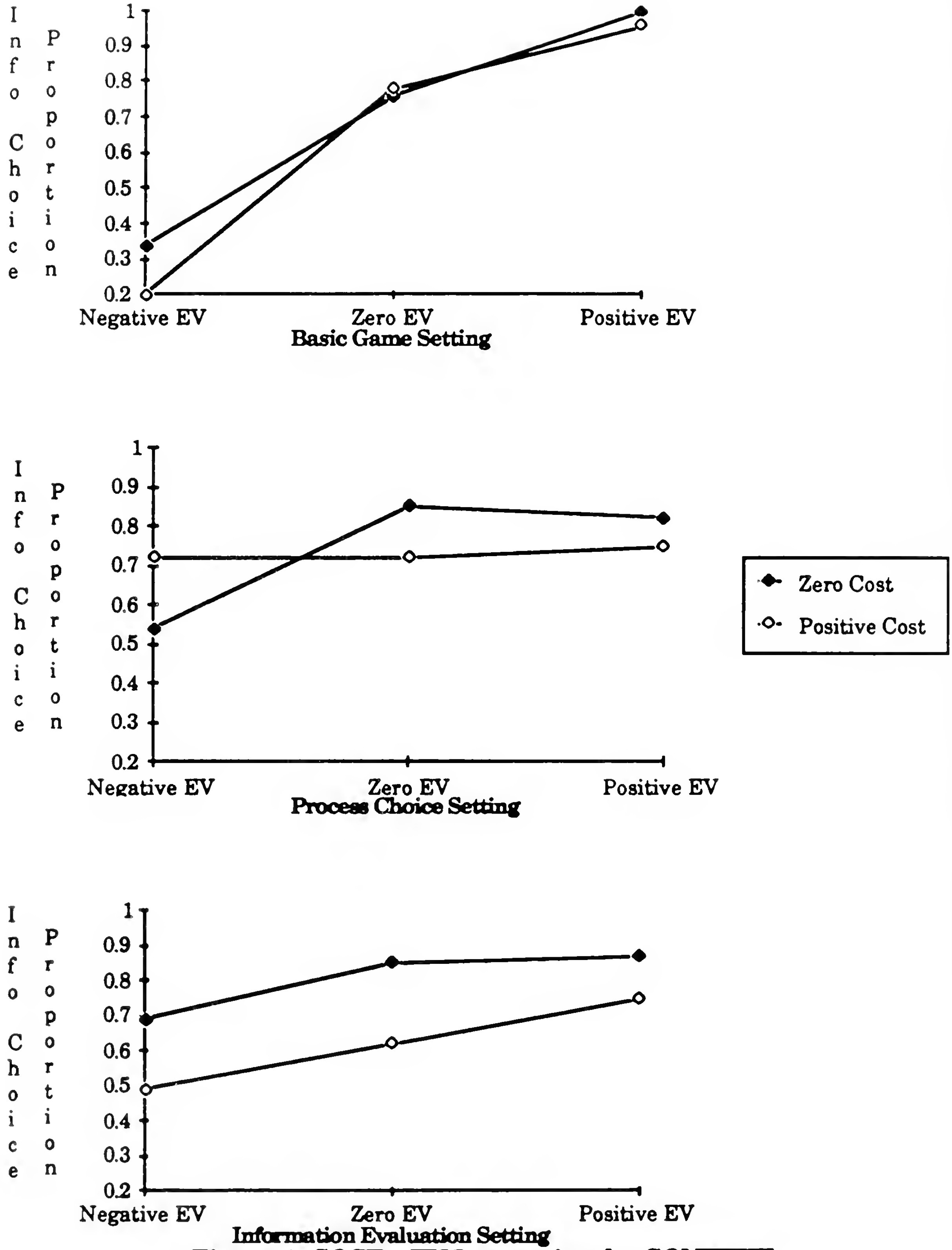


Figure 4--COST x EV Interaction: by CONTEXT

State 1 p(s1) = 0.6

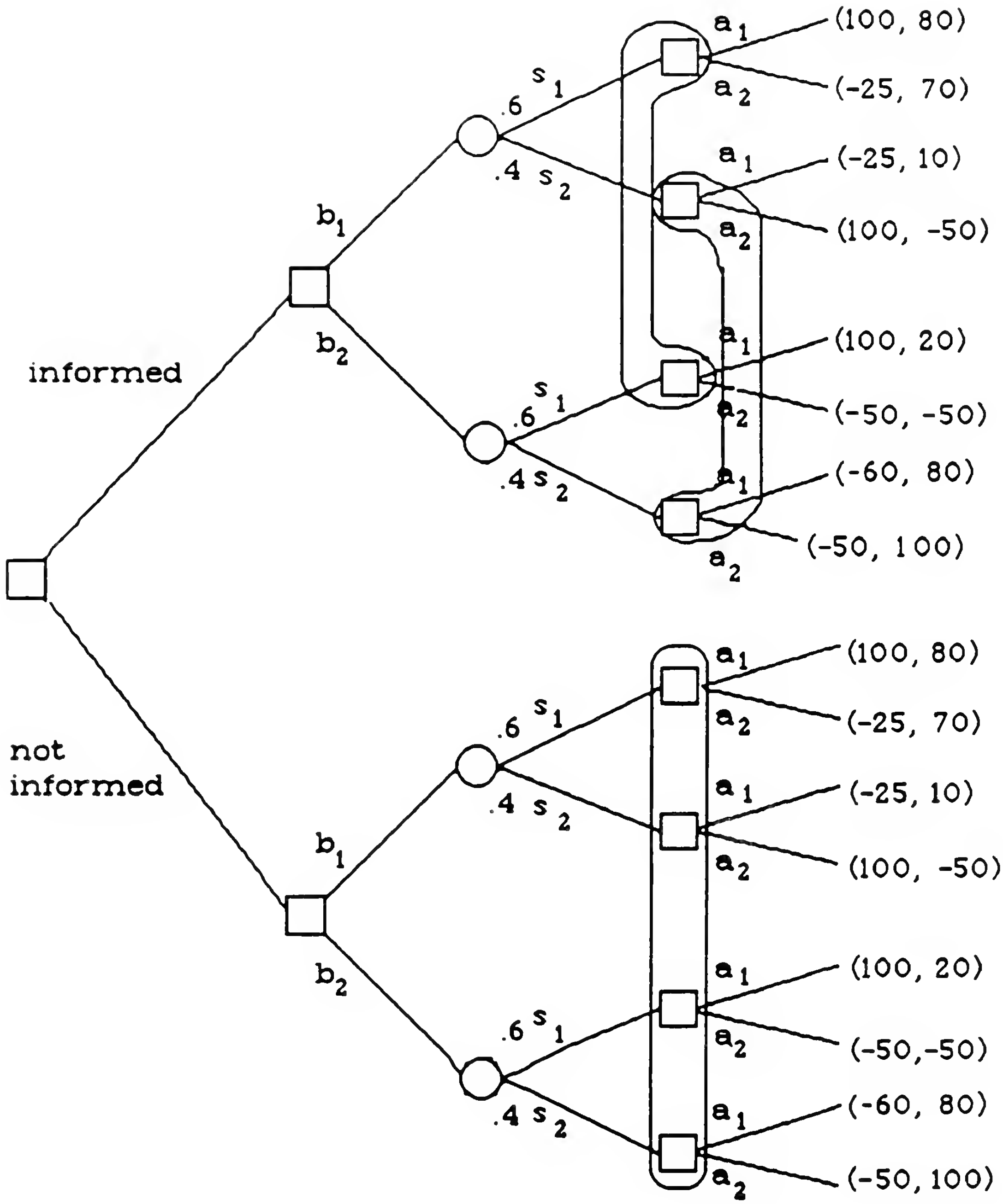
	b1	b2
a_1	(100, 80)	(100, 20)
a_2	(-25, 70)	(-50, -50)

State 2 p(s2) = 0.4

	b1	b2
a_1	(-25, 10)	(-60, 80)
a_2	(100, -50)	(-50, 100)

Figure A1

Game Parameters



Manager 1   Manager 2 Nature   Manager 1

Figure A2
Extensive Form of the Game

	b_1	b_2
a_1	(50, 52)	(36, 44)
a_2	(25, 22)	(-50, 10)

No Information Subgame

	b_1	b_2
a_{11}	(50, 52)	(36, 44)
a_{12}	(100, 28)	(40, 52)
a_{21}	(-25, 46)	(-54, 2)
a_{22}	(25, 22)	(-50, 10)

Private Information Subgame

Figure A3

Strategic Form of the Game