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THE INFLUENCE OF PARTIAL MODELS AND CRITERION MEASUREMENT SCALES ON CONSIDERATION OF INCOMMENSURATE CRITERION VARIABLES IN A COMPLEX DECISION

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of the Ohio State University

By

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College. Officers attending these military schools volunteered to serve as subjects in the experiment.

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<tr>
<td>Alternative</td>
<td>A course of action open to the decision maker.</td>
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<td>Decision</td>
<td>A choice among alternatives.</td>
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<tr>
<td>Criterion variable</td>
<td>A dependent variable in the decision; an operational measure of the desired objective or system state.</td>
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<td>Incommensurate criterion variables</td>
<td>Criterion variables which cannot be measured on a common scale.</td>
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<tr>
<td>Input variables</td>
<td>The set of independent variables associated with each alternative</td>
</tr>
<tr>
<td>Model</td>
<td>A set of functions transforming values of the input variables into values of the criterion variables.</td>
</tr>
<tr>
<td>Whole model</td>
<td>A model which includes the relevant criterion variables.</td>
</tr>
<tr>
<td>Partial model</td>
<td>A model which omits a relevant criterion variable.</td>
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I

INTRODUCTION

Problem Background

As the products of technology become more complex, so do the management decisions that are required for the design and operation of large scale socio-technological systems. These decisions typically involve such a large number of interacting variables that the decision maker cannot relate them all "in his head", and cannot be certain that all the important variables are included in his model. Furthermore, the decision maker must satisfy multiple objectives with incommensururate criterion variables.

This complexity has forced an increased reliance on explicit models as aids in decision making. The trend has been most evident in the Department of Defense, where systems analysis has been used in determining which new weapon systems will be developed and deployed. The models used in systems analysis are structured to provide an explicit tradeoff between cost and a measure of system effectiveness (Hitch & McKeen, 1960). However, there is considerable
controversy over the value of such models, and it is not clear whether decisions based on them have produced the intended results (United States Senate, 1967).

Although decisions concerning national defense usually involve multiple objectives with incommensurate criterion variables, the cost-effectiveness models cannot optimize more than one effectiveness criterion or one cost criterion, and can only account for those variables that can be "quantified" (Knorr, 1966, p. 2). Systems analysts claim that their models are useful despite these limitations. Held (1967) reports the views of economist William Gorham, who applied systems analysis to defense problems and as Assistant Secretary of Health, Education, and Welfare:

Gorham says of his experience in dealing with military problems that the dominant characteristics in a decision are often not those that can be measured, but if one does what is possible with numbers, it leads those involved in a decision to be clearer about the non- or less-quantifiable factors on which the decision may be based, and such an influence is often useful (p.23).

Dr. Alain Enthoven, who served as Assistant Secretary of Defense for Systems Analysis, holds a similar view (Enthoven, 1967-1968):

Systems analysis is not a substitute for judgment; it is an aid to judgment. . . . It is based on the fact that most decisions
in defense are at least partly susceptible to rational treatment, and tries to deal with these in a disciplined way. ...(p.12).

A good systems analyst does not leave considerations that cannot be quantified out of the analysis. Inevitably such considerations will be left out of the calculations, but a good analyst will and does list and describe such factors (p. 14).

Does cost effectiveness analysis or systems analysis lead to an overemphasis on factors that can be reduced to numbers? Not necessarily. A good analysis of the numerical factors leaves a decision maker more time and energy to weigh the intangibles (p. 55).

This rationale implies that a decision maker's awareness of the relative importance of the various criterion variables is not influenced by the fact that only two of these criterion variables are included in his cost-effectiveness model. This is a crucial assumption. It is particularly important in a bureaucracy such as the Department of Defense, where the decisions made by people at different organizational levels should be consistent with national goals and priorities established at the top (Knorr, 1966, p. 6).

The criterion variables used in systems analysis are operational measures of system behavior that are used to determine how proposed actions affect system objectives. The system objectives are presumably established consistent with some ultimate goals of the organization or society (Hitch & McKean, 1960,
If important criterion variables are neglected in decisions about system design and operation, there is obviously less chance that the resultant system will contribute to these goals.

Knorr, (1966, pp. 5-6) and Rickover (1967) present evidence that Defense Secretary McNamara may have been unduly influenced by cost calculations when he decided not to build a nuclear powered carrier, and that he did not appear to give comparable consideration to effectiveness criteria that could not be expressed in his model. Secretary McNamara is presumed to have been thoroughly familiar with the use and limitations of cost-effectiveness models, and was supported by Dr. Enthoven and his staff of skilled analysts. If even under these circumstances he was not able to keep the relevant criteria in perspective, the assumption that a decision maker is able to exercise independent judgment and evaluate alternatives on the basis of criterion variables omitted from his model is suspect.

Specific Aims

The controversy over the usefulness of cost-effectiveness models raises two important questions:

1. Will a decision maker evaluate the alternatives on the basis of a relevant criterion variable if it is
omitted from his explicit decision model?

2. Does whether a decision maker considers a criterion variable that is omitted from his explicit model depend on the scale on which it is measured, relative to the measurement scale of criterion variables included in his model?

In this study the criterion variables are classified according to Stevens' (1951) definitions of measurement scales. It was predicted that in general decision makers would act as if they ignored criterion variables omitted from their explicit model, and would be more likely to ignore an ordinal criterion variable when the model includes a ratio scale criterion variable than vice versa.
II
RELATED RESEARCH

Applicable Studies and Theories

No studies were found in the literature concerning how decision making is affected by the use of an explicit model, although Corman (1957) reported on the use of models as training aids. Applicable research on problem solving without the use of models is referenced and summarized in Table 1.

Three theories are relevant. Utility theory (Von Neumann & Morganstern, 1953) offers a method and rationale for equating all criterion variables to a common scale, so that there are no incommensurates. Satisficing (March & Simon, 1958) is proposed as a more descriptive theory of decision behavior in organizations. The Theory of Cognitive Dissonance (Festinger, 1957, 1964) provides a useful concept about the way people perceive a complex decision situation.

Utility Theory

The concept of utility was originally developed to provide a "scientific" basis for political and
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<th>Findings</th>
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<tr>
<td>Do people act as if they maximize utility?</td>
<td>Yes, in simple repetitive choices with two criterion variables</td>
<td>Siegal, Siegal, &amp; Andrews (1964)</td>
</tr>
<tr>
<td></td>
<td>Not always. People made a deliberate evaluation of four alternatives with one criterion, but not when there were 15 salient criteria.</td>
<td>Hendrick, Mills, &amp; Kiesler (1968)</td>
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<td></td>
<td>No. Architects use a trial and error satisficing strategy rather than comparing alternatives in a complex design problem with multiple criteria.</td>
<td>Eastman (1968)</td>
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<td>Is there a limit to the number of concurrent comparisons that a person can make?</td>
<td>Yes. A survey of research shows that single channel theory is the best approximation to elemental processes in the brain.</td>
<td>Welford (1967)</td>
</tr>
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<td></td>
<td>Yes. Some capacity adjustments among brain functions appear possible, but overall channel capacity for conscious decision processes is limited.</td>
<td>Moray (1967)</td>
</tr>
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<td>Question</td>
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<td>Can salient information inhibit further model development?</td>
<td>Yes. When solution of an insight problem requires new or combined functions, knowledge of inapplicable function-object relationships can block the necessary function development. Yes. Irrelevant data fitting familiar functions leads students to calculate irrelevant solutions to mathematical problems.</td>
<td>Maier &amp; Janzen (1968) Rosca (1964)</td>
</tr>
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<td>Are perceptions biased by a need to avoid ambiguity in decisions?</td>
<td>Yes. People act as if they need to convince themselves that decisions they have made are correct. Yes. People create objective rationalizations for their value judgments. Yes. People avoid making decisions that are likely to result in high dissonance.</td>
<td>Festinger (1964) Maier &amp; Janzen (1967) Festinger (1964), pp. 145-151</td>
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economic decisions (Bentham, 1968). Utility is a common scale to express all of an individual's preferences among possible events (Von Neumann & Morganstern, 1953). Economic theorists have therefore considered maximization of utility as the standard for rational decisions (Ellsberg, 1968, p. 274).

A utility function can be calculated from a consistent, transitive set of preferences among ratio scaled criteria, if linearity and independence can also be assumed (Churchman, Ackoff, & Arnoff, 1957). Siegal (1964) presents a general method for scaling peoples' preferences for up to seven distinct outcomes, assuming only transitivity and consistency.

The present study of a decision maker's consideration of incommensurate criterion variables is obviously irrelevant if valid utility measures can be obtained. However, decisions about complex system design and operation usually involve far more than seven possible outcomes, preferences among criteria are seldom linear and independent, and criterion variables are not always measurable on a ratio scale. Important decisions can involve qualitatively different outcomes for which people are unwilling or unable to express consistent, transitive preferences (e.g. human life, honor, and money). Such decisions involve an apparently
irreducible set of incommensurate criterion variables. Research referenced in Table 1 (Siegal et al., 1964; Eastman, 1968; Hendrick et al., 1968) indicates that people act as if they were maximizing utility when only one or two criterion variables are salient, but not in complex decisions where they need to consider several criterion variables.

Satisficing Theory

The concept of satisficing (March & Simon, 1958) is incompatible with utility maximization. Decision making in organizations is viewed as an adaptive process, in which people act to maintain an equilibrium rate of expected rewards to individuals and organization units. The search for new alternatives is costly and the rewards uncertain. Therefore managers do not seek optimum solutions but tend to accept the first alternative that maintains the desired equilibrium.

March and Simon’s theory may not be an accurate description of organizations engaged in systems planning, particularly when systems analysis is the established method of evaluating alternatives and defending decisions. However, the question of interest is not whether optimal alternatives are identified, but which criterion variables are considered in choosing among the available alternatives.
The concept of satisficing under uncertainty might describe a decision maker's search for functions omitted from his model. Experiments referenced in Table 1 indicate that knowledge of some functions can inhibit the search for others (Rosca, 1964; Maier & Janzen, 1968).

Cognitive Dissonance

Festinger's (1964) Theory of Cognitive Dissonance explains behavior in terms of people's need to maintain a constant perception of their environment. "Dissonance" is anxiety or regret when this equilibrium is disturbed. Numerous experiments (Festinger, 1964) show that people perceive information selectively to reinforce decisions that they have already made. Festinger (1964) emphasizes that such rationalization only occurs after the decision maker is committed to his choice, and reports experimental evidence that predecision information search is apparently unbiased.

The experiments described by Festinger (1964) involved simple decisions between closely matched alternatives in order to maximize the likelihood of postdecision dissonance. Dissonance was inferred from the observed bias in the subject's willingness to receive new information. However, the reported
lack of bias in predecision information search does not imply that people do not anticipate dissonance. If anything, anticipated dissonance might stimulate search for all relevant information in order to increase confidence that the decision made will be correct.

Braden and Walster (Festinger, 1964, pp. 145-151) showed that many people avoid making decisions when they anticipate high postdecision dissonance. This implies that anticipated dissonance can influence predecision behavior. Other forms of compensatory behavior might be expected when a decision cannot be evaded. No research on this possibility was found.
III
THEORY

Scope
The theory developed below applies to decisions in which there are a large number of potentially important interacting variables, and there are independent incommensurate criterion variables. These are critical characteristics of many decisions about complex systems. The theory does not cover the complete process in which problems are defined and alternatives developed, but is specific to the way in which the final choice among identified alternatives is made.

Anticipated Dissonance
The need to reduce anticipated postdecision dissonance will determine decision making behavior. This is contrary to Festinger's (1964) conclusion that dissonance only influences behavior after a decision has been made. It is consistent with research by Braden and Walster (Festinger, 1964) indicating that anticipated dissonance affects people's willingness to enter into a decision.
situation.

Explicit Models as Decision Aids

Studies referenced in Table 1 (Moray, 1967; Hendrick et al., 1968) imply that the human brain operates as a single channel processor in complex decision processes, and is not capable of making a large number of concurrent comparisons. An unaided decision maker could be overwhelmed by a complex system problem. An explicit model of the system enables the complex relationships between input variables and a criterion variable to be computed externally in serial order. This reduces the number of comparisons that a decision maker needs to "do in his head".

