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# THESIS



**Reducing the Effect of Irrelevant Information with Cognitive Feedback**

by

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Thesis Advisor: Professor Kishore Sengupta

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This thesis was a study which deals with two basic concepts in human decision making. The first is the role of information relevance, specifically the adverse effects of irrelevant information on decision quality. The second key concept was cognitive feedback and its value in support of decision making. The thesis was designed to research the effectiveness of cognitive feedback in reducing the adverse effects of irrelevant information. The experiment tested the Lens Model indices achievement, consistency, and matching in task conditions of high and low predictability. Subjects were divided into blocks which differed in the availability of cognitive feedback and predictability. The results of the experiment showed the subjects performed better in all Lens Model indices in the cognitive feedback condition. Subjects also had superior performance across all Lens Model indices in the high predictability condition. This thesis was intended to contribute to research in the subject of human decision making. The results were of importance in support of future design of decision support systems.

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# Reducing the Effects of Irrelevant Information with Cognitive Feedback

by

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## ABSTRACT

This thesis was a study which deals with two basics concepts in human decision making. The first is the role of information relevance, specifically the adverse effects of irrelevant information on decision quality. The second key concept was cognitive feedback and its value for supporting decision making. The thesis was designed to research the effectiveness of cognitive feedback in reducing the adverse effects of irrelevant information. The experiment tested the Lens Model indices: achievement, consistency and matching in task conditions of high and low predictability. Subjects were divided into blocks which differed in the availability of cognitive feedback and predictability conditions. The results of the experiment showed the subjects performed better in all Lens Model indices in the cognitive feedback condition. Subjects also had superior performance across all Lens Model indices in the high predictability condition. This thesis was intended to contribute to the research in the subject of human decision making. The results were of importance in support of future design of decision support systems.

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# I. Introduction

## A. Research Context

### 1. Use of feedback on decision making

Researchers in several fields have studied the effects of feedback on decision making. From the fields of psychology and psychiatry, research has studied the way in which cognitive feedback is used by an individual to understand his/her environment (Doherty and Balzer, 1988). Researchers in the field of marketing have been interested in how "good" decision makers depend on the use of cognitive feedback (Jacoby, Mazursky, Troutman, and Kuss, 1984). Research has shown that some forms of feedback can have an effect on the quality of decision making. From this research, and others, there have emerged several theories which support this thesis. These topics will be discussed in detail in Chapter II.

### 2. Effects of irrelevant information in decision making

The effect of irrelevant information on decision making has been a subject of continuing attention in the field of social and clinical psychology. Research has been directed at the effects of information relevance on decision making (Streufert S., 1973), reducing the effects of irrelevant information on experienced decision makers (Gaeth and Shanteau, 1984), and the perception of information relevance (Streufert and Streufert, 1970). One well accepted theory concerning information relevance is that the presence of irrelevant information is detrimental to decision making. The concept of information relevance is of key importance to this thesis. Research and theories pertaining to information relevance will be discussed in Chapter II.

The research proposed here addresses the two points made above - (a) given that the presence of irrelevant information has an effect on decision making, (b) can the use of feedback reduce the effects of irrelevant information. In this study we will examine the effects of irrelevant information in task environments characterized by different degrees of predictability. We will draw conclusions as to the effectiveness of feedback as a method of reducing the effects of irrelevant information.

### 3. Relevance to information systems research

The relevance of this studv to research to Information Systems (IS) is in the domain of Decision Support Systems (DSS). With the rapid growth of demand for both specialized and off-the-shelf DSS, emphasis is being placed on the quality of design. DSS provide users with information in order to enhance the quality of their decisions. Not all information displayed to the user at one time is relevant. If the decision maker is given the opportunity to study his/her own decision rules through the use of some form of cognitive feedback, he can improve his/her decision rules. Not all DSS of today provide CFB to the user. This research will help to determine if such a capability can improve the quality of the DSS.

## B. Problem domain

In this section, we outline the elements of the problem domain, thereby constituting the basis for the research question - the notion o-. cognitive feedback as an aid to decision making in environments characterized by the presence of irrelevant information.

### 1. Irrelevant information

The effects of irrelevant information on decision making have been studied extensively. The consensus from this research yields two basic premises that are essential to this study. First, the presence of irrelevant information is a detriment to decision making (Gaeth and Shanteau, 1984). Second, the adverse effects of irrelevant information are greater in complex environments than in relatively simple environments (Streufert and Streufert, 1973).

### 2. Cognitive feedback

The term feedback describes an environment that returns some measure of the output of a system back to the system which produced the output. Feedback then allows a person to compare his/her present state to an ideal state, to adjust itself in light of that comparison (Doherty and Balzer, 1988). Feedback can be provided in two forms - outcome and cognitive. Outcome feedback deals with the accuracy of a response. Cognitive feedback provides information as to how that response was generated. Cognitive feedback is the return of some measure of the output of a person's cognitive processes, to help that person come to terms with his/her environment.

Cognitive feedback can take three forms in an experimental setting:

(a) information about the relationships between cues and criterion, i.e. information about the task:

(b) information about relationships between cues and the person's inference, i.e. information about the person's cognitive state, sometimes referred to as insight;

(c) information about relationships between cognitions and distal objects. This category comprises indices of "functional validity" information (Doherty and Balzar, 1988).

### 3. Research question

Given that the presence of irrelevant information adversely affects task performance, can the use of cognitive feedback improve the quality of decisions?

## C. Organization of the thesis

The discussion proceeds as follows. Chapter II reviews the research in the effects of irrelevant information and the use of feedback in task situations. Chapter III describes the experimental setting and chapter IV discusses the data analysis and results. Chapter V summarizes and draws conclusions.

# II. RESEARCH

## A. The Research Question - A Conceptual Framework

The research question deals with two basic theoretical areas: *information relevance* and *cognitive feedback*. The purpose of this chapter is to lay the groundwork in these two research areas, giving logical support for the hypotheses to be made later in Chapter III. Important to both of these research areas is the topic of human judgment.

### 1. Human Judgment

Understanding human judgment is important in the context of this research. Changes in human judgment are what we hope to effect by manipulation of the dependent variables. A background discussion of human judgment theories is included in section A.1. The mathematical and experimental representation of human judgment is provided by the lens model (Dudycha and Naylor, 1966). The lens model and issues surrounding linear models of human judgment will be discussed in section B.1.

### 2. Information Relevance

Research in the area of information relevance is extensive (Streufert, 1973; Gaeth and Shanteau, 1981, 1984; Adelman, 1981). It is commonly accepted that irrelevant information serves as a detriment to decision making. The effects of information relevance vary under different circumstances. Section C will discuss the elements of information relevance as it pertains to this research.

### 3. The Research Problem

The research problem can be framed by the following statements:

(i) Individuals make models of decision processes.

(ii) Irrelevant information serves as a detriment to successful development and use of a decision model.

(iii) Cognitive feedback has been proven successful in improving decision making, by providing decision makers a better insight into their model development and usage strategy.

(iv) So, given that cognitive feedback improves decision making, can it be useful in overcoming the detrimental effects of irrelevant information?

## B. Human Judgment

According to Brehmer, knowledge is a relation between two systems. One system in this relationship is, for the purpose of studying human judgment, a person and the other is some portion of the environment. A person who is believed to "know" a great deal is someone who understands relationships with his/her environment better that someone who understands these relationships less. These relationships are believed to be probabalistic. Thus, perfect knowledge is infeasible, only knowledge where the person has a high probability that what he believes he knows, is actually the case.

It has been the focus of many researchers in experimental and clinical psychology to study the way in which humans seek relationships between themselves and their environment (Brunswik, Brehmer, Doherty and Balzer, et al). Doherty and Balzer referred to knowledge representation as a complex set of relations called a policy. Policies are sampled from the stimuli and then analyzed for their relevance. The relevant components are then tried for their usefulness, either one by one or in some combination (Doherty and Balzer, 1980).

The use of linear models was first suggested by Brunswik (1944) for studies of perception. A linear model suggests that there is a probablistic and functional relationship between an individual and his environment, and that the functions can be described and measured. These methods are used to test a series of hypotheses about the nature of the judgment process, hypotheses about the nature of cue weights, function forms, combination rules, and predictability (Brehmer, 1979). The name of the model developed by Brunswik was the Lens Model.

### 1. The Lens Model

The Lens Model is a linear regression model developed by Brunswik for assessing the dynamics of human choice behavior in a probablistic environment. The following text from Dudycha and Naylor describes well the components of the Lens Model:

> The three basic elements to the model are the cues or stimulus dimensions ($X_1$ .... $X_k$), the correct response or answer ($Y_e$), and the observed response of the individual ($Y_s$). Any choice or decision situation (trial) must of necessity include these three elements. Given many such decision trials it is possible to determine the statistical relevance of a cue $X_i$ as a predictor of the criterion $Y_e$ by computing the zero-order correlation $r_{ei}$ over trials. This true cue validity, when squared, can be interpreted as an index of the diagnostic power of that cue as a source of information for predicting the correct state of nature.

Also from Dudycha and Naylor are the following values used in the model:

$r_e$ = the correlation between the true or observed criterion and the predicted criterion.

$r_s$ = the *index of subject consistency*, or the degree to which the subject consistently utilized his strategy as defined by his multiple regression equation.

$r_a$ = the correlation which denotes subject achievement. It measures the degree of agreement between the criterion values and responses of the subject over n observations.

$r_m$ = the correlation between the two sets of n predicted values, which reflects the degree to which the regression (policy) equation of the subject "matches" the regression (optimal) equation of the ecology.

$r_{oe}$ = the correlation which reflects the degree that the optimal equation of the environment can predict the actual responses of the subject.

$r_{cs}$ = the correlation which reflects the degree to which the policy equation of the subject can predict the true criterion. (The above variables and definitions taken from Dudycha and Naylor, 1966).

The Lens Model is an accepted method for interpreting subject responses in single or multiple cue probablistic learning environments with linear tasks. Tucker further developed the model for tasks in which the judgment is a linear additive function to yield the following relationship:

$$r_a = G R_e R_s$$

$R_e$ represents the predictability of the environment, $R_s$ represents the consistency of the subject, and G is the correlation between the predictions derived from the linear model of the environment with the linear model of the subject (matching index). Thus, $r_a$ is called the achievement index.