However, a model cannot reduce the number of incommensurate criteria. There is a minimum number of concurrent comparisons that the decision maker must make in order to evaluate all alternatives on the basis of all criterion variables (Hendrick et al., 1968). As shown in Appendix A, this number of comparisons is an increasing function of the product of the number of alternatives and the number of incommensurate criterion variables. It can quickly exceed a decision maker's limited mental capacity for such comparisons. When this happens the decision maker
has to use some "short-cut" method, such as ignoring some criterion variables, or satisficing in the evaluation of alternatives. He is likely to have less confidence in a decision arrived at by such "short-cuts", so he will anticipate greater dissonance when he is aware that a large number of comparisons are required.

The Effect of Omitting a Criterion Variable

A decision maker never knows whether he has identified enough variables and relationships in a complex system decision. At the same time, it is assumed that he wants to feel confident in his choice and minimize postdecision dissonance. Additional functions relating to a criterion variable already in the model do not increase the number of comparisons in the evaluation (Appendix A). A decision maker can reduce anticipated postdecision dissonance by adding such functions until he perceives a clear cut difference among the alternatives, and the salient input variables are all included.

However, adding another criterion variable increases the necessary number of comparisons he needs to make and is likely to increase anticipated dissonance. Decision makers faced with a complex problem will therefore tend to ignore a criterion variable
omitted from their model.

The Effect of Measurement Scale

A ratio scale criterion variable provides an explicit measure of the amount of difference between alternatives; an ordinal scale only ranks them (Stevens, 1951). The relative size of differences between ranked alternatives is a purely subjective "intangible" judgment. Decisions based on ratio scale criterion variables are therefore easier to justify explicitly, and induce less anticipated dissonance.

A partial model is defined as a model which omits a relevant criterion variable. Decision makers will tend to accept a partial model as sufficient if it shows a clear cut difference between alternatives in terms of the relevant ratio scale criterion variables. If an ordinal scale criterion variable is omitted from such a model, they will tend to ignore it in making their decision.

On the other hand, a decision based on a model providing only ordinal scale criterion variables will result in higher anticipated dissonance, especially if a relevant ratio scale criterion is known to exist. The decision maker will want to include functions for the missing ratio scale criterion variable in his model in order to reduce this dissonance.
Decisions With Partial Models

In choosing among alternatives in a complex problem, a decision maker will act as if he ignores incommensurate criterion variables that are not included in his explicit model. This makes the evaluation more manageable and reduces his anticipated postdecision dissonance. However, he is likely to anticipate more dissonance when he bases his decision on ordinal rather than ratio scaled criteria. He will therefore have less tendency to ignore a missing ratio scale criterion variable when the model includes only an ordinal criterion variable than vice versa.
General Approach

The questions (pp. 4-5) of whether a decision maker tends to ignore a relevant criterion variable if it is not included in his explicit model, and whether his consideration of an omitted criterion variable depends on its measurement scale relative to measurement scale of the model criterion, were investigated in a laboratory experiment. Subjects were asked to decide between two complex alternatives after receiving a description of the problem that emphasized the importance of each of two incommensurate criterion variables. One of these criterion variables was measured on a ratio scale while the other was ordinal.

Each subject in an experimental conditions was given a partial model that included only one of the incommensurate criterion variables, while the model given to subjects in control conditions contained the necessary functions to evaluate both criteria. All subjects could ask for and obtain any
functions missing from their model. The task was structured so that the alternative chosen by the subject would imply whether one of the criterion variables was ignored.

Critical characteristics of this experimental task were isomorphic with decisions about complex systems: there were a large number of variables given, a larger number of potentially important variables, and the criterion variables were incommensurate. The problem was analogous to decisions made with systems analysis in that each subject had an explicit system model, and could obtain whatever additional information he needed by submitting requests to the experimenter. This feature was essential since a system manager may decide to get more data and add functions to his model before making a choice.

Two dependent variables were used to infer which criterion variables were considered by the decision maker. The alternative chosen was taken as the behavioral measure, and the introspective measure was whether the subject's written rational mentioned a criterion variable omitted from his model. To test the theory that a decision maker would ignore a criterion variable that was omitted from his model, the responses of subjects having a whole model (i.e. a model with both criterion variables) were compared
Fig. 1. Comparison of Subjects' Responses
with responses of subjects having a partial model with one criterion variable omitted. To determine whether the measurement scales of the omitted and included criterion variables made any difference, responses of subjects having a partial model with an ordinal criterion were then compared with the responses of subjects having a partial model with a ratio criterion. This sequence of analysis is shown schematically in Figure 1.

Subject Selection

The population of decision makers whose behavior is of interest consists of people who make decisions concerning the design, development, and acquisition of complex systems. Cost-effectiveness models are used extensively in making such decisions within the Department of Defense. The behavior of military officers who are likely to be making decisions with this technique, using models generated by others, is of more relevance than the behavior of college students or other civilian populations that might have been sampled.

It was not feasible to use the people presently occupying decision making positions in the Department of Defense as experimental subjects. However, permission was obtained to use volunteers from
selected programs at five military postgraduate schools. Assignment to these programs leads directly to subsequent assignment in systems management positions. Furthermore, most of the higher ranking officers in this population have had considerable prior experience in military systems management.

The operational specification for subject selection was military officer on active duty with rank of O-3 (Air Force Captain) or above, and assigned to the Defense Weapon System Management Center, Air War College, or an Air Force Institute of Technology program in systems management, program management, or systems and logistics. Since these subjects have a maximum likelihood of being assigned to positions where they will be using models in making decisions about complex systems, their behavior in the experiment is assumed to be representative of the behavior of the future population of the military systems decision makers.

The Decision Task

A business decision was used as subject matter for the experimental task so that the content would be generally familiar to the military officers serving as subjects, but minimized the likelihood that any of them would have detailed knowledge or experience in the
specific details.

The subjects were asked to take the role of an executive who must choose between two alternatives for corporate expansion. He could market a new dog food developed by his research laboratory, or he could acquire an established spot remover business through merger. There were two incommensurate criterion variables: rate of dollar payback, measured on a ratio scale; and effect on the corporate image, measured on an ordinal scale.

Each subject received a problem statement explaining the importance of these two criterion variables, and a narrative description of the dog food and spot remover alternatives that included the values for all relevant input variables. Each subject also received a model relating the input variables to one or both of the criterion variables. Since the criteria are incommensurate, the final choice involved a subjective judgment by the decision maker. This decision task is shown schematically in Figure 2. The complete problem is included in Appendices C and D.

**Independent Variables**

The independent variables to test the proposed theory are whether the model omitted a
Input data to the model:
Values of the variables for each alternative

Dog food

\( x_1 \)
\( x_2 \)
\( \ldots \)
\( x_n \)

Spot remover

\( w_1 \)
\( w_2 \)
\( \ldots \)
\( w_m \)

The model:
Functions relating input variables to values of a criterion variable

\[ Y_1 = f_1(x_1 \ldots x_j) \]
\[ Y_2 = f_2(w_1 \ldots w_j) \]

Functions relating input variables to corporate image criterion variable \( Y \)

Functions relating input variables to rate of payback criterion variable \( Z \)

\[ Z_1 = f_3(x_h \ldots x_k) \]
\[ Z_2 = f_4(w_h \ldots w_k) \]

Output of the model:
Values of the criterion variables and differences between the alternatives in terms of the criterion variables \( Y, Z \)

Decision:
Choice of an alternative involves a subjective value judgment between incommensurate criteria (\( Y \) and \( Z \))

\[ \Delta Y \]

\[ \Delta Z \]

Fig. 2. Schematic of the Decision Task
relevant criterion variable, and the measurement scale of criterion variables omitted and included in the model.

The experiment involves additional independent variables that are not used to test the theoretical predictions: officer rank and input data set. Officer rank is a correlate of many individual characteristics of the subjects (e.g. age, experience, education), and might therefore be useful in explaining any large variability due to individual differences. Different sets of input data must be used in order to make the required inferences about which criteria were considered, as discussed below (p. 29).

Dependent Variables

There is no direct way to measure the extent to which a person considers a criterion variable in reaching his decision. Any conclusions about the decision process that are drawn from the experiment are necessarily indirect; they must be inferred from an observable response.

The primary dependent variable in this experiment is the subject's choice of an alternative. This is the most relevant behavioral measure of any decision process. However, the alternative chosen can only be used to infer a subject's consideration of incommensurate
criteria if the task is structured in such a way that the alternative chosen and the criteria used are directly and unequivocally related. The methods by which this relationship is established and verified are discussed in detail below (pp. 29-33).

Advantages of using the observed decision as dependent variable are that it is unambiguous and can be obtained without interfering with the decision process under study. The disadvantage is that it is not necessarily a reliable basis for inferences about the criterion variables considered, since decisions are influenced by many other factors that are difficult to control or eliminate as sources of variation.

An alternative way to infer the extent to which a subject considered a criterion variable is to ask him. While this introspection may seem the most simple and direct method, it has severe limitations. If the subject knows he will be asked for this information, that knowledge might alter his decision process and bias the outcome. If he is asked afterward, he may not remember all that he considered during the hour or hour and a half that he was working on the task. In this experiment, subjects were asked to prepare a narrative explanation of their decision rationale. They were not asked explicitly to indicate
### TABLE 2
Experimental Variables and Constants

<table>
<thead>
<tr>
<th>Conditions held constant by the experimenter</th>
<th>Independent variables</th>
<th>Dependent variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>No interpersonal contact</td>
<td>Whether the model given to a subject omits a relevant criterion variable</td>
<td>The alternative chosen by the subject (behavioral measure)</td>
</tr>
<tr>
<td>90 minute time limit</td>
<td>The measurement scale of the criterion variables included in and omitted from the model</td>
<td>Criterion variables mentioned in the subject's written rationale (introspective measure)</td>
</tr>
<tr>
<td>Two mutually exclusive alternatives</td>
<td>The subject's military rank</td>
<td></td>
</tr>
<tr>
<td>Two incommensurate criterion variables</td>
<td>The set of values for the input variables that is given to the subject</td>
<td></td>
</tr>
<tr>
<td>The same external information base available to all subjects</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
their decision criteria. This was done to minimize the risk of influencing the decision process.

In order to minimize possible subjective bias by the experimenter in interpreting this introspective data, the dependent variable used was whether the subject mentioned any effect on a criterion variable at all, without regard to his indication of its importance. This variable provides an independent check on inferences based on subject's choice of an alternative, and permits an analysis where the intended relationship between subject's decision and criteria considered is not obtained.

The complete set of variables is listed in Table 2.

Input Data to the Decision Model

As discussed above (p. 25), the task must be designed so that the alternative chosen by the subject can be used to infer which criterion variables he used in reaching his decision. This is accomplished by arbitrarily setting the values of input variables such that subjects with a whole model (both criterion variables) are likely to choose a different alternative than subjects who only consider the one criterion variable contained in a partial model.

In condition "A", the partial model contains
only the ratio scale rate of payback criterion variable and omits corporate image. The values of the input variables are set to produce a small difference in rate of payback in favor of the spot remover, but a large difference in corporate image effects favoring the dog food. If a subject with a partial model does not obtain the additional functions necessary to evaluate effects on corporate image, he is likely to choose spot remover on the basis of the larger payback. In contrast, control group subjects with both criterion variables in their model are likely to choose dog food because of the large difference in corporate image. A highly simplified example is illustrated in Figure 3. A comparison of the choices made by the experimental and control groups shows whether the omission of a criterion variable from the model affects subjects' consideration of that criterion in their decision. The complete problem used for condition "A" is contained in Appendix C.

The set of input data used in condition "A" cannot be used to test the effect of a partial model containing only the ordinal scale corporate image criterion. In that case both the experimental and control group subjects would be likely to decide on the dog food because of the large image difference (Figure 3). Since the payback would not affect the
Data set "A":

Dog food:
- $x_1 = 20.15$ million
- $x_2 = 17.90$ million
- $x_3 = 2.88$ million
- $x_4 = \text{depressed urban core area}$
- $x_5 = \text{meat, etc.}$

Spot remover:
- $w_1 = 24.00$ million
- $w_2 = 21.60$ million
- $w_3 = 2.75$ million
- $w_4 = \text{small town, no new employment}$
- $w_5 = \text{CCl}_4$

Model:

$Y = \text{Corporate image}$

$Y_{DF}: x_4 \rightarrow \text{increase} \rightarrow Y \rightarrow Y_0$

$Y_{SR}: w_5 \rightarrow \text{government} \rightarrow Y \rightarrow Y_0$

Output:

$Z = \text{Annual rate of payback}$

$Z_{DF} = \frac{x_1 - x_2}{x_3} = 78\%$

$Z_{SR} = \frac{w_1 - w_2}{w_3} = 87\%$

Decision:

$Y$ favors dog food; $Y_{DF} \rightarrow Y_0 \rightarrow Y_{SR}$

$Z$ favors spot remover; $(\Delta Z = 9\%)$

Where:

$x_1 = \text{annual sales of dog food}$

$x_2 = \text{annual cost}$

$x_3 = \text{initial outlay}$

$x_4 = \text{location of proposed plant}$

$x_5 = \text{ingredients of product}$

$w_1 = \text{annual sales of spot remover}$

$w_2 = \text{annual cost}$

$w_3 = \text{initial outlay}$

$w_4 = \text{new employment plans}$

$w_5 = \text{active chemical ingredient}$

Fig. 3. Input Data for Condition "A": A Simplified Example
decision, the alternative chosen by the experimental group could not be used to infer whether they had considered the criterion variable omitted from their partial model. Obviously, a different set of input data is required.

In condition "B", the partial model includes only the corporate image criterion variable, and omits the rate of payback criterion variable. The "B" set of values of the input variables (x,w) results in a small image difference (Y) in favor of the spot remover, but a large difference in rate of payback (Z) in favor of the dog food when the whole model is used.

The perceived differences that these data sets are intended to induce are shown in Figure 4. These "large" and "small" differences between incommensurate criteria in Figure 4 are subjective value judgments. They were categorized from the responses of a sample of military and civilian volunteers during preliminary tests at Wright-Patterson Air Force Base. The logic used to make inferences about which criterion variables were considered depends entirely on the experimental subjects judging differences between criterion variable values in this way. This is a necessary condition for the experiment, not a test of the theory.

If everyone with a whole model picks dog food,
Condition "A": Partial model omits the corporate image criterion variable:

Input data set "A"

Model for corporate image criterion variable

Model for rate of payback criterion variable

Y_{DF} \Rightarrow Y_0 \Rightarrow Y_{SR}

Dog Food

Spot remover if corporate image is ignored

Condition "B": Partial model omits the rate of payback criterion variable:

Input data set "B"

Model for corporate image criterion variable

Model for rate of payback criterion variable

Y_{DF} \Rightarrow Y_0 \Rightarrow Y_{SR}

Z_{DF} \Leftarrow Z_{SR}

Spot remover if payback is ignored

Dog Food

Fig. 4. The Relationship Between Alternative Chosen and Criterion Variable Considered in the Decision
then any spot remover responses from subjects with a partial model can be attributed to the effect of the independent variable. The power to detect differences due to the experimental variables with any given sample size varies with the proportion of subjects with a whole model who choose dog food.

**Design of the Experiment**

The basic design of the experiment to measure how omitting a criterion variable from the model affects a subjects' choice of an alternative is shown in Fig. 5. This experiment was performed with two different combinations of criterion variable measurement scale: with a partial model including only the ratio scale payback criterion, using data set "A"; and with a partial model including only the ordinal scale corporate image criterion, using data set "B".

The complete experimental design (Figure 6) is simply the combination of the basic "A" and "B" experiments, with an additional segregation of subjects by rank. Since a different data set of values for the input data must be used with each partial model (p. 31), the independent variables "criterion variable measurement scale" and "input data set" are unavoidably confounded in the partial model conditions.

The design to evaluate how the independent
Using input data set "A":

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>I₁ = partial model with ratio scale criterion variable</th>
<th>I₂ = whole model with both criterion variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>K₁ = dog food</td>
<td>n₁₁</td>
<td>n₂₁</td>
</tr>
<tr>
<td>K₂ = spot remover</td>
<td>n₁₂</td>
<td>n₂₂</td>
</tr>
</tbody>
</table>

\[ \Sigma n_{1k} \quad \Sigma n_{2k} \quad N = \Sigma \Sigma n_{1k} \]

Using input data set "B":

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>I₁ = partial model with ordinal scale criterion variable</th>
<th>I₂ = whole model with both criterion variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>K₁ = dog food</td>
<td>n₁₁</td>
<td>n₂₁</td>
</tr>
<tr>
<td>K₂ = spot remover</td>
<td>n₁₂</td>
<td>n₂₂</td>
</tr>
</tbody>
</table>

\[ \Sigma n_{1k} \quad \Sigma n_{2k} \quad N = \Sigma \Sigma n_{1k} \]

Where: \( n \) = the number of subjects with model I₁ who choose alternative \( K_k \)

\( N \) = the total number of subjects (one response per subject)

Fig. 5. The Basic Experiment
### Independent variables:

- **$H_1 = \text{Data set } "A"$**
  - $I_1 = \text{Partial model with ratio scale criterion variable}$
  - $J_1 = \text{Captain}$
  - $J_2 = \text{Field grade}$
- **$H_2 = \text{Data set } "B"$**
  - $I_1 = \text{Partial model with both criterion variables}$
  - $J_1 = \text{Captain}$
  - $J_2 = \text{Field grade}$

#### Subject's response

- **$K_1 = \text{Dog food}$**
  - $n_{1111}$
  - $n_{1121}$
  - $n_{1211}$
  - $n_{1221}$
  - $n_{2111}$
  - $n_{2121}$
  - $n_{2211}$
  - $n_{2221}$

- **$K_2 = \text{Spot remover}$**
  - $n_{1112}$
  - $n_{1122}$
  - $n_{1212}$
  - $n_{1222}$
  - $n_{2112}$
  - $n_{2122}$
  - $n_{2212}$
  - $n_{2222}$

Where: $n = \text{frequency of subjects responding } K_k$

$N = \text{total number of subjects (each subject provides one response)}$

**Fig. 6. The Complete Experimental Design**
variables affect the introspective dependent measure.

"mention of criterion variable omitted from the partial model" is similar to Figure 6, except for the change in dependent variable.

Test Procedure

The participants in the experiment were all volunteers, and the experiment could only be conducted during their off-duty time. The selection procedure was unavoidably nonrandom. However, assignment of volunteers to experimental conditions was random, and from 60% to 100% of the eligible officers volunteered in all but one of the classes approached. In that instance a very limited schedule probably prevented broader participation.

In order to process a sufficient number of subjects during their limited off-duty hours, and to reduce the risk that subjects would obtain prior information about the experiment if it were conducted over long periods of time, subjects were processed four at a time. Screened cubicles were used to assure that they worked independently and without interference. A description of the set up and the instructions given to the subjects are included in Appendix B.

Subjects in control conditions had a complete model relating the input variables to both of the
criterion variables. Subjects in experimental conditions had only those portions of the model relating to one of the criterion variables. All subjects could obtain the complete model simply by asking for it.

Standard answers for most questions had been developed in preliminary tests of the procedure on twenty military and civilian volunteers at Wright-Patterson Air Force Base. The answer given to each new question that arose was similarly recorded so that it could be used if the same question was ever asked again. In this way all subjects had access to an identical pool of external information.

Subjects who finished early were given a set of insight problems (Daniels, 1964, pp. 103-106) to keep them seated and working until everyone had completed the experiment. There was no evidence of any facilitation effects on either the number of questions asked or the time to complete the experiment. These two factors had been considered the most sensitive to possible facilitation influences. As an added precaution, both experimental and control conditions were administered within each group processed.

When everyone had submitted a decision, the experimenter assembled the group and gave a complete explanation of the purpose and results. The
participants were encouraged to express their reactions and opinions. At the conclusion of the session the experimenter asked that they not discuss the experiment with anyone else. There is no indication that anyone violated this request.

Analysis

The dependent variables in this experiment are nominal measures. Chi square is the appropriate statistic for making inferences about differences between discrete populations based on samples of nominal data (Hays, 1963, p. 579). The necessary assumptions are that observation categories are independent, that each observation represents one and only one joint event possibility (fits into only one cell), and that there is a sufficiently large expected frequency in each cell. There is "no hard and fast rule" to establish what is sufficiently large for every case (Hays, 1963, pp. 596-597). In this study it is verified by plotting the computed chi square for each cell against the true chi square distribution (Appendix E).

The requirement for a sufficiently large expected frequency arises because the chi square is derived from the continuous normal distribution, but is used to draw inferences about discontinuous
frequency data. This difference is negligible unless there is a small expected cell frequency in conjunction with few degrees of freedom (Hays, 1963, p. 584). In this case the variance of the computed Pearson statistic will be greater than the variance of a chi square statistic with the same parameters. The significance will therefore be exaggerated (Mather, 1947, pp. 174-175).

The expected cell frequencies are estimated from the marginal frequencies of the dependent variable, so they could not be determined until the data were collected. Since cell frequencies are combined for the analysis of main effects and interactions in the factorial design, the requirement for adequate expected frequencies is not particularly restrictive, except where individual cell comparisons are required.

The appropriate chi square partitioning (Mather, 1947; Suitcliffe, 1957) for analyzing this experiment (Figure 6) is shown in Table 3. Frequencies of the independent variables are fixed in the design and have no degrees of freedom. The null hypotheses are that there are no interactions between the dependent variable and any independent variable or combination of independent variables.

If any of the three factor interactions are
TABLE 3
Partitioned Chi Square

Three independent variables, each with two classes, and one dependent variable whose expected cell frequencies are estimated from the marginal totals.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Chi Square</th>
<th>Degrees of Freedom</th>
</tr>
</thead>
<tbody>
<tr>
<td>HK</td>
<td>$\chi^2_{HK} = \sum \sum \left[ \left( \sum_{i,j} n_{hijk} - \frac{\sum_{i,j} n'<em>{hijk}}{N} \right)^2 / \sum</em>{i,j} n'_{hijk} \right]$</td>
<td>1</td>
</tr>
<tr>
<td>IK</td>
<td>$\chi^2_{IK} = \sum \sum \left[ \left( \sum_{h,j} n_{hijk} - \frac{\sum_{h,j} n'<em>{hijk}}{N} \right)^2 / \sum</em>{h,j} n'_{hijk} \right]$</td>
<td>1</td>
</tr>
<tr>
<td>JK</td>
<td>$\chi^2_{JK} = \sum \sum \left[ \left( \sum_{i,h} n_{hijk} - \frac{\sum_{i,h} n'<em>{hijk}}{N} \right)^2 / \sum</em>{i,h} n'_{hijk} \right]$</td>
<td>1</td>
</tr>
<tr>
<td>HIK</td>
<td>$\chi^2_{HJK} = \sum \sum \sum \left[ \left( \sum_{i,j} n_{hijk} - \frac{\sum_{i,j} n'<em>{hijk}}{N} \right)^2 / \sum</em>{i,j} n'<em>{hijk} \right] - [\chi^2</em>{HK} + \chi^2_{IK}]$</td>
<td>1</td>
</tr>
<tr>
<td>IJK</td>
<td>$\chi^2_{IJK} = \sum \sum \sum \left[ \left( \sum_{i,j} n_{hijk} - \frac{\sum_{i,j} n'<em>{hijk}}{N} \right)^2 / \sum</em>{i,j} n'<em>{hijk} \right] - [\chi^2</em>{IK} + \chi^2_{JK}]$</td>
<td>1</td>
</tr>
<tr>
<td>HJK</td>
<td>$\chi^2_{HJK} = \sum \sum \sum \left[ \left( \sum_{i,j} n_{hijk} - \frac{\sum_{i,j} n'<em>{hijk}}{N} \right)^2 / \sum</em>{i,j} n'<em>{hijk} \right] - [\chi^2</em>{HK} + \chi^2_{JK}]$</td>
<td>1</td>
</tr>
<tr>
<td>HIJK</td>
<td>$\chi^2_{HIJK} = \chi^2_{TOTAL} - [\chi^2_{HK} + \chi^2_{IK} + \chi^2_{JK} + \chi^2_{HJK} + \chi^2_{IJK} + \chi^2_{HIK}]$</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>$\chi^2_{TOTAL} = \sum \sum \sum \sum \left( \sum_{h,l,j,k} n_{hijk} - \frac{\sum_{h,l,j,k} n'<em>{hijk}}{N} \right)^2 / \sum</em>{h,l,j,k} n'_{hijk}$</td>
<td>7</td>
</tr>
</tbody>
</table>

Note: $n$ = observed frequency, $n'$ = expected frequency, $K_k$ = dependent variable.
significant, separate analyses of their effects are warranted. If any two factor interaction is significant in these analyses, then each pair of cells should be analyzed separately using a simple chi square test (Winer, 1962, pp. 631-632).