## C. Information Relevance

Relevant information is viewed as any information to which a meaningful task-oriented response is possible (Streufert, 1973). Thus, information which is not useful in the generation of meaningful responses is irrelevant. In an experimental setting, as well as in nature, irrelevant information is often mixed with relevant information.

In terms of the lens model, irrelevant information is a cue which has a low $r_{ei}$. A cue with little or no diagnostic power (diagnostic power is described in the previous section) is mostly or entirely irrelevant.

Study in information relevance has been extensive. Most data suggest that increases in irrelevant information decrease performance to criterion (Streufert, 1973; Streufert and Streufert,1971; Gaeth and Shanteau, 1984; Ettenson and Shanteau, 1987; et al). This premise is well accepted as a starting point for further research in the area of information relevance.

Gaeth and Shanteau (1984) sought to discover if this influence extended to experienced decision makers. In their study, the decision makers were trained agricultural students. They were asked to describe soil texture. Irrelevant to this determination is moisture in the soil. One important result of the experiment is benefit of training in reducing the adverse effects of irrelevant information. If this influence extends to experienced decision makers, then one reasonable approach to improving judgmental skills would be to reduce the effects of irrelevant information (Gaeth and Shanteau, 1984).

### 1. Effects of Irrelevant Information

The effects of irrelevant information are known to vary in different task environments. For example, adding irrelevant information in simpler environments usually does not have as great an effect in producing decrements in task performance (Streufert and Streufert, 1970). A subject can perform well in a task environment where irrelevant information is present as long as he can sort out relevant and irrelevant information. In complex environments it is more difficult to differentiate between relevant and irrelevant information.

Streufert (1973) performed a study demonstrating the decreases in performance levels previously believed to be the effect of load increases were actually a function of information relevance.

2. **Effectiveness of Training**

Gaeth and Shanteau's research using training is of hallmark importance to research in information relevance. The study utilized experienced agricultural judges in a soil sampling task. In a pretest, irrelevant information was shown to influence the decisions of the judges. This pretest is of some consequence, for it shows that even experts are subject to the effects of information irrelevance. Subsequent training, in two different forms: lecture training and interactive training, was shown to improve accuracy and reduce the influence of irrelevance. Gaeth and Shanteau's research utilizing training is of hallmark importance as it is the first substantial work investigating the potential for reducing the adverse effects of irrelevant information. Additionally, it is of great significance that the study was able to differentiate between improvements in accuracy and decreases in the effects of irrelevant information, proving that the two are mutually exclusive. A follow-up study showed that the benefit from training was shown to extend for a year after the training was held.

## D. Feedback

### 1. Outcome Feedback

The procedure of informing the subject in an experiment of the correct value in a task situation ($Y_e$) immediately after that subject produces a response ($Y_s$) defines outcome feedback (OFB) (Doherty and Balzer, 1988). Research has attempted to correlate improvements in decision quality based of the use of OFB. It is commonly accepted that OFB alone is of little assistance to decision makers learning complex inference tasks. OFB can in some cases serve as a detriment to decision making because it encourages departure from linearity (Lindell, 1976). This departure from linearity is especially likely when the task environment is less than complete predictability.

Brehmer (1980) explains the reasons why OFB is not useful for enhancing decision making:

> Confirmation will, of course, not teach the subjects about the actual validity of their hypothesis; it will only tell which hypotheses work, although the reason why the hypotheses work may be very different from what the subject thinks... When we have to learn from outcomes, it may in fact, be almost impossible to discover that one really does not know anything. This is especially true

when the concepts are very complex in the sense that each instance contains many dimensions.

One effect seen when OFB is used alone is when a subject is given OFB demonstrating that his response is incorrect, he will often abandon the policy which was employed to produce the response, even if it was the correct policy. Repeated failure to get the "right" answer may cause the subject to abandon the idea that there is a policy at all and he may resort to guessing (Doherty and Balzer, 1988).

Outcome feedback in a less than perfectly predictable task apparently acts to confuse subjects and lower their consistency. Achievement is also adversely affected, because of this lowered consistency (Schmitt, Coyle, and Saari, 1977). It follows that outcome feedback in task environments of low predictability is not useful for policy revision.

**2. Defining cognitive feedback**

Cognitive feedback is described as the return of some measure of the output of a person's cognitive processes, to help that person come to terms with the environment. Cognitive feedback provides the person with information describing the relationships:

(a) between cues and the criterion (Task Information TI);

(b) between cues and the person's inference, i.e. information about the person's policy (Cognitive Information; CI) and/or

(c) between cognitions and the distal objects. This category comprises indices of functional validity (Doherty and Balzer,1988). The third category, above, is added to parallel the lens model accurately. In the lens model, TI includes the indices on the ecological side of the lens. CI includes all information on the subjects side. Functional validity refers to all three measures $r_a$, G, and C described in section B.1.

In terms of the Lens Model, TI is represented by $R_e$ or $R_e^2$, ecological validities (earlier called $r_{ei}$ or diagnostic power, see section B.1) or function forms relating the criterion to the cues. CI is represented by the values $R_s$ or $R_s^2$ in the Lens Model as correlation indices of predictability of the subject (consistency). Another form of CI are the usage coefficients (e.g., $r_{is}$; the subject's decision policy) and function forms relating the judgment to the cues.

### 3. Effectiveness of Cognitive Feedback

Cognitive feedback has been used in numerous experiments to produce changes in decision making policy. Cognitively oriented feedback results in higher levels of achievement than outcome feedback over different task properties (Adelman, 1981). Other studies have demonstrated the superiority of CFB to no information, as evidenced by policy change between blocks after providing CFB. Research has been conducted to determine which component of CFB (TI, CI, or FVI) is most effective in making change. The bulk of research on the subject shows that TI alone is sufficient to facilitate change. There has been research investigating the use of CI alone, and TI + CI. There is not adequate research to make assumptions about differential effects. All lens model indices seem to be influenced by TI and TI + CI with $R_s$ being more sensitive (Doherty and Balzer, 1988).

The use of CFB has been found to be related to task predictability. The use cognitive feedback under conditions of extremely high task congruence and predictability has not been shown to produce higher accuracy than outcome feedback alone. Schmitt et al. (1977) found that as task predictability decreased, achievement with cognitive feedback became significantly higher than that with outcome feedback (Adelman, 1981). Predictability is varied in experimental settings to manipulate task complexity (Steinman, 1976).

One finding of double-systems studies pertains to the effects of task predictability on the cognitive systems of the subjects. Results obtained in a variety of circumstances show that the consistency of a cognitive system varies with the redictability of the task, the lower the consistency of the cognitive system (Brehmer 1979). This effect is related to the theory that policy formation and utilization is probablistic.

## E. Framing the Research Question

The previous sections are valuable for demonstrating the need for and validity of research in the proposed area. In the section on irrelevant information it was shown that a measurable portion of difficulty experienced by decision makers in complex tasks was due to the effects of irrelevant information. Streufert went one step further in showing that similar losses in accuracy previously blamed on load were actually a result of irrelevant information. Some research has begun to discover means for recouping or avoiding these losses. Gaeth and Shanteau have had success using training as a means to this end. They further point out that research in irrelevant information is abundant, while research into correcting for it is overdue (Gaeth and Shanteau, 1981).

The use of cognitive feedback has been proven to be an effective means of improving performance in many different task oriented environments. The bulk of the research indicates that the more complex and predictable the task is, the more profound the benefit is when cognitive feedback is utilized. It is reasonable, then, to believe that it will also have a measurable effect on decision making in task environments subject to the presence of irrelevant information.

These are the fundamental principles of the study. It is clear from these themes that not only is the theoretical foundation for the study valid, but there is evidence that the results of the research will benefit all pertinent areas of study. The research question is further developed Chapter III, which describes the experimental methodology, and Chapter IV, which discussed the same research but in relation to the outcome of the experiment.

# III. METHOD

## A. Scope

This chapter describes the experimental design used in the research. The experiment was divided into three phases: training, experiment, and debriefing. The rationale for the training is explained in the previous chapter. Its results will be described in this chapter in section G. Section I discusses the debriefing phase, and section J is a summary of this chapter.

## B. Hypotheses

The first hypothesis is discussed in terms of the lens model index for achievement. All hypotheses were formulated on the individual level.

$H_1$: Subjects receiving CFB will attain higher decision quality than those receiving only OFB.

$H_2$: Subjects will perform better in task environments of high predictability than those in environments of low predictability.

### 1. Description of Hypotheses

Based on arguments discussed previously in Chapter II, we postulate that performance will improve in the cognitive feedback condition. Performance in this sense means that the subject's responses will more closely resemble the committee score. Similarly, the subject's policy will resemble the committee policy.

Section C.1 of Chapter II reviews Streufert's findings that the presence of irrelevant information is more detrimental to decision makers in environments of higher task difficulty. It is proposed in $H_2$ that this effect will also hold true to differences in task predictability.

## C. Experimental design

The purpose of this section is to describe the experimental design of the experiment. The experiment has three phases: training phase, experimental phase, and debriefing.

### 1. Description of design

The experimental design has two components - between subjects effects and within subjects effects. The design chosen to accomplish this was a 2 (OFB vs CFB) X 2 (High vs Low Predictability) X 3 (Block sequence) factorial design.

The between-subjects effect is the difference in performance between those subjects given cognitive feedback and those only given outcome feedback. Another between-subject effect is the difference in performance between those subjects in the high predictability task environment and those in the low predictability environment. The between subjects design is described by Figure 1 below.

| | Task | |
|---|---|---|
| Feedback | CFB/HI | CFB/LO |
| | OFB/HI | OFB/LO |

**Figure 1**

As well as determining if systematic differences exist among experimental conditions, this study also seeks to study the effect within each condition over time. This within-subjects design involves measurements that occur over time. Time of response will be measured for all subjects to see if learning was occurring with each subject.

The within-subjects effect of irrelevant information was operationalized by varying which cue (of three) was irrelevant for each block. The order that each subject receives the blocks of trials was then operationalized using a Latin Squares design following the procedure in given in Kirk (1982).

The following figure demonstrates the separation of within-subjects.

| | Group 1 | Group 2 | Group 3 |
|---|---|---|---|
| Task order: | Cue 2 | Cue 3 | Cue 1 |
| | Cue 1 | Cue 2 | Cue 3 |
| | Cue 3 | Cue 1 | Cue 2 |

Therefore, group 1 gets the order 2, 1, 3; group 2 gets the order 3, 2, 1; and group 3 gets the order 1, 3, 2. For example, subjects in group 1 will receive a task sequence of the following order: in block 1, cue 2 was irrelevant; in block 2, cue 1 was irrelevant; and in block three, cue three was irrelevant.

### 2. Experimental setting

The sessions were conducted in a closed room in the presence of the experimenter. The training and experimental phases were conducted on an IBM compatible personal computer. Brief instructions were provided by the experimenter at the beginning of the training phase. From that point, the subject used the instructions provided and on-screen help provided by the software to progress through the experiment. The software was written by the experimenters. The debriefing phase involved filling out a brief questionnaire attached to the instruction booklet.

## D. Subjects

### 1. Choice of subjects

The experiment was conducted with sixty subjects at the Naval Postgraduate School. Each subject participated individually. Each participant was assigned to one of four cells of subjects. These four blocks are described in Figure 1. Subjects were assigned to one of four between-subjects conditions and one of three within-subjects conditions. Randomization was ensured in both of these assignment procedures.

Information of demographics and task specific factors that may impinge on the results of the experiment was collected. Demographic factors studied for interaction in the experiment include: age, sex, full-time work experience, familiarity with computers, and time lapse since undergraduate study. The task-specific factor was related to whether the subject had any previous experience in the task.

**2. The use of students as subjects**

One limitation of the study centers around the use of students in a laboratory environment. All participants had a minimum of four years management experiment. The issue is the extent to which it is possible to make a reasonable comparison between the subjects of the experiment and real-life decision makers.

Previous research using graduate students as surrogates for managers failed to find any significant difference between the two groups in making production scheduling decisions. It is reasonable to assume that graduate students are acceptable as representative of decision makers.

It is difficult to claim external validity for laboratory studies. The bulk of the research conducted in support of the premises which frame the research question is conducted in a laboratory setting. The similarities between other research in the area of irrelevant research and this research indicates that it is no less suitable for generalization to real-life.

**E. Task**

The following section describes in detail the experimental task (see Appendix). Also described are the different task environments in which subjects groups performed.

**1. Description**

The instruction booklet given to each subject varied based on the task. Subjects allowed to use cognitive feedback were given additional instructions describing the different types of feedback at their disposal and the function keys to access them. The debriefing questionnaire was also different for the two different types of subjects. The only difference in the debriefing questions pertained to how useful the subject found the types of feedback were in making their decision rules.

The task presented to the subject was a candidate screening scenario. The subject was given a set of three cues representing three scores of a potential job applicant. The three scores ranged from 1 to 9. Each of the three scores represented an applicants score or rating on each of three variables or conditions: experience relevant to the position (variable 1), general abilities test score (variable 2), and interviewer rating of management abilities (variable 3).

Based on these ratings the subject was then required to award an overall rating of these candidates on a scale of 1 to 9.

In the training phase these sets of three cues were presented to the subject one set at a time. The subject gave his response and the committee score was then shown. In the experimental phase, the sets of cues were blocked into groups of 26 applicants. This allowed for the subject to see the effects of his policy over several cases. There was no irrelevant cue in the training phase.

## F. Feedback

The use of cognitive feedback was provided to half of the subjects in the experiment. Feedback was explained to the subject and made available. It was given to the subject only *on request*, and was available in a variety of forms. The various types of feedback are described in the next sections.

### 1. Subject policy feedback

The purpose of policy feedback is to allow the subject to see the policy he is using in order to refine and improve upon it. This type of feedback was presented to the subject in the form of a bar graph. Each cue was represented on the bar graph in a different color or shade (see Figures 2 and 3 below). The size of each shade was determined by the weight that the subject was placing on this variable in arriving at his overall score for the applicant. If the cue has negative value, i.e. a high score in a variable would lower the overall

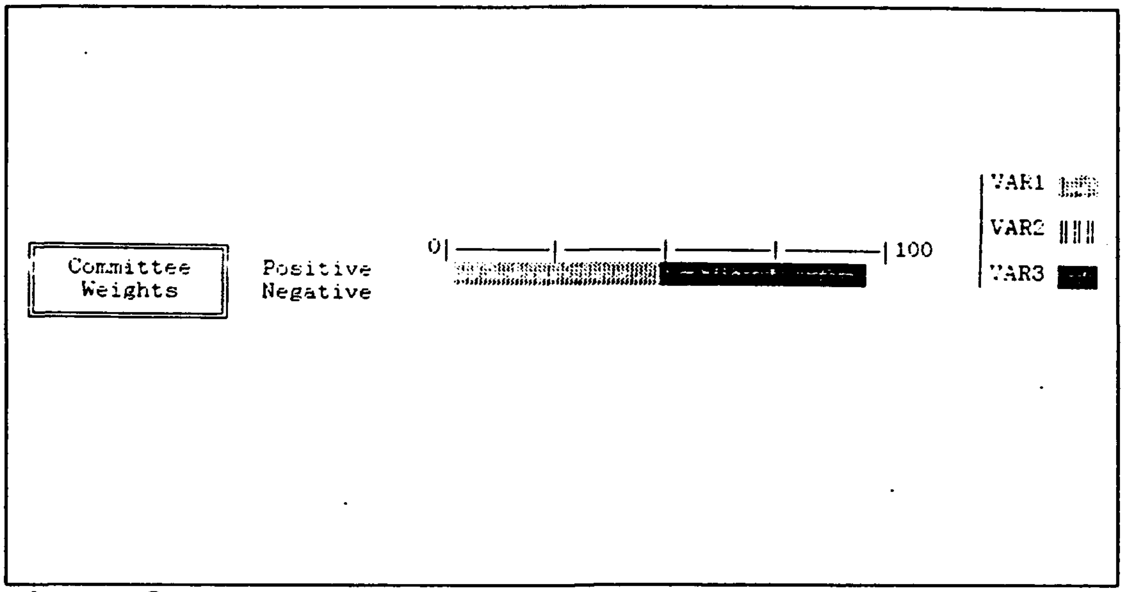

**Figure 2**

score, it was shown in appropriate size for its negative weight, but below the positive values.

In previous research conducted on representation of cognitive feedback, it was found that visual information was the most useful to the subject (Doherty and Balzer, 1988). Hammond (1971) stressed the importance of giving the subject a picture of his cognitive processes. For this reason, the graphical representation shown in the above figure was used. Each of the three cues was clearly distinguishable, making the figure clear and easy to understand.

Cue weights were calculated as follows:

(a) Beta weights were calculated from a multiple regression of cue values and the subject's estimates.

(b) The weights were then transformed to represent percentages of the sum of the squared weights. Thus, beta

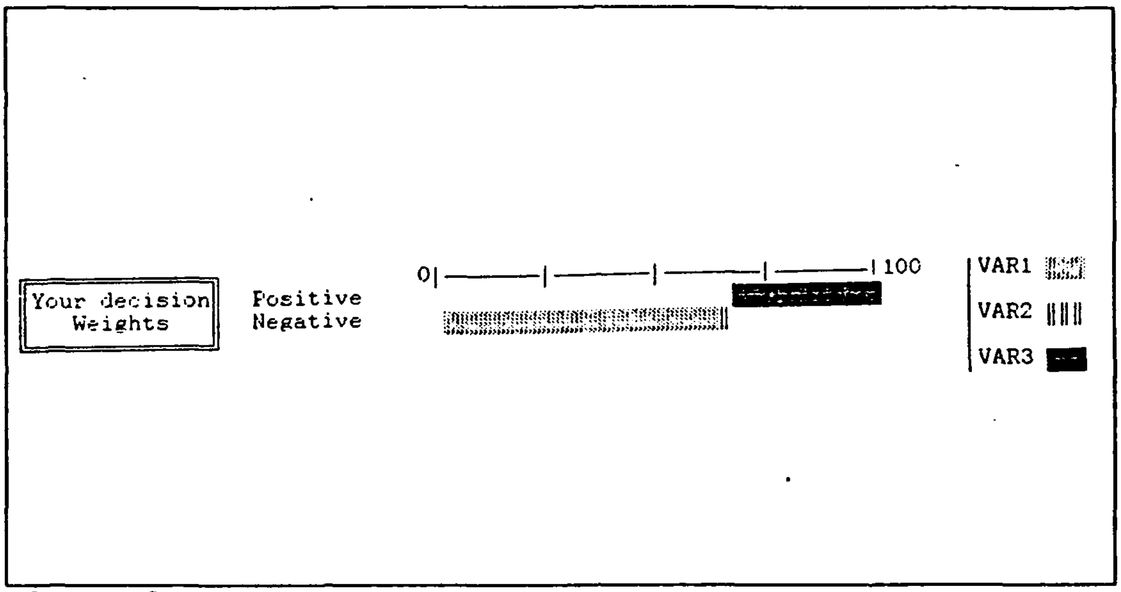

**Figure 3**

values of 0.4, 0.8, and 0.2 were shown as 0.2, 0.75, and 0.05.

(c) Transformed weights on the three cues were then displayed as a horizontal stacked bar, on a 1-100 scale (i.e., the transformed weights added up to 100).

This form of feedback is described as a type of Cognitive Information (CI) in Chapter II. This type of feedback provides the subject with the function forms that relate his/her judgment to the cues. The other type of cognitive information discussed in Chapter II is consistency information.

**2. Consistency feedback**

Consistency feedback gives the subject an indication as to how well he was conforming to his decision policy. It may not be inherently obvious that different sets of responses can generate the same policy, but one set of responses may be much more tightly grouped around the committee scores. Thus, the consistency feedback will provide the subject an indication as to how consistent he was with his mental model. It was designed also to give some assistance in improving his consistency. Both of these goals were achieved by providing the subject with consistency scores on individual cases. In other words, the subject will be given the values that he would have generated if he conformed strictly to his decision rule.

Consistency feedback is a form of CFB called cognitive information (CI) by Doherty and Balzer (see section 2.4.) In terms of the lens model, consistency information is $R_s$ or $R^2_s$. It can be expressed in terms of the correlation indices of predictability of the subject. The use of consistency "scores" was chosen to make it easy for the subject to understand and use.

Consistency scores were calculated as follows:

(a) First beta weights were derived from a multiple regression of cue values and the subject's estimates.