The experimental group in condition "A" had a partial model with a ratio scale criterion variable, while the experimental group in condition "B" had a partial model with an ordinal scale criterion variable. If, as predicted (p. 17), decision makers are more likely to ignore a missing ordinal scale criterion when their model includes only a ratio scale criterion than vice versa, then the difference between the responses \( K_k \) of subjects in the experimental group and control group should be greater in condition "A" than in condition "B". This is indicated in the analysis by a significant HIK interaction.

However, criterion variable measurement scale is confounded with data set (H) in the experimental design, so an HIK interaction could also indicate differences due to data set. The predicted effect of measurement scale cannot be isolated unless the difference in subjects' responses due to the different sets of input data is negligible. This is a necessary condition to enable a valid test of the prediction about the effect of measurement scale, and not a test
of that prediction.

The necessary condition that there be no difference due to data set is tested by comparing the responses of the two control groups ($H_1I_2$ and $H_2I_2$ in Figure 6). If there is no difference in the response of subjects in these control groups, the differences in input data do not influence the results. The predicted difference due to criterion variable measurement scale can then be tested directly by comparing the responses of the two experimental groups ($H_1I_1$ and $H_2I_1$ in Figure 6).

Hypotheses and Predictions

The theory (pp. 15-17) predicts that subjects will tend to ignore a criterion variable missing from their model. They are more likely to ignore a missing ordinal scale criterion variable when they have a model giving them a ratio scale criterion, but less likely to ignore a missing ratio scale criterion variable when their model only includes an ordinal criterion.

The same hypotheses are used to test this theory whether the inference is made from the behavioral dependent variable "choice of an alternative" or the introspective dependent variable "mention of the criterion variable omitted from the model". These
hypotheses are stated below in terms of the experimental
design shown in Figure 6 and analysis shown in Table 3.

Given a complex decision problem with a known
set of incommensurate criterion variables, one measured
on a ratio scale and one on an ordinal scale; a known
set of input variables; and the opportunity to request
and receive all functions relating to any criterion
variable omitted from the model:

It makes no difference in the dependent
variable whether one of the criterion variables is
omitted from the model:

\[ H_0 : \chi^2_{IK} < \chi^2_{.05} \]

It makes no difference in the dependent
variable whether the criterion variable included in
the model is measured on a ratio scale and the criterion
variable omitted is measured on an ordinal scale,
or vice versa:

\[ H_0 : \chi^2_{HIK} < \chi^2_{.05} \]

and

\[ H_0 : \chi^2_{HI_1K} < \chi^2_{.05} \]
provided that

\[(4) \quad H_0: \quad \chi^2_{HI_{2K}} > \chi^2_{.50}\]

The predicted outcome for each interaction term in the analysis is shown in Table 4. In the case of the dependent variable "subject's choice of an alternative," these predictions are based on the assumption that most of the subjects with a whole model choose dog food. This is a necessary condition to enable inferences about the subjects' consideration of criterion variables from their observed decision (pp. 28-33). It is a test of the experiment and not of the theory.

If the theory is correct, subjects with a partial model (I₁) will ignore the missing criterion variable and select spot remover (K₂). Since subjects with a complete model will make the opposite choice, the null hypothesis of no IK interaction will be rejected.

If differences in the measurement scale of the criterion variable in the partial models have the predicted effect, there will be a significant HIK interaction. A separate comparison of control and experimental groups will then be necessary. The
### TABLE 4
Predicted Outcomes

<table>
<thead>
<tr>
<th>Null hypothesis</th>
<th>Prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tests of the theoretical predictions</strong></td>
<td></td>
</tr>
<tr>
<td>$\chi^2_{\text{TOTAL}} &lt; \chi^2_{0.05,7}$ = 14.07</td>
<td>Reject. The data matrix will differ from chance</td>
</tr>
<tr>
<td>$\chi^2_{\text{IK}} &lt; \chi^2_{0.05,1}$ = 3.84</td>
<td>Reject. There will be a difference between the responses of subjects with a whole model and subjects with a partial model</td>
</tr>
<tr>
<td>$\chi^2_{\text{HIK}} &lt; \chi^2_{0.05,1}$ = 3.84</td>
<td>Reject. A significant interaction will require partial analysis for measurement scale effects</td>
</tr>
<tr>
<td><strong>Partial analysis</strong></td>
<td></td>
</tr>
<tr>
<td>$\chi^2_{\text{HIJK}} &gt; \chi^2_{0.50,1}$ = 0.45</td>
<td>Reject. Unless there is no difference due to data set, no test of the effect of measurement scale is possible</td>
</tr>
<tr>
<td>$\chi^2_{\text{HIJK}} &lt; \chi^2_{0.05,1}$ = 3.84</td>
<td>Reject. There will be a difference between partial model conditions due to different criterion variable measurement scales</td>
</tr>
<tr>
<td><strong>Other terms in the statistical analysis</strong></td>
<td></td>
</tr>
<tr>
<td>$\chi^2_{\text{HK}} &lt; \chi^2_{0.05,1}$</td>
<td>Accept. Confounded data set and criterion variable measurement scale will make no difference</td>
</tr>
<tr>
<td>$\chi^2_{\text{JK}} &lt; \chi^2_{0.05,1}$</td>
<td>Accept. Rank will make no difference</td>
</tr>
<tr>
<td>$\chi^2_{\text{HJK}} &lt; \chi^2_{0.05,1}$</td>
<td>Accept. There will be no interaction with rank</td>
</tr>
<tr>
<td>$\chi^2_{\text{IJK}} &lt; \chi^2_{0.05,1}$</td>
<td>Accept. There will be no interaction between model and rank</td>
</tr>
<tr>
<td>$\chi^2_{\text{HIJK}} &lt; \chi^2_{0.05,1}$</td>
<td>Accept. No higher order interaction</td>
</tr>
</tbody>
</table>
theory predicts that dog food will be chosen less often when the subjects' model contains only the ratio scale criterion \((H_1^2 I_1^1)\) than when it contains only the ordinal criterion \((H_2^2 I_1^1)\). Therefore the null hypotheses of no HI^2K and no HI^1K interactions will be rejected.

However, this test will only be valid if there is no difference due to data set, and the null hypothesis that there is more than a chance probability of an HI^2K interaction is rejected.

Except for the total interaction, none of the other interaction terms in the statistical model should be significant. A significant JK, IJK or HJK interaction could indicate that the correlates of rank have an effect not presently accounted for in the theory. It could also indicate that rank correlates affect a subject's response to the experimental conditions, or his value judgment of differences between incommensurates. In the latter case, the experiment might not be valid. A significant HK interaction would have no simple interpretation since data set and criterion variable measurement scale are confounded.
RESULTS

Summary of Results

The results of the experiment are summarized in Table 5. The null hypothesis that omitting a criterion variable makes no difference was clearly rejected with both the behavioral and the introspective dependent variables. There was an unexpectedly large variability in the decisions made by subjects in the control groups which precluded a valid test of measurement scale effects with the behavioral dependent variable. However, the null hypothesis that measurement scale makes no difference was rejected in the analysis using the introspective dependent variable.

These results support predictions based on the proposed theory. Use of a partial model appears to bias a decision maker's consideration of incommensurate criterion variables, and thereby results in different decisions than are made when the model used by the decision maker includes all of the relevant criterion variables. It is more likely that a decision maker will ignore an ordinal scale criterion variable
### TABLE 5

**Summary of Results**

<table>
<thead>
<tr>
<th>Null hypothesis</th>
<th>A,B Experimental condition: Behavioral dependent variable</th>
<th>A,C Behavioral dependent variable</th>
<th>A, B+C Introspective dependent variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi^2_{IK} &lt; \chi^2_{P,1}$</td>
<td>Rejected*</td>
<td>Rejected*</td>
<td>Rejected**</td>
</tr>
<tr>
<td>$\chi^2_{HIK}$ and</td>
<td>Rejected*a</td>
<td>Accepted*a</td>
<td>Rejected**</td>
</tr>
<tr>
<td>$\chi^2_{HI_1K} &lt; \chi^2_{P,1}$</td>
<td>No test*a</td>
<td>No test*a</td>
<td>Rejected**</td>
</tr>
<tr>
<td>$\chi^2_{HI_2K} &lt; \chi^2_{SO,1}$</td>
<td>Accepted</td>
<td>Inconclusive</td>
<td>Rejected by inspection</td>
</tr>
</tbody>
</table>

**Note:**

- $\chi^2_{IK} = \text{effect of partial versus whole model}$
- $HIK = \text{interaction of model and confounded data set and criterion variable measurement scale}$
- $HI_1K = \text{effect of criterion variable measurement scale}$
- $HI_2K = \text{effect of different sets of input data}$

* $p \leq .05$

** $p \leq .025$

*a Test of hypothesis about the effect of criterion variable measurement scale not possible since the necessary condition that there be no effect due to data set was not met.
if he has a partial model relating to a ratio scaled criterion variable, and less likely that he will ignore a ratio scaled criterion if he has only an ordinal criterion variable in his model.

The Initial Experiment

The necessary condition for inferences about the subjects' consideration of criterion variables was obtained as 21 of the 28 subjects with a whole model (control group) selected the dog food. The tests of significance are tabulated in Table 6. The null hypothesis of no IK interaction was rejected, confirming the predicted difference between the alternatives chosen by subjects with whole models and the alternatives chosen by those with partial models.

The null hypothesis of no HIK interaction was also rejected, but the necessary condition that HI$_2$K interaction be no greater than chance was not met. In fact, the difference between the control groups was significant at the .01 level. It was therefore impossible to infer anything about the effects of criterion variable measurement scale from the alternatives chosen by the subjects. Furthermore, there was a significant JK interaction, indicating that some correlate of rank had an unanticipated effect. The presence of significant and unexpected
### TABLE 6

Chi Square Analysis of the Initial Experiment

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of freedom</th>
<th>Chi square</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tests of the theoretical predictions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>7</td>
<td>21.81(^*)^(^c)</td>
</tr>
<tr>
<td>IK</td>
<td>1</td>
<td>8.73(^*)</td>
</tr>
<tr>
<td>HIK</td>
<td>1</td>
<td>3.99(^*)</td>
</tr>
<tr>
<td><strong>Partial analysis</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HI(_2)K</td>
<td>1</td>
<td>7.00(^a)</td>
</tr>
<tr>
<td>HI(_1)K</td>
<td>1</td>
<td>(____) (^b)</td>
</tr>
<tr>
<td><strong>Other terms in the statistical analysis</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HK</td>
<td>1</td>
<td>1.53</td>
</tr>
<tr>
<td>JK</td>
<td>1</td>
<td>4.08(^*)^(^a)</td>
</tr>
<tr>
<td>HJK</td>
<td>1</td>
<td>3.21(^*)^(^c)</td>
</tr>
<tr>
<td>IJK</td>
<td>1</td>
<td>.04</td>
</tr>
<tr>
<td>HIJK</td>
<td>1</td>
<td>.21</td>
</tr>
</tbody>
</table>

\(^*\) \text{ p} < .05

\(^a\) Result contrary to expectation (Table 4)

\(^b\) Since the necessary condition of no difference due to data set was not met, the difference due to criterion variable measurement scale could not be isolated and tested for significance

\(^c\) Corrected for unequal sampling by rank (J)
interactions warranted further analysis of the separate components (Tables 7 and 8).

In condition "A" the input variables were assigned values that would result in a small difference in payback in favor of spot remover, but a large difference in image in favor of dog food (p. 29). Subjects in the experimental condition were given only the portion of the model relating to the ratio scale (rate of payback) criterion variable. The theory (p. 17) predicted that they would not ask for the missing functions to evaluate the ordinal scale (corporate image) criterion variable, and would therefore pick the spot remover. The control group, with the whole model, was expected to pick dog food on the basis of the large image difference in its favor (pp. 29-30).

The intended control group response was obtained, and the observed difference between the experimental and control groups was significant beyond a .001 rejection level. This result is a strong confirmation of the theoretical prediction that subjects would act as if they ignored an ordinal scale criterion variable missing from their model. Rank had no effect.