(b) Criterion values were computed by multiplying cue values with respective beta weights.

3. **Committee decision policy**

The purpose of this type of feedback was to provide the subject with a reference to model his policy after. It was stated in the instructions that the purpose is to model the decisions of the committee. This type of feedback was presented to the subject in the same manner that his own policy was presented, i.e. through the use of a bar graph. As before, each cue was given a section of the bar graph proportional to the weight that the committee places on that cue. In every set of cues, two of the three were weighted equally and the third was irrelevant.

This type of feedback is called task information (TI) by Doherty and Balzer (see section 2.4). It is accepted as the most useful in effecting a change in behavior. This information provides the subject the function forms relating the criterion to the cues.

**4. Outcome feedback**

The purpose of this type of feedback was to provide the subject some indication as to his performance, also known as the committee score. This form of feedback was presented to the subject as a single number value. This value was calculated by summing the result of multiplying each cue by its beta weight. This type of feedback gives the subject an indication of his achievement. This value is denoted as $R_{\alpha}$ in the lens model.

**5. Combined feedback**

The purpose of this feedback was to allow the subject to view two different types of feedback at one time. For example, the subject can ask to see the committee policy and his own policy side by side. This was a convenience provided the subject to allow him the best conditions for refining his policy. The types of combined feedback allowed to the subject are: committee and subject policy rules, information on subject decision rule and consistency.

#### 6. Multiple requests for feedback

The subject was allowed to request feedback many times. The only restraint on this was that once a subject has requested outcome feedback, he may no longer make revisions to those scores for which the committee score was given.

### G. Training

#### 1. Basis for training

The purpose of training in the experiment was ensure that all of the subjects begin the experiment with the same knowledge of the task. Due to the context of the experiment, some subjects may come into the experiment with some preconceived ideas about which variables should have greater weights in their policy, i.e. some may feel that the interview score is more important than job experience. In the training phase, all cues were weighted equally (there was no irrelevant cue). At the end of the training phase, all subjects should have adequate knowledge of the task to perform well.

### 2. Training procedure

During the training phase, all subjects received the same set of data. Each subject was asked to respond to 70 cases. The subject was required to give each candidate an overall score from 1 to 9. This was followed by the actual committee score. The cues, subject response, and committee score would remain on the screen until the subject presses a key to bring on the next set. Thus, the subject could take as long as he needed for the training but could only view one case at a time.

## H. Experimental phase

### 1. Experimental procedure common to all subjects

The experiment was conducted over three blocks of twenty-six cases each. The order in which these blocks were presented to the subject was randomized in order to discount the effect of order effects. Appendix A contains details of the instructions given to each of the subjects at the beginning and end of the experiment. Each block required the subject to perform a repetition of one type of task. Each subject would sit at the terminal and read the introductory screen explaining how to progress through the experiment. After pressing a key, the subject was presented with twenty-six sets of three cues. The screen was split down the middle so that thirteen cases appear on each side. Each cue represents a value as described in section C.1. The subject was allowed to make an overall evaluation of the candidate and award a score between 1 and 9. The subject may use the arrow keys to move from one case to another. No requirements exist that require the subject to evaluate the cases in order.

2. **Use of cognitive feedback**

After ten scores have been filled in by the subject, he can request one of the types of feedback as described in section 3.5. To view the options for feedback, the subject need only press the END key. If no feedback was required, the subject may return to the experiment by pressing the N key. The subject may request outcome feedback at any time, but may no longer change his scores after doing so. When all cases have been evaluated, the subject again presses the END key and then was led through a series of questions to ensure that he was through with the block and then the next block was presented. No time limit was placed on the subject. After completion of each block, the subject was required to fill out a short questionnaire.

## I. Debriefing

The objective of the debriefing phase was to have the subject provide a description of his own policy and thought processes as he progressed through the experiment. Information provided in this section will give insight into how the subjects viewed different aspects of the experiment. The debriefing results will provide the experimenter information concerning how clear all phases of the experiment were to the subjects.

## J. Summary

This chapter explained the experimental environment. Of special interest in this chapter are the following points:

(1) The experiment included four different groups of fifteen subjects each. Within each of these groups, the subjects were further differentiated by the order in which the blocks were presented. This is to discount order effects, should one block of data be significantly different from another.

(2) The first phase of the experiment was the training phase. The purpose of this phase is to ensure that all subjects enter the experiment with equivalent knowledge of the task and no prejudices about the simulated task were carried into the experiment. The training consisted of seventy-two trials.

(3) Cognitive feedback was provided (for half the subjects) in three different forms: subject policy information, subject consistency information, and committee policy information.

(4) Subjects all performed the same task in the simulation. They evaluated potential job candidates based on three values: work experience, test scores, and interview score. Outcome feedback was provided for all subjects upon request.

## IV. RESULTS

### A. Statistical Model

The following analysis of variance (ANOVA) model suited for multiple Latin Squares was used to test hypothesis:

$$Y_{ijk(l)}m = \mu + \alpha_i + \beta_j + \Gamma_k + x_l + \sigma_m + (\Gamma x)_{kl} + (\Gamma\alpha)_{ki} + (\Gamma\beta)_{kj} + e_{ijk(l)m} \quad \text{where:}$$

$\mu$ is constant,

$\alpha_i$ is the sequence of experimental tasks (see Chapter III, p.21),

$\beta_j$ is the order of the task ($j = 1,\ldots 3$),

$\Gamma_k$ is the feedback condition,

$x_l$ is the experimental task (i.e., cue 1 irrelevant, cue 2 irrelevant, etc.),

$\sigma_m$ is the experimental participant (or subject, $m = 1,\ldots,53$), and

$e_{ijk(l)m}$ is the experimental error term.

This model was run for lens model indices achievement ($R_a$), consistency ($R_s$), and matching (G), and number of iterations (ITER) performed by the subject within a block. The analyses were conducted on SAS[R] statistical software, using the General Linear Models procedure. The general linear models procedure was chosen because the number of subjects assigned to each condition varied. The assignments of subjects to blocks was as follows: CFB/H = 12, CFB/L = 14, OFB/H = 13, OFB/L = 12.

## B. Results

### 1. Training

The results of the training phase are summarized in table 1. The same dependent variables were analyzed in the training phase data. Different sets of cues were given to the subjects in the training phase based on assignment to task predictability conditions (i.e. all subjects in the high predictability conditions received the same cues in the training phase). All subjects received one block of decisions during the training phase. The only significant effects seen in the training data was a significant variance between groups (high/low predictability) in the training phase. Analysis of training phase data is displayed in Table 1.

### 2. Experimental Results

Tables 2 - 6 summarize the means and standard deviations for all of the independent variables for the experimental phase. Graphical representation of this data is provided for each set of data in the tables.

#### a. *Means and Standard Deviations*

*Achievement*

Achievement is the measure of the agreement between the criterion values and responses of the subject over *n* observations. An inspection of the means for achievement (RA)

## Table 1 TRAINING DATA ANALYSIS

| Class | Levels | Values |
|---|---|---|
| GROUP | 4 | CFB/H CFB/L OFB/H OFB/L |
| SEQ | 3 | 1 2 3 |

Number of observations in data set = 53

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| **Dependent Variable: RA** | | | | | |
| Model | 11 | 0.490 | 0.0446 | 4.07 | 0.0005 |
| Error | 41 | 0.449 | 0.0109 | | |
| Crctd Total | 52 | 0.939 | | | |
| GROUP | 3 | 0.4096 | 0.1365 | 12.48 | 0.0001* |
| SEQ | 2 | 0.0123 | 0.0062 | 0.56 | 0.5733 |
| GROUP*SEQ | 6 | 0.0682 | 0.0113 | 1.04 | 0.4141 |
| **Dependent Variable: G** | | | | | |
| Model | 11 | 0.010 | 0.0009 | 0.79 | 0.6478 |
| Error | 41 | 0.048 | 0.0012 | | |
| Crctd Total | 52 | 0.058 | | | |
| GROUP | 3 | 0.005 | 0.0017 | 1.50 | 0.2277 |
| SEQ | 2 | 0.0017 | 0.0008 | 0.72 | 0.4949 |
| GROUP*SEQ | 6 | 0.0032 | 0.0005 | 0.46 | 0.8345 |
| **Dependent Variable: RS** | | | | | |
| Model | 11 | 0.0918 | 0.0080 | 0.97 | 0.4896 |
| Error | 41 | 0.3537 | 0.0090 | | |
| Crctd Total | 52 | 0.4454 | | | |
| GROUP | 3 | 0.0321 | 0.0107 | 1.24 | 0.3064 |
| SEQ | 2 | 0.0130 | 0.0065 | 0.76 | 0.4763 |
| GROUP*SEQ | 6 | 0.0466 | 0.0078 | 0.90 | 0.5036 |

* - Significant at 0.05 level

## Table 2 MEANS AND STANDARD DEVIATIONS FOR ACHIEVEMENT

| Group | Block 1 | Block 2 | Block 3 |
|---|---|---|---|
| CFB/H | .841(.106) | .818(.192) | .864(.131) |
| CFB/L | .576(.207) | .607(.137) | .609(.149) |
| OFB/H | .768(.117) | .744(.081) | .709(.105) |
| OFB/L | .502(.169) | .470(.231) | .457(.183) |

* Mean(St.Dev.)

in Table 2 show that subjects in the CFB/H condition had the highest degree of accuracy. The graphical representation of this data, in Figure 4, shows that achievement in the cognitive feedback conditions improved in consecutive blocks while achievement declined in both outcome feedback conditions. This result supports $H_1$ as discussed in Chapter III. From the graph and the table it is also clear that for subjects within the same feedback condition, those in the high predictability condition had higher values for achievement than those in the low predictability condition. This supports $H_2$ as discussed in Chapter III.

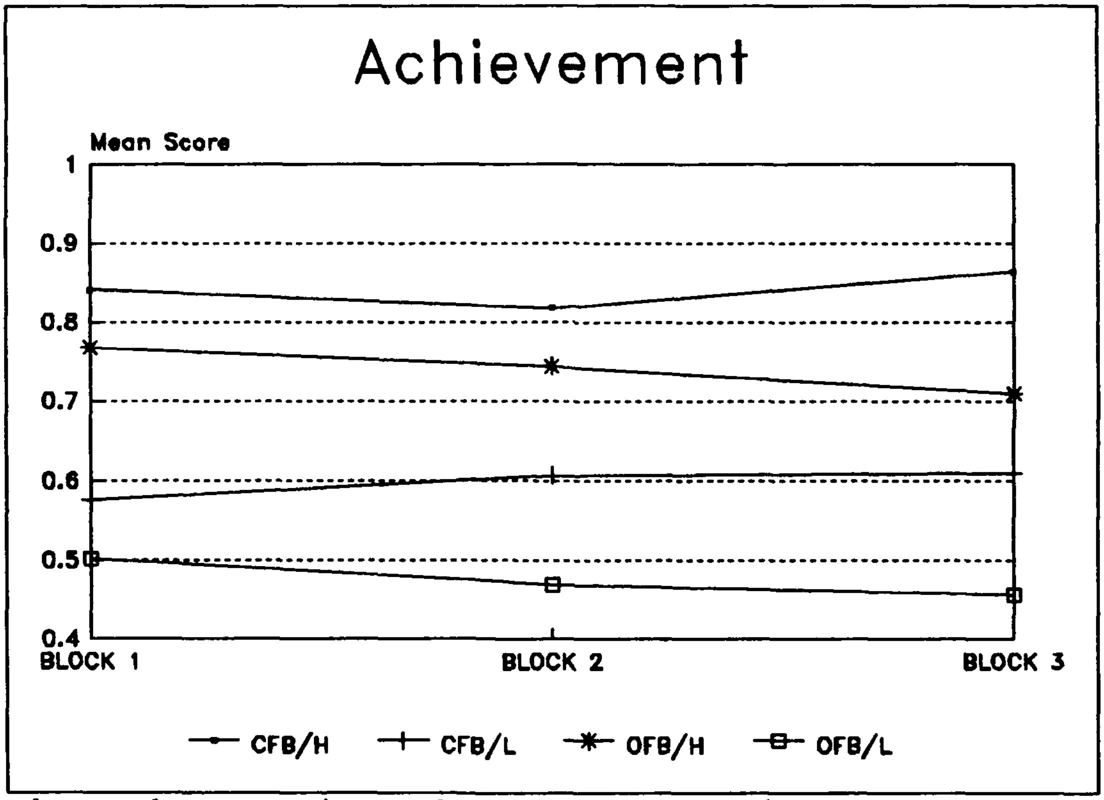


**Figure 4** Experimental results for achievement

*Consistency*

Consistency is defined as the multiple correlation between the cues and the criterion. Consistency for a subject is calculated from estimates made by the subject in his/her final iteration in a given block. The values for consistency in Table 3 indicate that subjects in the CFB conditions were the most consistent in the utilization of their decision rules, as defined by the multiple regression equation. The graphical representation of this data, in Figure 5, shows that consistency improved in subsequent blocks in the cognitive feedback condition.

**Table 3 MEANS AND STANDARD DEVIATIONS FOR CONSISTENCY**

| Group | Block 1 | Block 2 | Block 3 |
|---|---|---|---|
| CFB/H | .914(.086) | .911(.077) | .944(.032) |
| CFB/L | .914(.046) | .885(.107) | .923(.053) |
| OFB/H | .898(.045) | .886(.049) | .866(.073) |
| OFB/L | .867(.101) | .839(.105) | .840(.117) |

* Mean(St.Dev.)

The highest mean for consistency was found in the CFB/H Block 3 condition, while the lowest was found in the OFB/L Blocks 2 and 3 condition. Subjects in the CFB condition tended to become extremely consistent in the final block, with very little variation, as indicated by the small standard deviation.

*Matching*

Matching is defined as the correlation between model estimates of the subject with the model of the environment (committee policy). The values for matching in Table 4

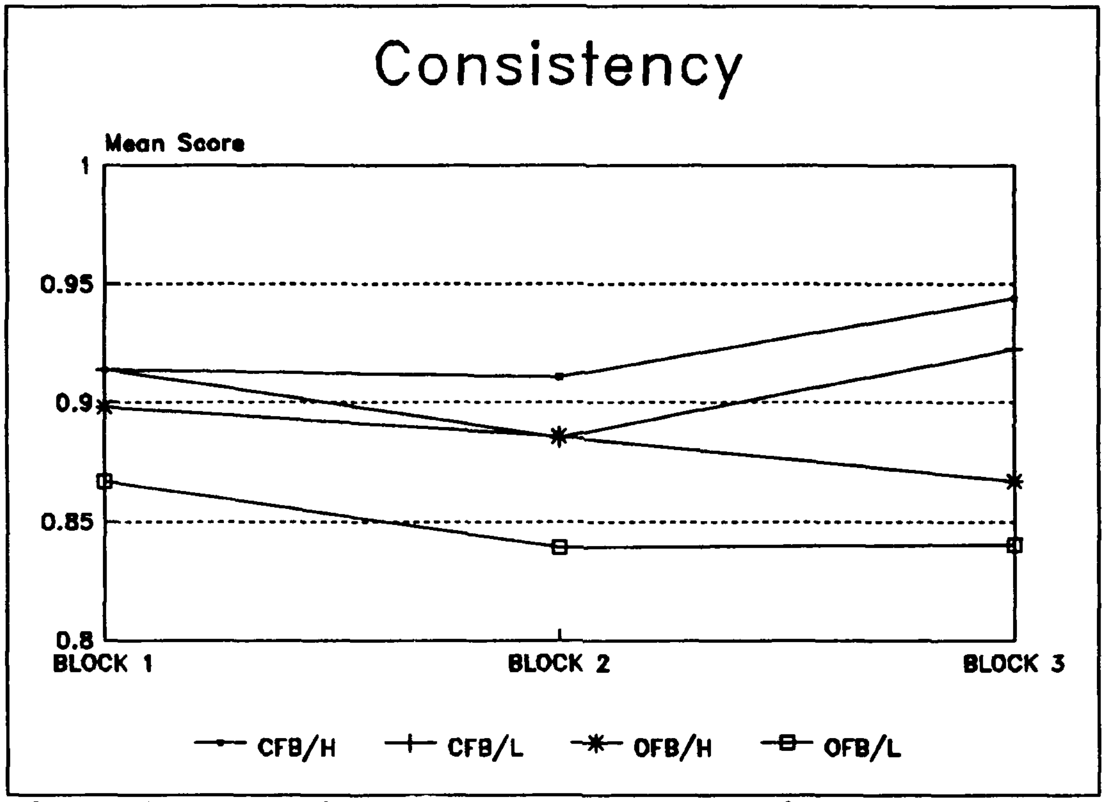


**Figure 5** Experimental results for consistency

indicate that subjects in the high predictability had the greatest success in matching the committee policy with their own policy. Graphical representation of this data, in Figure 6, shows that matching was best with cognitive feedback and high predictability conditions. The higher degree of matching between subject and committee in the cognitive feedback condition support $H_1$ as suggested in Chapter III.

For cognitive feedback - low predictability conditions, matching improved with each subsequent block. It should be noted that although the matching index was on the average higher in the OFB/H condition than in the CFB/L condition, in the third block subjects in the CFB/L condition

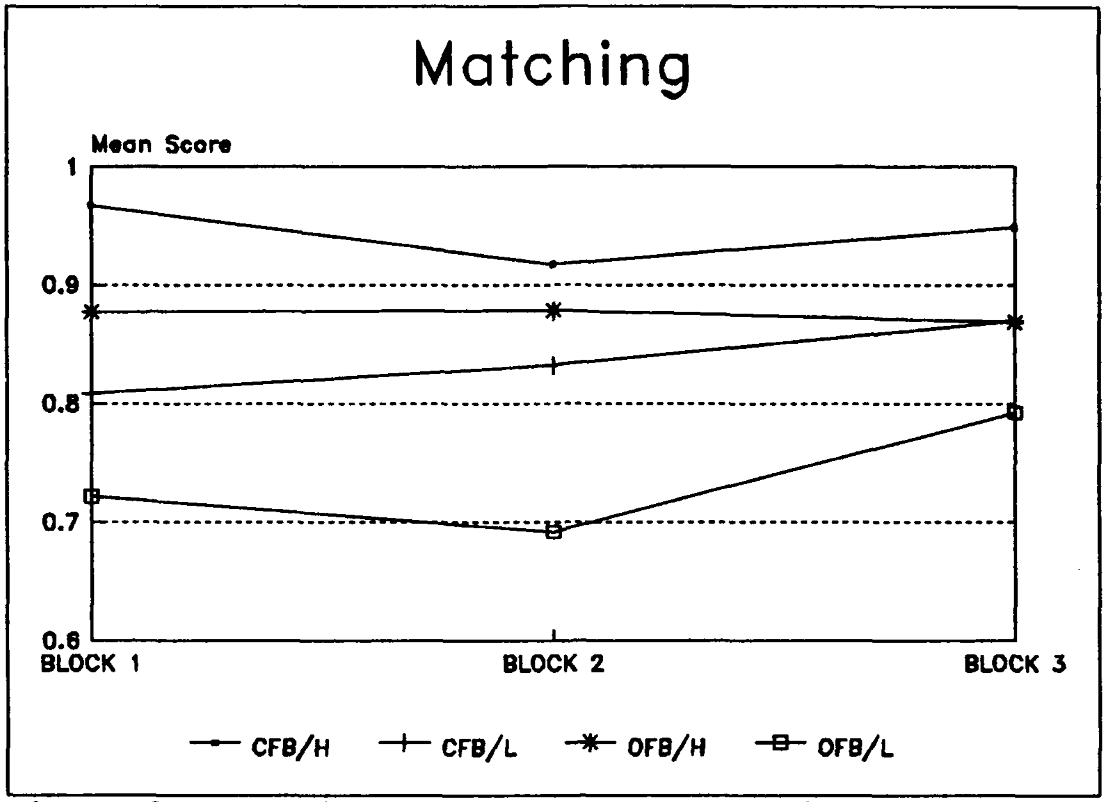


**Figure 6** Experimental results for matching

**Table 4 MEANS AND STANDARD DEVIATIONS FOR MATCHING**

| Group | Block 1 | Block 2 | Block 3 |
|---|---|---|---|
| CFB/H | .967(.040) | .917(.032) | .948(.120) |
| CFB/L | .809(.201) | .832(.162) | .870(.157) |
| OFB/H | .877(.148) | .878(.075) | .869(.111) |
| OFB/L | .722(.181) | .692(.273) | .793(.099) |

* - Mean(St.Dev.)

were able to surpass the matching ability of subjects in any of the OFB conditions.