In condition "B", the values of the variables
### TABLE 7

**Observed Responses in Conditions "A" and "B"**

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Condition &quot;A&quot;</th>
<th>Condition &quot;B&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Partial model</td>
<td>Whole model</td>
</tr>
<tr>
<td></td>
<td>Captains</td>
<td>Field grade</td>
</tr>
<tr>
<td>Dog food</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Spot remover</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Dog food</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Spot remover</td>
<td>2</td>
<td>5</td>
</tr>
</tbody>
</table>
**TABLE 8**

Separate Analyses of Conditions "A" and "B"

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of freedom</th>
<th>Chi square</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Condition &quot;A&quot;</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
<td>13.52*</td>
</tr>
<tr>
<td>IK</td>
<td>1</td>
<td>13.34*</td>
</tr>
<tr>
<td>JK</td>
<td>1</td>
<td>.14</td>
</tr>
<tr>
<td>IJK</td>
<td>1</td>
<td>.04</td>
</tr>
<tr>
<td><strong>Condition &quot;B&quot;</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
<td>8.55*</td>
</tr>
<tr>
<td>IK</td>
<td>1</td>
<td>.17</td>
</tr>
<tr>
<td>JK</td>
<td>1</td>
<td>8.24*a</td>
</tr>
<tr>
<td>IJK</td>
<td>1</td>
<td>.14</td>
</tr>
</tbody>
</table>

* p < .05

*a unanticipated effect of rank on subject's choice of an alternative
were intended to produce a small corporate image difference in favor of the spot remover, but a large difference in rate of payback in favor of the dog food (p. 31). Subjects in the experimental condition were given a partial model relating to the corporate image criterion variable only. The theory predicts significantly less difference between the experimental and control group responses than in experiment "A" (p. 17).

The difference between the alternatives chosen by the control and experimental groups in condition "B" was not significant at .05, and rank-model interaction was also negligible. However, the effect of rank was significant beyond .005. The intended control group response (dog food) was obtained from captains, but not from the field grade officers (Table 7). The subjects' written narrative explanations and their verbal comments during post-experiment discussions confirmed that field grade officers did not judge the supposedly large advantage in dollar payback from the dog food as sufficient to outweigh the risk of some negative effects on corporate image. This unexpected variability in the control group precluded any valid test of criterion variable measurement scale effects.
The Experiment with Revised Input Data

The "B" portion of the experiment was repeated with another sample of subjects drawn from the same population, but using a revised set of values for input variables. This test was designated condition "C". The only differences between the input data in "B" and "C" were the sales and cost figures for the spot remover. These were adjusted to produce a negligible payback for the spot remover alternative, doubling the ratio of payback difference between the two alternatives. It was anticipated that this large difference would exceed the range of variation in subjects' valuation of the incommensurates, and thereby reduce variability in the control group.

Tests of significance in the combined analysis of conditions "A" and "C" are tabulated in Table 9. The null hypothesis of no IK interaction was rejected, confirming the predicted difference between the responses of subjects with whole models and subjects with partial models. This difference was significant beyond .001.

The analysis of differences due to criterion variable measurement scale was again inconclusive. The expected frequency of a spot remover response in the control group was less than two. This is too small for an accurate chi square test of the necessary
### TABLE 9

Chi Square Analysis of the Experiment
With Revised Input Data

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of freedom</th>
<th>Chi square</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tests of the theoretical predictions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>7</td>
<td>16.45*&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>IK</td>
<td>1</td>
<td>12.60*</td>
</tr>
<tr>
<td>HIK</td>
<td>1</td>
<td>2.41&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Partial analysis</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H&lt;sub&gt;I&lt;/sub&gt;K&lt;sub&gt;2&lt;/sub&gt;</td>
<td>1</td>
<td>___&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>H&lt;sub&gt;I&lt;/sub&gt;K&lt;sub&gt;1&lt;/sub&gt;</td>
<td>1</td>
<td>___&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Other terms in the statistical analysis</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HK</td>
<td>1</td>
<td>.05</td>
</tr>
<tr>
<td>JK</td>
<td>1</td>
<td>.27</td>
</tr>
<tr>
<td>HJK</td>
<td>1</td>
<td>.45&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>IJK</td>
<td>1</td>
<td>(-.18)&lt;sup&gt;cd&lt;/sup&gt;</td>
</tr>
<tr>
<td>HIJK</td>
<td>1</td>
<td>(-.19)&lt;sup&gt;cd&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

* * p < .05

**a** Expected frequency too small for an accurate chi square test of significance

**b** Since the necessary condition of no difference due to data set was not established, the difference due to measurement scale could not be isolated and tested for significance

**c** Corrected for unequal sampling by rank (J)

**d** Computed by approximate method of partition (Table 3). When the sums of squares are partitioned by Fischer's exact method (Mather, 1947, pp. 178-186) this term is shown to be a very small positive number.
condition (p. 42) that input data makes no difference. With data set "C", 10 of 13 subjects in the control group chose dog food, versus 15 of 16 with data set "A". These responses are not close enough to be assumed equal in the absence of a statistical test. Since input data and criterion variable measurement scale are confounded in the test design, and input data cannot be eliminated as a possible source of variation, it is not possible to draw any conclusions about the effects of criterion variable measurement scale.

**Analysis of the Second Dependent Measurement**

In the preceding analyses, the alternative chosen by a subject was used to infer which criterion variables were considered by the decision maker in choosing an alternative. The variability in the decisions made by subjects in the control groups did not affect the test of differences due to whole or partial models, but it was just large enough to preclude a conclusive test of criterion variable measurement scale effects.

An alternative measurement is available in the subjects' written explanations of their decision rationale. The analysis was repeated using "mention of the criterion variable missing from the partial model" as the dependent variable (pp. 27-28). This
introspective measurement has no apparent relationship to a subjects' valuation of differences between the incommensurate criteria, so it was expected to be independent of differences in the data sets.

Inspection of the control group data from conditions "A", "B", and "C" confirms the expectation that this dependent measure is not affected by changes in the problem input data: 40 of the 41 subjects in control groups mentioned the appropriate criterion variable.

The experiments with input data sets "B" and "C" were identical in all respects except for the difference in the values of the input variables (p. 55). Inspection of the results from "B" and "C" (Table 10) shows that this difference in input data had no effect on whether subjects mentioned the ratio scale criterion that was omitted from the partial model. The expected frequencies were again too small for an accurate chi square test. Since there was no evident difference between them, the "B" and "C" data were pooled to obtain larger expected values in the analysis.

Some of the expected cell frequencies were below five even with the pooled data. This is due to the extremely low frequency of a "did not mention" response in the control groups. The rejection level was therefore tightened to .025 to avoid erroneous
TABLE 10
Comparison of Experiments in Which the Ratio Scale Criterion Variable Was Omitted from the Partial Model

<table>
<thead>
<tr>
<th>Dependent variable: Whether subject mentioned the ratio scale criterion variable in his written decision rationale</th>
<th>Independent variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Partial model with ordinal scale criterion variable</td>
</tr>
<tr>
<td>With input data set &quot;B&quot;</td>
<td></td>
</tr>
<tr>
<td>K₁ = mentioned</td>
<td>11</td>
</tr>
<tr>
<td>K₂ = did not mention</td>
<td>1</td>
</tr>
<tr>
<td>With input data set &quot;C&quot;</td>
<td></td>
</tr>
<tr>
<td>K₁ = mentioned</td>
<td>12</td>
</tr>
<tr>
<td>K₂ = did not mention</td>
<td>1</td>
</tr>
</tbody>
</table>
rejection of a null hypothesis. A comparison of the chi square statistic computed with these observations and the true chi square distribution is shown in Appendix E.

The results of the significance tests are shown in Table 11. The null hypothesis of no IK interaction was rejected, confirming the predicted overall difference in the responses of subjects with complete models and those with partial models. The HIK interaction was significant, warranting a separate analysis of the experimental and control groups to isolate the effect of criterion variable measurement scale.

The control group responses were nearly identical. All 16 of the subjects with a whole model mentioned the appropriate criterion variable in condition "A", and 24 of 25 in pooled "B + C". This was taken as sufficient evidence of no difference, satisfying the necessary condition for a test of hypothesis (p. 42).

Of the 16 subjects given a partial model containing only the ratio scale (rate of payback) criterion variable, 6 did not mention the ordinal (corporate image) criterion at all. Others made some mention but did not seek information about the missing functions nor apparently consider it in their decisions.
TABLE 11
Chi Square Analysis of the
Introspective Dependent Variable

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of freedom</th>
<th>Chi square</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tests of the theoretical predictions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>14.91*</td>
</tr>
<tr>
<td>IK</td>
<td>1</td>
<td>6.11*</td>
</tr>
<tr>
<td>HIK</td>
<td>1</td>
<td>5.57*</td>
</tr>
<tr>
<td><strong>Partial analysis</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H&lt;sub&gt;1&lt;/sub&gt;IK</td>
<td>1</td>
<td>___&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>H&lt;sub&gt;2&lt;/sub&gt;K</td>
<td>1</td>
<td>5.40*</td>
</tr>
<tr>
<td><strong>Other terms in the statistical analysis</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HK</td>
<td>1</td>
<td>3.23</td>
</tr>
</tbody>
</table>

* p < .025

<sup>a</sup> Rank (J) was pooled to increase the size of the expected cell frequencies

<sup>b</sup> The necessary condition that there be no difference due to input data set was confirmed by inspection of the experimental data (Appendix E), since the expected cell frequency was too small for an accurate chi square test
All but one of the 13 subjects who were given a model containing only the ordinal criterion variable mentioned the missing ratio scale criterion variable. This difference between experimental groups was significant beyond .025. Furthermore, a plot of the chi square statistic computed from these data compares favorably with the true chi square distribution, as shown in Appendix E.

The null hypothesis of no \( H_{1K} \) interaction was therefore rejected, supporting the predicted difference due to the measurement scale of the criterion variables included and omitted from the partial models.
VI
DISCUSSION

Test of the Theory

The experiment was designed to answer specific questions raised by the controversy over the usefulness of cost-effectiveness models in complex systems decisions (p. 4). The results show that a decision maker is likely to ignore a criterion variable that is not included in his model, particularly if it is measured on an ordinal scale and the model includes a ratio criterion measure. The system analysts' assumption that a decision maker exercises independent judgment in his consideration of criterion variables (p. 3) is not tenable.

Although the experiment provides answers to the specific questions and all theoretical predictions were supported, it does not constitute a complete test of the proposed theory. One mental comparison was necessary for a subject to evaluate the two alternatives on the basis of the single criterion variable included in a partial model. Three concurrent comparisons were necessary if both criterion variables were used
(eq. (9), Appendix A). Further research is needed to investigate decision behavior under higher mental loads, and to show how measurement scale and mental load interact over a broad range. If the theory (p. 15) is correct, the tendency to ignore a missing criterion variable should be greater as load is increased. Now that an initial effect has been demonstrated, a more extensive investigation would appear worthwhile.

Valuation of Incommensurates

The one unanticipated finding was an apparent relationship between the subjects’ rank and their relative valuation of incommensurate criteria. Field grade officers in the condition “B” control group gave more weight to avoiding the effects of an unfavorable corporate image than captains did under the same conditions (Table 7). The written rationale provided by these subjects indicates that all these officers considered both criterion variables, but valued them differently. The dollar payback difference between alternatives had to be made much larger (Condition “C”) before field grade officers judged that it outweighed a higher risk of unfavorable corporate image effects (p. 55). There are several possible explanations for this behavior:

1. Captains are likely to have had more
recent and more extensive formal training in mathematics and quantitative analysis. Some field grade officers could be reluctant to base decisions on computations which they do not fully understand. In this case, a ratio scale criterion would increase anticipated dissonance, in contrast to the proposed theory. However, almost all of the officers in the sample population have at least an undergraduate degree, frequently in a technical or scientific field. Only one officer (a Lieutenant Colonel in control group "C") gave any indication that he was unable to comprehend the model calculations. He ignored the ratio scale criterion completely. The fact that there was no significant difference between the responses of captains and field grade officers once the size of the payback difference was increased indicates that this explanation is not adequate.

2. Cost and performance estimates for new military systems are often inaccurate. Field grade officers are likely to have had more direct experience with erroneous estimates, and may be more suspicious of any figures that they are given. Several of the officers in condition "B" expressed scepticism about the cost and sales data in the problem. Field grade officers apparently accepted the figures given in condition "C"
because the difference in dollar payback was so large that the outcome seemed assured even if the estimates were somewhat inaccurate.

3. The field grade officers may have learned through experience to expect trouble in any complex system. They were more reluctant to choose a course of action involving a potentially serious risk. Risk avoidance was mentioned by several of the officers who chose the spot remover in conditions "B" and "C".

Caution should be exercised in drawing conclusions from this observation without further research, since it is based on the response of only one control group consisting of six captains and six field grade officers (Table 7). Furthermore, although the way in which officers of different ranks might perceive differences in the values of criterion variables and value risks is interesting and potentially important, it does not lead to any change in the proposed theory.