*Iteration*

Iteration is described as the number of times that a subject requests feedback in a given block. The data in table V indicates that subjects in the cognitive feedback condition

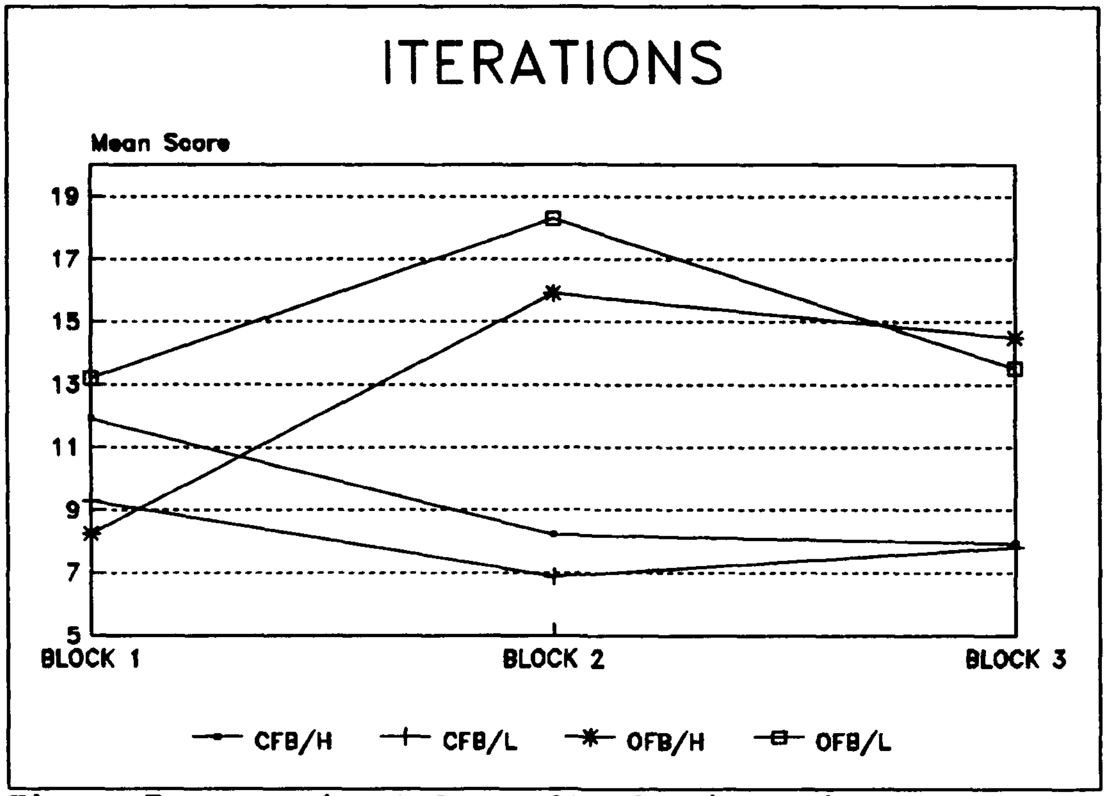


**Figure 7** Experimental results for iteration

completed each block in the fewest number of iterations. This observation does not indicate that the subjects in the cognitive feedback conditions completed the blocks in the shortest amount of time. The graphical representation of this data is in Figure 7.

**Table 5 MEANS AND STANDARD DEVIATIONS FOR ITERATION**

| Group | Block 1 | Block 2 | Block 3 |
|---|---|---|---|
| CFB/H | 11.9(7.90) | 8.21(4.92) | 7.93(3.71) |
| CFB/L | 9.29(7.18) | 6.86(4.00) | 7.79(5.54) |
| OFB/H | 8.23(7.63) | 15.9(8.97) | 14.5(7.37) |
| OFB/L | 13.29.86) | 18.3(10.4) | 13.5(9.28) |

* Mean(St.Dev.)

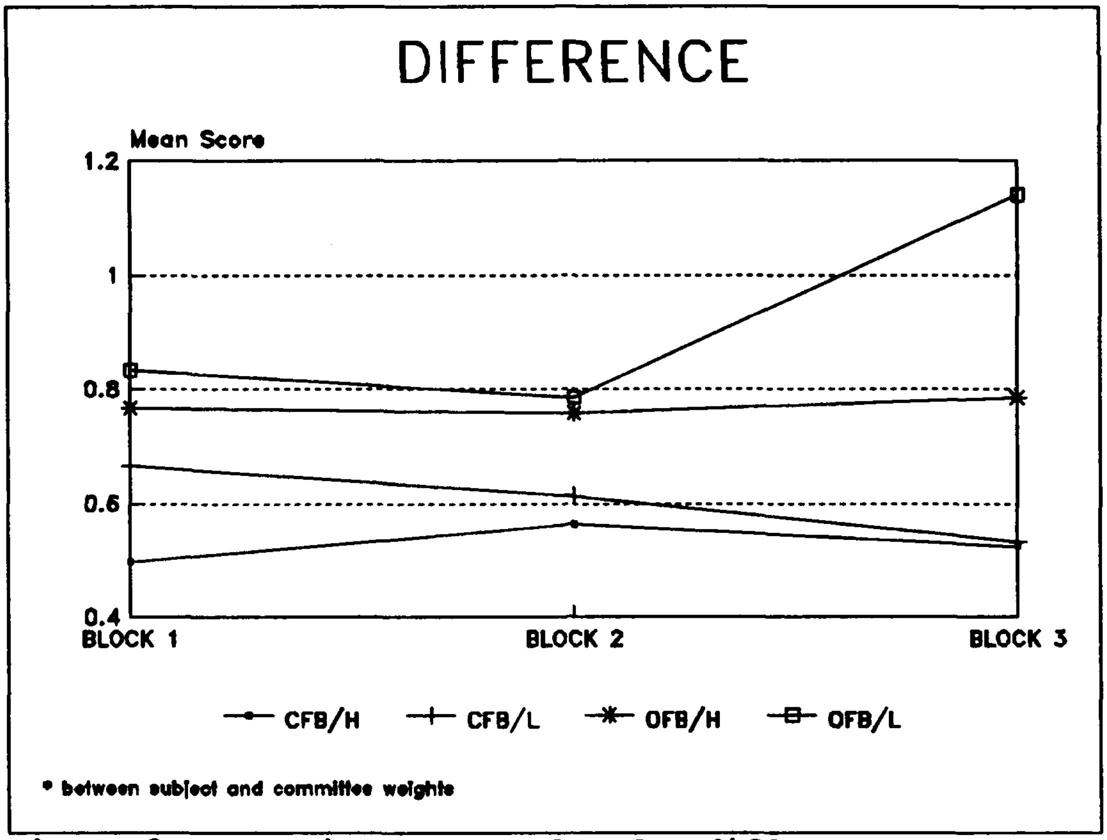


**Figure 8** Experimental results for difference

*Difference*

Difference is described as the difference between the weights used by the subject and the committee weights. Thus, a small value for DIFF would indicate that the subject utilized similar cue weights as the committee. This value is smallest for subjects in the cognitive feedback condition. Graphical representation of this data is found in Figure 5.

The means for achievement indicate that the main effects are due to groups (task condition) and subject (variations from one subject to another). The same is true for consistency and matching.

**Table 6 MEANS AND STANDARD DEVIAITONS FOR DIFFERENCE**

| Group | Block 1 | Block 2 | Block 3 |
|---|---|---|---|
| CFB/H | .497(.193) | .563(.287) | .524(.250) |
| CFB/L | .666(.292) | .613(.314) | .531(.263) |
| OFB/H | .767(.311) | .758(.209) | .785(.278) |
| OFB/L | .834(.277) | .863(.413) | 1.14(1.29) |

* - Mean(St.Dev.)

### b. *ANOVA Results*

The ANOVA was conducted on the same variables in the previous section, namely: RA, RS, ITER, G, and DIFF. The results of the ANOVA are summarized in tables 7-9.

**Table 7 ANOVA RESULTS FOR ACHIEVEMENT**

| Source of Variation | DF | Sum of Squares | F Value | Pr > F | R-Square |
|---|---|---|---|---|---|
| Model | 62 | 4.75825204 | 3.95 | 0.0001* | 0.718280 |
| GROUP | 3 | 2.99613739 | 51.37 | 0.0001* | |
| BLOCK | 2 | 0.00370189 | 0.10 | 0.9093 | |
| SEQ | 2 | 0.08812805 | 2.27 | 0.1092 | |
| TASK | 2 | 0.03695659 | 0.95 | 0.3901 | |
| LNAME | 47 | 1.57564399 | 1.72 | 0.0125* | |
| GROUP*BLOCK | 6 | 0.05768413 | 0.49 | 0.8110 | |

* - Significant 0.05 level

The ANOVA for accuracy (RA) showed significant main effects for group (p,0.0001) and participant ($p<0.05$). Variances in accuracy not found to be significant were between blocks, sequence, task, and group-block.

ANOVA for matching (G) showed that the variance of matching was significant in the same categories as consistency, groups (0.0001) and last name (0.0196). Matching did not vary significantly in any other conditions tested.

**Table 8 ANOVA RESULTS FOR ACHIEVEMENT**

| Source of Variation | DF | Sum of Squares | F Value | Pr > F | R-Square |
|---|---|---|---|---|---|
| Model | 62 | 0.66091699 | 2.84 | 0.0001* | 0.647277 |
| GROUP | 3 | 0.11970669 | 10.64 | 0.0001* | |
| BLOCK | 2 | 0.00897107 | 1.20 | 0.3070 | |
| SEQ | 2 | 0.00463097 | 0.62 | 0.5416 | |
| TASK | 2 | 0.03546305 | 4.73 | 0.0110* | |
| LNAME | 47 | 0.46653530 | 2.65 | 0.0001* | |
| GROUP*BLOCK | 6 | 0.02560992 | 1.14 | 0.3465 | |

* - Significant at 0.05 level

ANOVA for consistency showed that variance was significant between groups (0.0001), task (0.011), and last name (0.0001) Consistency did not vary significantly between blocks, sequence, or group-block.

**Table 9 ANOVA RESULTS FOR MATCHING**

| Source of Variation | DF | Sum of Squares | F Value | Pr > F | R-Square |
|---|---|---|---|---|---|
| Model | 62 | 2.68665623 | 2.20 | 0.0002* | 0.587311 |
| GROUP | 3 | 0.87393415 | 14.81 | 0.0001* | |
| BLOCK | 2 | 0.04132201 | 1.05 | 0.3537 | |
| SEQ | 2 | 0.09566424 | 2.43 | 0.0932 | |
| TASK | 2 | 0.08119316 | 2.06 | 0.1325 | |
| LNAME | 47 | 1.52604186 | 1.65 | 0.0196* | |
| GROUP*BLOCK | 6 | 0.06850081 | 0.58 | 0.7450 | |

* - Significant at 0.05 level

### c. *Scheffe's Test*

Scheffe's Test is a posterior test performed to determine if differences within a variable are significant enough to account for observed differences in experimental results. Scheffe's test was performed between the following variables and all possible combination of task conditions: RA, G, RS, ITER.

In achievement, Scheffe's Test indicated that the means were significantly different from each other ($p < 0.05$) between all task conditions. In matching, Scheffe's Test indicated that means were significantly different ($p < 0.05$) in all conditions except when compared between CFB/H - OFB/H and CFB - OFB/H. In consistency, all means were significantly different at the same level except when compared between CFB/H - CFB/L, CFB/L - OFB/H, and OFB/H - OFB/L.

# V. CONCLUSIONS

## A. Scope

The purpose of this chapter is to revisit the research topics discussed in earlier chapters in light of the results of this research. The limitations of this research and the potential impact on potential research will be included in this chapter. This chapter also discusses the conclusions of the research in terms of the majors areas of study with which it deals: information relevance and cognitive feedback; and limitations of this research. The chapter ends with a discussion of the relevance of this thesis to research in computer systems.

## B. Conclusions

### 1. Previous Research

We argued previously that while research in information relevance was abundant, research in finding means of reducing the effects of irrelevant information is an important next step. In addition to this research, an example of such an effort is the research done by Gaeth and Shanteau (1984).

The results of the research performed by Gaeth and Shanteau is particularly of importance in terms of improving decision quality in environments where irrelevant information is present. In their research, training was found to be an effective measure in improving experienced decision makers decision quality, by reducing the effects of irrelevant information. Similarly, in this research, the use of cognitive feedback was shown to be effective as well in improving decision quality when irrelevant information was present.

### 2. Research Question

The question posed by this study was: given that irrelevant information serves as a detriment to decision quality, can the use of cognitive feedback reduce the adverse effects of this detriment.

## C. Findings of the study

*Lens Model Indices*

Decision quality was operationalized in terms of the following three lens model indices: achievement, consistency, and matching.

- *Achievement*: Achievement was shown to be the highest in conditions where subjects in the high predictability task environment received cognitive feedback. Achievement improved in subsequent blocks in the cognitive feedback condition while declining in the outcome feedback condition.
- *Matching*: Subjects receiving cognitive feedback recorded higher matching index than those receiving only outcome feedback.
- *Consistency*: Consistency was highest for subjects in the cognitive feedback conditions. Further, for subjects in

the cognitive feedback condition consistency improved in subsequent blocks.

### D. Application of Cognitive Feedback

Brehmer has been a major contributor to research concerning cognitive feedback. His work emphasizes the importance of cognitive feedback to the point of dismissing outcome feedback entirely. Only cognitive feedback can give a person insight into relations between variables. Further, only cognitive feedback is of use in describing subject consistency.

In support of Brehmer, Doherty and Balzer state that the human learning process is imperfect - "we need help" (Doherty and Balzer, 1988) Their research also points out the strong link between consistency and cognitive feedback.

Cognitive feedback can be operationalized in three forms (discussed in chapter two): task information, cognitive information, and functional validity information. Various research on cognitive feedback has stressed each of these as important in different instances. While there has been some agreement in the research, it is clear that future research should focus on the distinctions between these forms of cognitive feedback and the importance of each.

The use of technology in the application of cognitive feedback is an exciting enterprise with potential for enormous growth. Personal decision support systems designed to assist the user in decisions such as major purchases or solving interpersonal problems are within the realm of possibility in the near future. Providing the user with insight into his or her decision processes, with the promise of improving decision quality, is appealing to designers in a variety of areas.

## E. Limitations and Recommendations for Further Research

It is in the best interest of the experimenter to control and limit the scope an experiment in order to reduce the chance of numerous interaction effects or effects which cannot be explained by manipulation of the dependent variables. The loss associated with the gains of control of scope is that only a small part of a large picture may be examined at one time. The issues addressed in this section are the rest of the picture - those issues which bear some significance to the research topics but extend beyond the scope of this research

### 1. Information Relevance

From previous research on information relevance is clear as to the adverse effects associated with irrelevant information. Other aspects of information relevance are less clear from the research completed to date. Further research should direct emphasis upon the following points:

- Given that subjects in more predictable task environments are less affected by irrelevant information, where and why is this distinction seen? Why is cognitive feedback more effective in more predictable environments.
- How does an individual determine which information is relevant and which is not? Do methods for sorting

information based on relevance increase in complexity as the information itself increases in complexity?

- Overcoming the adverse effects of irrelevant information in decision making tasks.
- The impact of training in improving task performance in task environments where irrelevant information is present.

### 2. Cognitive Feedback

One limitation to experimental research on cognitions and policy formation is that an experimental setting leads subjects to form policies and cognitions differently than in the real world. One example of such is knowledge acquisition. In this research, for example, the subject is given three cues from which he must make a decision. The subject has *a priori* knowledge that he will be given sets of cues. He is not expected to do anything to get this information. This aspect of the experimental setting is different to the way in which individuals gain knowledge in the real world. In other words, an experimental subject may be led to know that he or she is expected to form a policy, and may even be led as to what form of policy is expected.

Another limitation of the study of human cognitive processes stems from the use of the Lens Model. The Lens Model, while an accepted model for studying human behavior, is rigid and limits the results to the confines of a finite number of coefficients.

Cognitive feedback studies thus far (including this research) have not explored *how* decision makers use cognitive feedback (perhaps because of the difficulty foreseen in operationalization). For example, when and why does a decision maker request feedback? Is feedback used to confirm an idea more effective than feedback used initially? What type of decision makers benefit the most from the different types of feedback?

An area for further research is the use of cognitve feedback in conjunction with training to assist people to detect irrelevant information. The results of the work done with training discussed in this thesis indicates that there is great promise in this venture.

## F. Relevance to Research in Computer Systems

One main thrust of research in computer systems is in decision support systems. The technology in decision support systems has reached a point where the competition is no longer between the capabilities of the hardware or the power of the coding. The limiting facto. in most interactive software is the user. Thus, the area of the most potential for growth or additional understanding is in putting more power in the hands of the user.

Conversely, power can be taken from the hands of the user of a decision support system through the presence of irrelevant information (supported by this research). The use of cognitive feedback shows great promise in the field of decision support systems. Fundamental to this is a greater understanding of the human cognitive process.

## G. Summary

The intent of this research has been to study decision making across different task situations. Through the employment of cognitive feedback, this study has shown that human decision making processes may be enhanced by simple decision aids. This result contributes to the knowledge base which deals with cognitive processes and decision making. A great deal is still unknown about the way humans make decisions. However, from this research and others, advances can be made in design technology for computer based decision tools.

# APPENDIX

The following appendix is the instruction set given to subject to guide them in completion of the experiment. The instruction set contained additional information for subjects in the cognitive feedback conditions. This additional information will be in bold.

YOUR NAME : ______________________________
SMC NO. : ______________________________

DESCRIPTION OF THE SIMULATION

* This simulation seeks to gain an understanding of how decision makers use information for making decisions. To investigate the use of information, we are asking a number of subjects to participate in a variety of business simulations. The task in this simulation involves screening applicants for a set of positions in a large software company. You are required to make decisions based on data presented to you. The simulation has three parts.

Part one is the training session. The objective here is to give you some practice on how to make decisions in this task.

Part two is the main, or, experimental phase. In this phase, you make decisions based on an actual set of cases.

Part three is the debriefing phase.

* You will be given a set of instructions at the beginning of each part.

* A brief questionnaire is to be filled out at the end of each part.

* The simulation will be run on a computer terminal. At all times, the bottom row of the screen will prompt you about what to do next.

* Please follow the guidelines strictly. The system prompts, along with instructions in this booklet, will guide you at every stage.

* When in doubt, ask the experimenter.

*** please turn over for further instructions ***

PART I: TRAINING

INSTRUCTIONS

* A large software company periodically recruits personnel for a variety of positions. The hiring decisions are made from a large pool of applicants. Because the number of applicants is large, the task of hiring is split into two stages:

First, a committee made up of experts from the human resource division screens the candidates.

The results of the screening exercise are sent to individual departments. These departments then conduct further interviews and make the final hiring decisions.

* The simulation focuses on the first part of the hiring task, i.e., screening candidates. In the training phase of the simulation, the committee of experts would like to train you, so that you can perform the screening task in the same way as they do. The objective of the training is to ensure that your decisions match decisions they would have made.

* The committee of experts uses the following three variables in screening a particular candidate:

Variable 1: Experience relevant to the position.
Variable 2: General abilities test score.
Variable 3: Interviewer rating of management abilities.

Decisions you make must also be based on these three variables only.

* Each variable is presented to the committee (and therefore, to you) as a range of values between 1-9, where the values imply the following:

1 ■——————■ 9
Very Poor ... Very Good

* You will be given profiles of several applicants. The profile of each applicant will be presented as a set of values on the three variables described above. This simulation requires you to rate the candidate on an overall basis, on a scale of 1-9, wherein:

1 ■————————————————■ 9
Very Poor ... Very Good

For Example,

| Variable 1 (given) | Variable 2 (given) | Variable 3 (given) | Dec. Maker's Score |
|---|---|---|---|
| 9 | 6 | 8 | 7 |
| 4 | 8 | 9 | 6 |
| . | . | . | ? |
| . | . | . | ? |
| . | . | . | ? |

etc.

For the first candidate, Variable 1 had a 9, Variable 2 had a 6, and Variable 3 an 8. The decision maker gave an overall score of 7 for the candidate. And so on. (By the way, the scores given above are just random, and not examples of actual values the committee would have given).