The field grade officers' apparent scepticism about the validity of small numerical differences does not make them more likely to consider an ordinal criterion omitted from their model. There was no difference between the responses of captains and field grade officers in the condition "A" experimental group.
where the subjects were given a model containing the ratio scale criterion variable and omitting the ordinal criterion variable. Most of the field grade officers in this condition chose the alternative indicated by the ratio scale criterion, and several did not mention the missing ordinal criterion at all (Appendix E).

Limitations of the Study

There are obvious limitations to the inferences that can be made about real system decision making from the results of a laboratory experiment:

1. The subject's were asked to take the role of a systems decision maker, but were not actually subject to the pressures of the simulated position. An actual systems decision maker would likely be motivated by extrinsic and intrinsic rewards, and would be committed to the real consequences of his action. These factors might lead him to engage in a more extensive information search than was observed in the laboratory experiment.

2. The necessarily short time limit in the experiment probably precluded observation of any effects due to subconscious decision processes. A business executive or military systems manager faced with a complex decision may spend days or weeks
mulling over the problem while performing his routine duties.

3. The experiment involved individual decision making in an isolated "sterile" laboratory environment, but systems decisions are made by people in interaction with one another in an organization. Others might suggest a criterion that one manager tends to overlook. On the other hand, the organization culture could reinforce a behavior pattern that considers only a limited set of criterion variables.

4. A business problem was deliberately selected for this study so that the military subjects would not have had experience with the specific content. Any manager will have learned through experience that certain criterion variables are important, and he will likely consider these over and above anything he is given in a model. The research results therefore apply primarily to decisions about complex new systems operating in a dynamic environment, where the past experience of an individual is not a reliable guide to the future.

**Implications**

Although inferences about decision making practices must be tempered by the limitations described above, the characteristics of the decision problem used
in this study were isomorphic with the critical characteristics of complex systems decisions (p. 19). The results show that a decision maker's consideration of incommensurate criterion variables depends on whether or not they are included in the decision model he is given, and on the scale by which they are measured. Further research in an organizational setting is necessary to determine whether this influence of a given model can be counteracted by the sanctions associated with a manager's decision making role, the time span during which the problem is considered, or interaction with other people in the organization. There is no evidence at present to indicate that it is.

It seems essential that the models used in making decisions about complex new systems include all of the relevant criterion variables, regardless of their measurement scale. The decision maker may have to participate actively in the model development to assure that this is done, since staff members of lower rank may not place the same degree of importance on the various incommensurate criteria. System models and decision procedures are needed which go beyond the simple optimization of one ratio scale criterion and present the full range of relevant considerations to the decision maker. Cybernetic modeling (Beer, 1969;
Howland, 1966) appears to offer an approach in this direction.

The consequences of many systems planning decisions involving national defense, health, and welfare are too serious to allow the chance suitability of an analytical model to influence the judgments on which decisions are based. This study shows that even when the decision maker knows it is important, a criterion variable that is not in the model may not be considered in the decision.
MENTAL LOAD IN DECISION MAKING

Mental Load

The relevant mental load imposed on a decision maker is the requirement for comparison and short term storage of information internally (Hendrick, et al., 1968). It is not necessarily related to the total information content of the decision problem. Assuming that the decision maker has auxiliary memory aids available (e.g. paper and pencil) to record and externally store the output of serial steps in his problem solving sequence, the maximum mental load imposed by a decision problem is the maximum number of comparisons required at any indivisible step. Mental load is a function of the perceived variables, criteria, and alternatives, and is not an invariant characteristic of the problem.

Identification of the relevant variables, criteria, and alternative solutions are externally divisible serial activities regardless of the sequence in which they are performed. As such, they need not impose any significant mental load. However, critical loads may occur in the assessment and comparison of
criterion variables, especially when a decision involves incommensurate criteria and variables with an ambiguous or uncertain relation to outcomes.

Evaluating Each Alternative

An alternative can be considered as a constraint limiting each input variable to a specific state or distribution of possible states. If the input variables are completely independent and each relates to a unique criterion variable in a one to one transformation, these can be evaluated in a sequence of independent comparisons:

\[(5) \quad L = 1\]

Where: \(L\) = the number of unique paired comparisons at any indivisible step (mental load)

At the other extreme, the input variables may be completely interdependent. In this case each pair of variables, and each variable with each criterion variable, must be considered simultaneously to determine their interaction and resultant state:

\[(6) \quad L_{\text{MAX}} = \binom{V}{2} + CV\]

Where: \(V\) = the number of input variables
\(C\) = the number of criteria
\(\binom{V}{2}\) = the number of combinations of \(V\) variables taken two at a time

Of course, if constraints exist (e.g., if each variable affects only one of the criterion variables,
or some pairs of variables are a-priori independent) it reduces the number of comparisons required, and may make it possible to divide the problem into a sequence of independent subproblems.

An explicit model can be viewed as a method of reducing complexity and removing mental load from the decision maker. The model permits the many-one transformations of variables into criterion variables to be performed externally and serially, such that \( L = 1 \). Mathematical models can be particularly powerful in this respect. The usefulness of explicit models is therefore in making complex alternatives tractable for comparison.

**Comparing Alternatives**

Neither constraints nor use of a model can reduce the number of comparisons required in the decision to less than the number of truly incommensurate criteria. Where perceived criteria are not truly incommensurate but can be transformed into a smaller set, the number of comparisons required can be substantially reduced. Utility, where it can be measured, is the ultimate transformation into a single universal criterion measure (p. 9).

In the simplest case, where there is only a single criterion or utility measure, each pair of
alternatives must be compared in order to reach a decision:

\[ L = \binom{A}{2} \]

Where: \( A = \) the number of alternatives

If the criterion variable can be expressed on an interval or ratio scale, alternatives can be examined in sequence and the results recorded. The load reduces to:

\[ L = 1 \]

Where there are several incommensurate criterion variables, the decision maker will need to consider the absolute value of each criterion variable as well as compare the differences among them. In order to do this he must compare each pair of alternatives on the basis of both the resultant values for each of the criterion variables and the differences among each of these paired comparisons of criterion variables; therefore:

\[ L_{\text{MAX}} = \left[ C + \binom{C}{2} \right] \cdot \left[ \binom{A}{2} \right] \]

Where: \( C = \) the number of incommensurate criterion variables

Constraints may exist which reduce this load. For example, if there is a limit to the amount of money available, the alternatives can be examined serially on the basis of this one criterion, and any that
exceeded the limit eliminated. The choice would then be made on the basis of incommensurate criteria from among the remaining alternatives.

Empirical studies of complex problem solving behavior (e.g. Eastman, 1968) show that people actually use strategies which do not assure an optimum solution, but enable them to attack the problem sequentially in iterative approximations, such that the mental load in any step does not exceed their capacity.

If a problem involves several criteria, a decision maker might select only one of the more important criteria and compare alternatives on that basis alone. He then could compare alternatives on the basis of lesser criteria in turn, to see whether there are any large differences which might lead him to reexamine his original decision. At any step comparing all alternatives on the basis of a single criterion imposes a mental load of:

\[ L = \binom{A}{2} \]

Conversely if the problem involves a large or unknown number of alternatives, a satisficing strategy might be used (March and Simon, 1958). In this case alternatives are evaluated serially and independently until the first acceptable solution is found. The load is therefore a function of only the number
criterion variables considered in evaluating each alternative:

\[ L = \binom{C}{2} \]
APPENDIX B
PROCEDURE

The experimenter was permitted to give a short, officially endorsed talk to each of the selected classes to request volunteers. The officers were only told that their help was needed, that it was a decision making experiment, that they would remain anonymous, and they would find it an interesting and insightful experience. Those who wished to volunteer could sign up on a schedule posted on their class bulletin board.

When all the volunteers for a particular session had assembled outside the room where the experiment was given, they were allowed to enter and each was seated at a cubicle. Within the cubicle each subject had paper, a pencil, and ash tray, and the problem materials. A sample set of these materials is included in Appendices C and D.

The experimenter reviewed the set of materials with the subjects, as follows:

Before you start I'd like you to check to be sure you're not missing anything. You should have a set of general instructions, a problem statement, something about dog food, something about spot
remover. You should have two different sets of information that start with "Your staff has assembled. . . . " Make sure they're different. Next you have an information request form. I'd like to discuss this for a minute. The problem here isn't like another homework exercise or a school examination - it's an experiment in decision making. You'll be asked to take the role of a business executive faced with a real decision. Please try to put yourself in his shoes and act as you would if you were in this position.

Of course, as an executive, you would have a staff available to answer any questions and get any information you needed. In this experiment I'll sit back here and simulate your staff. If there is anything at all that you want to know, any clarification, or any information, just fill out this request form and pass it through the slot in your screen, and I'll do my best to get you the answer. There is no limit to the number of questions you can ask.

Next you have an answer form. Once you've come to a decision indicate your choice at the top, and then please give a half page or a page explaining your rationale; the reasons why you made the choice you did and the factors you considered in coming to this decision. It doesn't have to be in fancy English - an outline is O.K. - but please include all the important points. This is a decision making experiment, and the reasons why you made your choice are important in the research.

You should also have some scratch paper and a pencil. If you need more, just ask for it. You can also make notes on any of the handouts. There is an hour and a half time limit, but you can turn in your answer as soon as you finish. If there is anything you want, just ask. You'll have a complete debriefing after you finish.

Upon completion of this check the experimenter answered any questions about procedure, and then the subjects began work. From that point on, the only communication was between subjects and experimenter,
in the form of written information requests and answers that were passed through a slot in each subject's screen (Figure 7).
Fig. 7. The Physical Arrangement
APPENDIX C

TEST MATERIALS FOR CONDITION "A" CONTROL GROUP

The complete set of test materials used for the condition "A" control group is as follows:

1. General instructions
2. Problem statement
3. Dog food alternative
4. Spot remover alternative
5. Model for evaluating payback from dog food
6. Model for evaluating payback from spot remover
7. Model for evaluating image effects of dog food
8. Model for evaluating image effects of spot remover
9. Information request form
10. Answer form

These materials are illustrated below. The experimental group in condition "A" received the same materials but without items 7 and 8.

The dog food alternative is adapted from the Gainesburger case reported in Brown, Cardozo, Cunningham, Salmon & Sultan (1968, pp. 720-804).
General Instructions

This is a simulated management decision making problem. You are to make a single decision: the selection of one from among two alternative courses of action. When you have reached your decision, indicate which alternative you have selected on the attached answer form. Include a brief (half page) narrative explanation of the factors you considered in coming to your decision, and why you decided in favor of the chosen alternative.

You may have up to 1½ hours to reach a decision, although you will probably not need this much time. Turn in your answer whenever you are finished.

As in any real management decision problem, your information is never complete. Additional information may be obtained by filling out an information request form and passing it through the slot in your screen. An information request can be submitted at any time while you are working on the problem, and you will receive an answer through the slot within a few minutes. Do not be surprised if some information you would like to have is not available (this will be indicated on the answer to your request).

Please try to put yourself in the position of the
business executive whom you are simulating and try to do as well as possible. If you have any questions on the procedure please ask them now. If there are no questions, you may begin (turn to next page).
The Problem

You are the chief executive of a national corporation producing a wide line of household products. Although your customers are the wholesalers and supermarket chains, you conduct extensive mass media advertising to create consumer demand. The industry is highly competitive and new products are constantly being promoted. Your firm must continually seek new product opportunities just to maintain its position in the industry.

You will be expected to come in with a solid recommendation for expanding the product line at the board meeting next week. Many possibilities have been examined and eliminated, and the choice is now between two alternatives: marketing a new dog food developed by your product research department, or buying out a small but well established manufacturer of a spot remover for home use. You can only spare enough capital and managerial talent to undertake one of these projects at the present time.

The uncertain environment and the continuous need to expand and update the product line puts a tight pinch on capital resources. Flexibility is essential to adapt to competitive changes. The board
does not like to tie up funds in any project that won't show a quick, profitable return. The rate of payback on the initial outlay and the time period necessary to recover the initial outlay are criteria used to evaluate short term profitability of proposals for new products and expansions. Initial outlay covers the nonrecurring costs of development, merger, new facilities and equipment, reorganization, and start-up.