* In the training phase, you will be given several cases (i.e., candidates), one at a time. After you enter a score on each case, the system will provide you with the actual value given by the committee (on the right hand side of your score).

Your task is to predict the committee values as closely as possible.

* Your first predictions will probably be guesses. However, as you work through the cases, you will be able to learn the relationships between the variables and the actual committee scores. You should try to come as close as possible to the actual committee scores. The task has been arranged so that you can learn to make predictions with moderate accuracy.

As in the real world, though, predictions (of committee judgments) cannot be perfectly accurate all the time.

* After completing the task, please answer the questions that follow immediately.

*    Be sure you understand the instructions.  When in doubt, ask the experimenter.

***    You are now ready to proceed with the task    ***

Questions to be answered after completing part 1

1. Describe (in words, equation, etc) what decision rule you followed in making your estimates.

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

2. Distribute 100 points among the three variables you used for reaching your overall estimate - in accordance with the importance you assigned them (be sure the total adds up to 100).

Variable1: ______
Variable2: ______
Variable3: ______

TOTAL: ______ (out of 100)

3. How clear were the instructions regarding the task in this part of the simulation?

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| Not at all Clear | | | | | | | | Very Clear |

4. Please try to describe the thinking process you went through in making your predictions:

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

*** END OF PART 1 ***

PART 2: your decisions

INSTRUCTIONS

* You are about to start part two of the simulation. In this part, you will make decisions about some actual applicants (i.e, cases drawn from resumes of real-life applicants). The task is the same as in part 1: rating applicants on a scale of 1-9.

* You will make decisions on screening applicants for three different job positions, one position at a time. There will, therefore, be three different blocks of cases: one block for each position.

* Descriptions of the individual job positions are not presented to you, so as not to bias your decisions (remember: your task is to emulate the committee, i.e, make decisions the committee would have made). However, you do need to know that the committee may (or may not) use somewhat different decision rules for different positions.

* Since the task is for real life applicants, the system will provide you with decision feedback to help you make better decisions (i.e., to be as close to the committee scores as possible). The next few pages explain what decision feedback is and how you can use it.

* For each block (i.e., each job position), the general sequence is as follows:

1. You are given a set of 26 cases.

2. You make estimates on these cases, in any order you like.

The up and down arrows can be used for moving around the score windows (you can change your scores by simply typing over the old score).

3. If you press the END key at any point, the system will provide you with **decision feedback (however, you need to enter at least 10 scores in order to get such feedback). If, after receiving decision feedback, you would like to change any score, you can do so.**

4. Once you have entered a score, you can get information about the actual value (i.e., the committee decision) at any time, **also** by pressing the END key. However, once you have received information about the actual value for a candidate, you cannot change your score for that candidate.

* Once you have completed a block (i.e., decided on all 26 scores), press the HOME key to move to the next block. At the end of each block, please answer the questions for that block on the questionnaire.

* At every stage, the bottom row of the screen will provide you with instructions about what to do next.

* **The next few pages explain decision feedback.**

* If you have a question, ask the experimenter.

## Decision Feedback

*    **What is Decision Feedback?**

Decision feedback is diagnostic information provided by the system on your decision processes and that of the committee. You can access this feedback when making your decisions about candidates. (In order to compute the information, however, the system needs at least 10 scores from you). By accessing such feedback, decision makers can derive better insight into their decisions processes. This enables them to revise and improve their decisions (or scores, in this case) through a what-if mode of analysis.

*    **How do I use Decision Feedback in Making Decisions?**

Typically, you the decision maker, would use the feedback as follows:

1. Make some tentative decisions (i.e., candidate scores).

2. Ask the system for feedback.

3. Refine your decisions accordingly.

You may do this 1-3 sequence within a block, as many times (and with as many scores) as you wish.

*    **Types of Decision Feedback**

The system will provide you with the following 5 types of feedback:

1. Information on your decision rule:

Decision makers are sometimes unable to specify precisely, a particular decision rule (in this case, weights assigned to variables). The system will track the weights you are using (in formulating your scores), and will display them through a stacked-bar chart in figure 1.

*SEE FIGURE 2 CHAPTER III PAGE 26*

How do I use it?

1. Make sure the weights displayed are actually the ones you want applied.

2. If not, revise your scores, and see how the weights change.

3. Iterate between 1-2 till the system shows weights you actually want applied.

2. Information on your consistency:

Sometimes, after decision makers have specified their decision rule, they are unable to apply them consistently. The system will calculate the scores you would have given had you been completely consistent with your decision rule.

How do I use it?

1. Check your scores against the consistency scores.

2. Revise your scores if you need or wish to.

3. Iterate between 1-2 till your scores match with or are close to the consistency scores.

3. Information on the committee's decision rule:

Instead of trying to figure out from several examples what rule the committee is using, it is more effective if

*SEE FIGURE 2 CHAPTER III PAGE 26*

How do I use it?

1. Use the feedback to get an idea of what decision rule the committee has been following.

4. Information on the committee's decision rule and yours

This is actually a combination of feedback 1 and feedback 3. It enables you to compare your decision rule with that of the committee and thereby emulate the committee better.

*SEE FIGURE 3 CHAPTER III PAGE 27*

**How do I use it?**

**1. Check weights you have given versus weights given by the committee.**

**2. Revise your scores if you need to.**

**3. Iterate between 1-2 till your weights match with or are close to the committee weights.**

**5. Information on your decision rule and consistency**

**This is actually a combination of feedback 1 and feedback 2. The idea here is to let you revise your weights without losing your consistency at the same time.**

**How do I use it?**

**1. Make sure the weights displayed are actually the ones you want applied.**

**2. If not, revise your scores, and see how the weights change.**

**3. Check your scores against the consistency scores.**

**2. Revise your scores if you need or wish to.**

*** You are now ready to proceed with the task ***

Questions to be answered after completing BLOCK 1

1. Describe (in words, equation, etc) what decision rule you followed in making your own estimates (in this block)?

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

2. Distribute 100 points among the three variables you used for reaching your overall estimate - in accordance with the importance you assigned them (be sure the total adds up to 100).

Variable1: ______
Variable2: ______
Variable3: ______

3. How do you think the committee weighted the three variables in this block? In other words, distribute 100 points among the three variables according to how you think the committee did.

Variable1: ______
Variable2: ______
Variable3: ______

**4. In this block, did you request decision feedback at any time from the system (Y/N)? ______**

**5. If YES, try to describe how you used decision feedback in making your decisions.**

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

*** PLEASE PROCEED TO BLOCK 2 ***

Questions to be answered after completing BLOCK 2

1. Describe (in words, equation, etc) what decision rule you followed in making your own estimates (in this block)?

______________________________________________

______________________________________________

______________________________________________

______________________________________________

2. Distribute 100 points among the three variables you used for reaching your overall estimate - in accordance with the importance you assigned them (be sure the total adds up to 100).

Variable1: ______
Variable2: ______
Variable3: ______

3. How do you think the committee weighted the three variables in this block? In other words, distribute 100 points among the three variables according to how you think the committee did.

Variable1: ______
Variable2: ______
Variable3: ______

4. In this block, did you request decision feedback at any time from the system (Y/N)? ______

5. If YES, try to describe how you used decision feedback in making your decisions.

______________________________________________

______________________________________________

______________________________________________

______________________________________________

*** PLEASE PROCEED TO BLOCK 3 ***

Questions to be answered after completing BLOCK 3

1. Describe (in words, equation, etc) what decision rule you followed in making your own estimates (in this block)?

________________________________________

________________________________________

________________________________________

________________________________________

2. Distribute 100 points among the three variables you used for reaching your overall estimate - in accordance with the importance you assigned them (be sure the total adds up to 100).

Variable1: ______
Variable2: ______
Variable3: ______

3. How do you think the committee weighted the three variables in this block? In other words, distribute 100 points among the three variables according to how you think the committee did.

Variable1: ______
Variable2: ______
Variable3: ______

**4. In this block, did you request decision feedback at any time from the system (Y/N)? ______**

**5. If YES, try to describe how you used decision feedback in making your decisions.**

________________________________________

________________________________________

________________________________________

________________________________________

*** PLEASE turn over for further instructions ***

Questions to be answered after completing PART 2

**1. To what extent were the concepts of decision feedback (as explained by the instructions and the experimenter) clear to you?**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | |
| **Not at all Clear** | | | | | | | | | **Very Clear** |

**2. To what extent was decision feedback helpful in improving your own decision?**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | |
| **Not at all Helpful** | | | | | | | | | **Very Helpful** |

3. To what extent was information about the actual committee scores helpful in improving your own decision?

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
| Not at all Helpful | | | | | | | | | Very Helpful |

4. How clear were the instructions regarding the task in this part of the simulation?

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
| Not at all Clear | | | | | | | | | Very Clear |

5. Now that you have completed the task, can you think of any other factor (other variables, etc) that may have influenced you in making your decisions?

________________________________________________
________________________________________________
________________________________________________

*** END OF PART 2 ***

PART 3: debriefing

1. Have you, in the past, been associated with applicant screening before (Y/N)?

______

2. If YES, to what extent was the task similar to this simulation?

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| Not at all Similar | | | | | | | | Very Similar |

3. How interesting was the task you just performed?

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| Not at all Interesting | | | | | | | | Very Interesting |

4. How realistic, in your opinion, was the task?

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| Not at all Realistic | | | | | | | | Very Realistic |

Please comment:

______________________________________________

______________________________________________

5. How serious were you in performing the task?

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| Not at all Serious | | | | | | | | Very Serious |

7. How clear were the instructions generally?

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| Not at all Clear | | | | | | | | Very Clear |

8. How easy was the system to use?

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| Not at all Easy | | | | | | | | Very Easy |

9. Please give us some information about yourself (in absolute confidence. At no time will your name appear in the results. The data will only be used in an aggregate statistical sense).

(a) Curriculum enrolled in: ____________________

(b) Sex ______

(c) Age ______

(d) Fulltime work experience (in years) ______

(e) How long ago (in years) did you complete your undergraduate education? ______

(f) How familiar are you with computers, generally?

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| Not at all Familiar | | | | | | | | Very Familiar |

(f) How many hours (per week) do you use computers?

__________

10. Your general comments regarding the simulation:

______________________________________________

______________________________________________

*** END OF SIMULATION ***
Thank you for your participation.

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