Your corporation received some damaging publicity recently when the output of your Pacific Coast smoked fish plant was condemned by federal inspectors. Although you have sold the whole fish operation, there are still serious repercussions. Consumers are more militant than they used to be, and politicians are capitalizing on the public discontent. You have already noticed tighter inspection and regulation, and now certain liberal legislators are proposing a public investigation of your other operations. More sensational publicity could irreparably damage consumer confidence in your firm's products. As a first step toward restoring a corporate image of quality and responsibility, you have increased the budget of your public relations department and impressed them with the urgency of getting favorable publicity in national
media.

Both the payback on initial investment and the effect on corporate image are important considerations as you weigh the merits of the following alternatives for expansion.
A New Dog Food

You do not currently have any pet foods in your product line. There are over 2,000 firms in the dog food business, sharing over $300 million annual sales. They range from small local producers of low priced canned food to large corporations marketing nationally advertised brands of dog meal.

Your researchers have developed a product resembling cube steaks. Although it includes enough meat and all known nutrient elements that a dog needs, it contains enough bulk food that they can be sold at a lower price than dog burgers now on the market (these average $1.67 for a 4½ pound package of 12 servings). Like dog burgers, the proposed dog steaks have no offensive odor, are semi-dry, look like fresh meat, do not have to be refrigerated, and will be packaged in convenient vacuum sealed plastic trays. The servings will be larger and more filling than dog burgers, although they will weigh slightly less.

The market research department conducted tests indicating that about 48% of all housedogs will like it better than the food they are now eating. Less than 15% will exhibit active dislike (by refusing to eat, etc.). Most of these will be dogs who are used to a diet of fresh meat and scraps from the table.
The results of consumer acceptance tests and market surveys are summarized and projected in the following tables showing estimated demand under different conditions:

<table>
<thead>
<tr>
<th>Retail price/4 lb. package of 12 dogsteaks</th>
<th>Annual sales cases of 12 packages</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1.69</td>
<td>375,000</td>
</tr>
<tr>
<td>$1.49</td>
<td>750,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Annual Advertising Expenditure (Mass Media)</th>
<th>Annual sales, cases of 12 packages*</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1,000,000</td>
<td>750,000</td>
</tr>
<tr>
<td>$2,000,000</td>
<td>1,500,000</td>
</tr>
<tr>
<td>$3,000,000</td>
<td>1,800,000</td>
</tr>
</tbody>
</table>

*At retail price of $1.49/package

It is planned to install a production facility with capacity for 3.5 million cases annually in an existing meat packing plant owned by the company. This plant is now mostly idle. The firm has several other plants and administrative offices in this area. There is a labor surplus in the vicinity of the plant (an urban core neighborhood). Most of the available workers are unskilled and will require a full three week training program. The jobs are not particularly difficult. The following cost figures reflect the estimated wage rates and training cost to adequately man
the facility under these conditions (with annual production of at least one million cases):

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation</td>
<td>$1.40</td>
</tr>
<tr>
<td>Warehousing</td>
<td>.40</td>
</tr>
<tr>
<td>Ingredients</td>
<td>4.50</td>
</tr>
<tr>
<td>Packaging material</td>
<td>2.20</td>
</tr>
<tr>
<td>Direct and indirect labor</td>
<td>1.70</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$10.20</strong> per case</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant depreciation</td>
<td>$275,000</td>
</tr>
<tr>
<td>Maintenance</td>
<td>110,000</td>
</tr>
<tr>
<td>Wages and overhead</td>
<td>215,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$600,000</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machinery and equipment</td>
<td>$2,100,000</td>
</tr>
<tr>
<td>Start-up and training</td>
<td>680,000</td>
</tr>
<tr>
<td>Product development</td>
<td>100,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$2,880,000</strong></td>
</tr>
</tbody>
</table>

The average markup between wholesale and retail is 25% of the retail price.

Sales buildup is expected to occur rapidly when the national advertising campaign gets underway. All equipment can be delivered, installed and checked out by the eighth month after go-ahead. Training and production for inventory will be phased in gradually so that advertising can be launched in the eleventh month. Forecast sales levels are expected to be reached by the thirteenth month after your decision to go-ahead with the dog food.
Acquisition of a Spot Remover Company

The company you are considering for take-over is a small but long established producer of a spot remover for home use. Their product is a carbon tetrachloride solution that has been sold under their own brand name for many years. They have an adequate plant and stable labor force, but are presently operating well below capacity. Because of their specialized line and small size, the firm has not been able to afford the active sales and distribution organization needed to maintain their competitive position. Major distribution is still through hardware and drug stores, whereas the competing products of larger firms are primarily sold through supermarket chains.

Although you already have various cleaning agents in your product line, your firm has the wholesale marketing capability to give this product wider distribution and a competitive share of shelf space in the cleaning product section of supermarkets. In this way you might be able to capitalize on their well known brand name and consumer's familiarity with the product. Your market research group estimates that annual sales of $24 million (at wholesale) could be achieved. This represents a 40% increase over the spot remover firm's current sales level of $17 million.
The spot remover company's balance sheet for the past year showed total assets of $30 million and a $1.7 million net operating loss. A discrete survey by an investment broker determined that much of the outstanding stock is held by institutional owners who would be receptive to a merger in which their shares were exchanged for those of a more powerful firm.

Members of the founder's family still manage the company, although they control less than ten per cent of the stock. They are likely to oppose any merger. You will have to buy enough stock on the open market to assure a favorable stockholder's decision before tendering your offer. Your financial staff estimates that five percent of the outstanding shares purchased over a two month period will assure control and not cause too much of an increase in the stock's price. This will require a cash outlay of about $1 million.

Even though the price will be driven up by your purchasing activity, and this will increase the number of shares that will have to be offered in exchange, the number of shares involved is not large enough to significantly affect your firm's price-earning ratio. The value of stock shares issued for the exchange need not be considered in evaluating short run payback.

The cost of soliciting approval from the spot
remover firm's stockholders, and of completing the merger transaction, is estimated to be in the neighborhood of $150,000. Furthermore, it will cost about $1,600,000 over a 6 month period to transfer management personnel, and to reorganize their general management and operations so that they are integrated with those of your firm.

Their production and packaging line is highly automated. Jobs are specialized and independent of output level. The firm could not lay off many people despite declining output, so the planned increase in production should be possible without hiring or training additional production employees. The existence of automated operations and a stable, experienced labor force is an important asset in view of the toxicity of the product. The safety record of this plant has been excellent. No major changes are planned in the production supervision or work crews.

The cost of the projected 40% increase in output is estimated to be:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation</td>
<td>$900,000</td>
</tr>
<tr>
<td>Warehousing</td>
<td>350,000</td>
</tr>
<tr>
<td>Ingredients</td>
<td>750,000</td>
</tr>
<tr>
<td>Packaging</td>
<td>500,000</td>
</tr>
<tr>
<td>Maintenance</td>
<td>600,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$3,100,000</strong></td>
</tr>
</tbody>
</table>

Furthermore, you can expect a $200,000 savings on distribution costs for the present level of output when your management assumes control of this function.
The forecast increase in sales is expected to be realized about one year after your decision to go-ahead and acquire the spot remover company.
Your staff has assembled the following information which you might find useful in analyzing the new dog food alternative:

(1) Sales volume is a function of both price and advertising:

\[ \text{Annual sales (millions of cases)} \]

<table>
<thead>
<tr>
<th>Retail price / pkg</th>
<th>Wholesale price/ case of 12 pkgs</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1.49</td>
<td>$13.44</td>
</tr>
<tr>
<td>$1.69</td>
<td>$15.24</td>
</tr>
</tbody>
</table>

(2) Receipts/case of 12 packages at wholesale (25% retail markup):
(3) For annual production between 1.0 million and 3.5 million cases:

\[ \text{annual cost} = (\text{cost/case}) \times (\text{number of cases}) + \text{annual fixed cost} + \text{annual advertising cost} \]

\[ \text{annual cost} = 10.20 \times (\text{number of cases}) + \$600,000 + \text{annual advertising cost} \]

(4) Annual return = (number of cases sold) \times \text{(wholesale price/case)} - \text{annual cost}

Your product planning section has computed and plotted the above function for various levels of price and advertising, based on the sales estimates made by market research:

![Graph showing annual return and advertising costs for different retail prices and annual advertising.]
(5) If you were to spend $2 million per year on advertising and set the retail price at $1.49 per package, annual payback on initial outlay would be:

\[
\frac{\$2,250,000 \text{ annual return}}{\$2,880,000 \text{ initial outlay}} = 78\% \text{ per year}
\]

At this rate, the initial investment will be fully recovered 2 years and 4 months after go-ahead.
Your staff has assembled the following information which might be useful in analyzing the spot remover alternative:

1. The expected change in total annual costs is:
   - additional production $3.1\text{ M}
   - more efficiency $-1.2\text{ M}
   - net increase in costs $2.9\text{ M}

2. Expected annual return (operating profit) is the present level of profit (loss) plus the net expected change in revenue minus the net expected change in costs:
   - current loss $-1.7\text{ M}
   - expected change in revenue $+7.0\text{ M}
   - expected change in costs $-2.9\text{ M}
   - expected annual return $2.4\text{ M}$

3. The initial outlay for computing payback criteria is the sum of all one time cash expenditures associated with acquiring the spot remover firm and integrating it into the organization:
   - stock purchase $1,000,000
   - exchange transaction $150,000
   - reorganization $1,600,000
   - Total $2,750,000

4. Your corporation assumes any operating losses on spot remover operations from the time the stock transfer is completed in the third month after go-ahead until sales reach profitable levels. Assuming sales, production, and costs change linearly during the reorganization period, the operation will begin showing a profit in the eighth month after go-ahead, and finish the first year with a net return of $100,000.
5. For the second and subsequent years, rate of payback is:

\[
\frac{\text{annual return}}{\text{initial outlay}} = \frac{\$2.4 \text{ M}}{\$2.75 \text{ M}} = 87\% \text{ per year}
\]

At this rate, the initial outlay will be fully recovered 2 years and 2 months after go-ahead.
Your staff has assembled the following information which you might find useful in analyzing the new dog food alternative:

1. Elected officials at all levels are concerned about unemployment and urban decay. The liberal legislators threatening an investigation would be particularly responsive to a well publicized program conducted by your firm to employ and train people from minority groups in a decaying urban area. Since the plans for dog food production call for such an employment program, maximum political leverage could be obtained if it is presented and publicized as a civic minded project.

2. City officials are worried about loss of jobs in core areas of the city. The proposed production of 2 million cases annually would provide a direct payroll of over $3 million and lead to at least another $3 million in additional jobs and services ancillary to the plant. The city administration has a campaign to attract new business. It could be persuaded to control overeager investigating and city inspecting agencies in return for locating the dog food operation as planned.

3. Public Relations could develop the "campaign to train and employ the unemployed" into publicity film releases to news media and articles in influential magazines to create a public image of a responsible, civic minded corporation.

4. The corporate reputation for quality products will be reinforced among the 48% of initial purchasers whose dogs like the product. There is a possibility of a negative impression among owners of dogs that express a dislike. However, tests indicate that this will be a relatively small proportion (less than 15%). Furthermore, these are likely to be dogs who are used to a diet of meat and tablescraps, and who won't eat any brand of commercial dog food. It is probable that any negative impression will be
associated with commercial dog foods in general rather than with a particular product and its manufacturer.

5. Since there are many competitors in the dog food business and no one dominates the market, there is little danger of anti-trust action from this expansion.
Your staff has assembled the following information which might be useful in analyzing the spot remover alternative:

1. Acquiring a well established brand might enhance some people's opinion of the quality of your firm's product line. However, it is unlikely that many consumers associate brand names with parent corporations unless brought to their attention (by publicity, sensational news, etc.).

2. There is a possibility of federal anti-trust action, since your firm is already a powerful marketer of related cleaning products. The Federal Trade Commission ruling in the Clorox case suggests that a firm might be prosecuted for a potential monopoly in marketing power even though they do not monopolize the market for any single product. Recent congressional concern with conglomerate mergers raises the possibility of more restrictive legislation. An anti-trust suit could involve much unfavorable publicity even if it is successfully contested.

3. The product has a good reputation among consumers and is usually safe when used as directed. However, the main ingredient is highly toxic. Inhaling even a small amount of carbon tetrachloride fumes is fatal under some conditions (e.g., when the user has any alcohol in his system). Because of this hazard, some consumer groups advocate legal restrictions on the labeling, advertising, and sale of carbon tetrachloride products. If some Ralph Nader picks this up and there are legislative hearings, your corporation might get a lot more unfavorable publicity.

4. The firm's management can be expected to seek sensational publicity about your large corporation driving out the independent businessman, even though in reality you would be saving their business from eventual bankruptcy.
5. There is no immediate political advantage to be gained with local officials, since the firm's employment is stable and will remain so after the merger. You are not bringing any new business to the town, and they recognize that if you don't buy out the spot remover business now, some other large firm will sooner or later.
INFORMATION REQUEST FORM

(Use whatever is applicable to your question)

What is ____________________________
______________________________?

How does ____________________________
affect______________________________?

What is ____________________________
when______________________________
is______________________________?

You will receive another blank request form whenever you submit a question.
I have decided to proceed with ____________________.

Brief explanation.
APPENDIX D

TEST MATERIALS FOR CONDITION "C" CONTROL GROUP

The materials used in condition "C" were identical to those used in condition "A" (Appendix C) except for items 3, 4, 6, 7, and 8. These are illustrated below. The experimental group in condition "C" did not receive items 5 and 6.
A New Dog Food

You do not currently have any pet food in your product line. There are over 2,000 firms in the dog food business sharing over $300 million annual sales. They range from small local producers of low priced canned food to large corporations marketing nationally advertised brands of dog meal.

Your researchers have developed a product resembling cube steaks. Although it includes enough meat and all known nutrient elements that a dog needs, it contains enough bulk food that they can be sold at a lower price than dog burgers now on the market (these average $1.67 for a 4½ pound package of 12 servings). Like dog burgers, the proposed dog steaks have no offensive odor, are semi-dry, look like fresh meat, do not have to be refrigerated, and will be packaged in convenient vacuum sealed plastic trays. The servings will be larger and more filling than dog burgers, although they will weigh slightly less.

The market research department conducted tests indicating that about 30% of all housedogs will like dog steaks better than the food they are now eating. About 20% will exhibit active dislike (by refusing to eat, etc.). Many of these will be dogs who are used to a diet of fresh meat and scraps from the table.
The results of recent consumer acceptance tests and surveys just completed by your market research department have been analyzed and projected in the following tables, showing expected demand under different conditions:

<table>
<thead>
<tr>
<th>Retail price/4 lb. package of 12 dogsteaks</th>
<th>Annual sales, cases of 12 packages</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1.69</td>
<td>375,000</td>
</tr>
<tr>
<td>$1.49</td>
<td>750,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Annual advertising expenditure (mass media)</th>
<th>Annual sales, cases of 12 packages*</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1,000,000</td>
<td>750,000</td>
</tr>
<tr>
<td>$2,000,000</td>
<td>1,500,000</td>
</tr>
<tr>
<td>$3,000,000</td>
<td>1,800,000</td>
</tr>
</tbody>
</table>

*At retail price of $1.49/package

It is planned to install a production facility with capacity for 3.5 million cases annually in an existing meat packing plant owned by the company. This plant is now mostly idle. There are other packing plants and a relatively high rate of employment in this area (a midwestern town). Most workers in this town have the necessary skills and will not require more than a minimal training program. The jobs are not particularly difficult. The following cost figures reflect the estimated wage rates that will have to be offered to adequately man the facility under these
conditions (with annual production of at least one million cases):

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation</td>
<td>$1.40</td>
</tr>
<tr>
<td>Warehousing</td>
<td>$0.40</td>
</tr>
<tr>
<td>Ingredients</td>
<td>$4.50</td>
</tr>
<tr>
<td>Packaging and material</td>
<td>$2.20</td>
</tr>
<tr>
<td>Direct and indirect labor</td>
<td>$1.70</td>
</tr>
</tbody>
</table>

$10.20 per case

- Plant depreciation: $275,000
- Maintenance: $110,000
- Wages and overhead: $215,000
- Total: $600,000

- Machinery and equipment: $2,300,000
- Start up and training: $480,000
- Product development: $100,000
- Total: $2,880,000

The average markup between wholesale and retail is 25% of the retail price.

Sales build up is expected to occur rapidly when the national advertising campaign gets underway. All equipment can be delivered, installed, and checked out by the eighth month after a decision to go ahead. Training and production for inventory will be phased in so that the advertising campaign can be launched in the eleventh month. Forecast sales levels are expected to be reached by the thirteenth month after your decision to go ahead with the dog food.
Acquisition of a Spot Remover Company

The company you are considering for take-over is a small but long established producer of a spot remover for home use. Their product has been sold under their own brand name for many years. They have an adequate plant and stable labor force, but are presently operating well below capacity. Because of their specialized line and small size, the firm has not been able to afford the active sales and distribution organization needed to maintain their competitive position. Major distribution is still through hardware and drug stores, whereas the competing products of larger firms are primarily sold through supermarket chains.

Although you don't yet have any cleaning agents in your product line, your firm has the wholesale marketing capability to give this product wider distribution and a competitive share of shelf space in the cleaning product section of supermarkets. In this way you would be able to capitalize on their well known brand name and consumer's familiarity with the product. Your market research group estimates that annual sales of $17.5 million (at wholesale) could be achieved. This represents a 40% increase over the spot remover firm's current sales level of $12.5 million.

During the past year the spot remover company incurred a $1.5 million net operating loss. A discrete
would be receptive to a merger in which their shares were exchanged for those of a more powerful firm.

A member of the founder's family still manages the company, but he is about to retire and has no male heir to take over. His only daughter is widowed and does not want to become involved in the business. He is likely to welcome the merger, but only owns 10% of the stock. You will have to buy enough stock on the open market to assure a favorable stockholder's decision before tendering your offer. Your financial staff estimates that another 10% of the outstanding shares purchased over a two month period will assure control and not cause too much increase in the stock's price. This will require a cash outlay of about $2.3 million.

Even though the price will be driven up by your purchasing activity, and this will increase the number of shares that will have to be offered in exchange, the number of shares involved is not large enough to significantly affect your firm's price/earnings ratio. The value of stock shares issued for the exchange need not be considered in evaluating short run payback.

The cost of soliciting approval from the spot remover firm's stockholders, and of completing the merger transaction, is estimated to be in the neighborhood of
Furthermore, it will cost about $1,600,000 over a 6 month period to transfer management personnel, and to reorganize and modernize their general management and marketing operations so that they are integrated with those of your firm.

Their production and packaging line is highly automated. Jobs are specialized and independent of output level. The firm could not lay off many people despite declining output, so the planned increase in production should be possible without hiring or training additional production employees. The existence of automated operations and a stable, experienced labor force is an asset in a process that involves handling flammable chemicals. The safety record of this plant has been excellent. No major changes are planned in the production supervision or work crews.

The cost of the projected 40% increase in output is estimated to be:

<table>
<thead>
<tr>
<th>Category</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation</td>
<td>$700,000</td>
</tr>
<tr>
<td>Warehousing</td>
<td>250,000</td>
</tr>
<tr>
<td>Ingredients</td>
<td>950,000</td>
</tr>
<tr>
<td>Packaging</td>
<td>500,000</td>
</tr>
<tr>
<td>Maintenance</td>
<td>600,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$3,000,000</strong></td>
</tr>
</tbody>
</table>

Furthermore, you can expect a $200,000 annual savings on distribution costs for the present level of output when your management assumes control of this
function.

Like most all effective spot removers on the market, the product is flammable and is toxic if taken internally. However, it has a good reputation among consumers and is safe when used as directed. It conforms to all federal, state, and local regulations on chemical contents, packaging, and labeling.

The forecast level of sales is expected to be reached about one year after your decision to go ahead with the acquisition of the spot remover company.
Your staff has assembled the following information which might be useful in analyzing the spot remover alternative:

1. The expected change in total annual costs is:

\[
\begin{align*}
\text{additional production} & \quad + \quad 3.0 \text{ M} \\
\text{more efficiency} & \quad - \quad 0.2 \text{ M} \\
\text{net increase in costs} & \quad = \quad 2.8 \text{ M}
\end{align*}
\]

2. Expected annual return (operating profit) is the present level of profit (loss) plus the net expected change in revenue minus the net expected change in costs:

\[
\begin{align*}
\text{current loss} & \quad = \quad 1.5 \text{ M} \\
\text{expected change in revenue} & \quad = \quad 5.0 \text{ M (sales)} \\
\text{expected change in costs} & \quad = \quad 2.8 \text{ M} \\
\text{expected annual return} & \quad = \quad 0.7 \text{ M}
\end{align*}
\]

3. The initial outlay for computing payback criteria is the sum of all one time cash expenditures associated with acquiring the spot remover firm and integrating it into the organization:

\[
\begin{align*}
\text{stock purchase} & \quad = \quad 2,300,000 \\
\text{exchange transaction} & \quad = \quad 150,000 \\
\text{reorganization (including automating office procedures)} & \quad = \quad 1,600,000 \\
\text{initial outlay} & \quad = \quad 4,050,000
\end{align*}
\]

4. Your corporation assumes any operating losses on spot remover operations from the time the stock transfer is completed in the third month after go-ahead until sales reach profitable levels. Assuming that sales, production and costs change linearly during the reorganization period, the operation will begin showing a profit 11 months after go-ahead, and end the first year with a net loss of about 300,000.
5. For the second and subsequent years, rate of payback is:

\[
\frac{\text{annual return}}{\text{initial outlay}} = \frac{\$0.7 \text{ M}}{\$4.05 \text{ M}} = 17\% \text{ per year}
\]

At this rate, the initial outlay will be fully recovered 7 years and 3 months after go-ahead.
Your staff has assembled the following information which might be useful in analyzing the new dog food alternative:

1. Since the plant to be used is located in a town with relatively high employment, many workers will have to be lured from other plants in the area. This is considered in the costs estimates. It may result in some ill will on the part of the management and owners of the other firms in town.

2. Since the town is already experiencing high employment and is not particularly anxious for rapid growth (it might attract an influx of minority group workers), there are no political benefits to be gained from the plant expansion.

3. A local plant expansion for a new dog food doesn't provide much useful material for national publicity releases.

4. The corporate reputation for quality products will be reinforced among the 30% of initial purchasers whose dogs prefer the product. There is a likelihood of an unfavorable impression among the owners of the dogs who express dislike (about 20% of all dogs). Some of these will be dogs who are used to a diet of meat and tablescraps, and won't eat any prepared dogfood. The owners of such dogs will probably have a negative reaction to commercial dogfoods in general rather than to the particular product and its manufacturer.

5. Since there are many competitors in the dog food business and no one dominates the market, there is little danger of anti-trust action from this expansion.
Your staff has assembled the following information which might be useful in analyzing the spot remover alternative:

1. Acquiring a well established brand might enhance some people's opinion of the quality of your firm's product line. However, it is unlikely that many consumers associate brand names with parent corporations (unless brought to their attention by publicity, sensational news, etc).

2. There is little danger of anti-trust action, since your firm does not now market any competing or closely related cleaning products.

3. Since the product is no more hazardous than most competing cleaning agents, meets all government standards, and is safe when used as directed, there is little likelihood of investigation or unfavorable publicity by the legislators concerned with consumer protection.

4. The spot remover firm's management will advocate the merger as saving the business and the jobs of the employees. This will assure a favorable corporate image in the local area, but probably will not have much national impact.

5. There is no immediate political advantage to be gained with local officials, since the firm's employment is stable and will remain so after the merger. You are not bringing any new business to the town, and they recognize that if you don't buy out the spot remover business now, some other large firm will sooner or later.
## APPENDIX E

### DATA

### TABLE 12

**EXPERIMENTAL DATA**

<table>
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<tr>
<th>Dependent variables</th>
<th>独立变量</th>
<th>条件 &quot;A&quot;</th>
<th>条件 &quot;B&quot;</th>
<th>条件 &quot;C&quot;</th>
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<td>Whole model</td>
<td>Partial model</td>
<td>Whole model</td>
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<td></td>
<td>Captains</td>
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<td>Captains</td>
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</tbody>
</table>
Fig. 8

Distribution of $\chi^2$, Subject's Decision as the Observed Dependent Variable

---

- Single cell \( \frac{(m-m')^2}{m'} \), conditions A, C
- True $\chi^2$, one degree of freedom
Fig. 9. Distribution of \( \chi^2 \), Observations With the Introspective Dependent Variable

- Single cell \( \frac{(m-m')^2}{m} \), conditions A, B+C
- Single cell \( \frac{(m-m')^2}{m} \), comparison of experimental groups with partial models to test effect of criterion variable measurement scale
- True \( \chi^2 \), one degree of freedom
REFERENCES


