INTRODUCTION

Many scholarly disciplines have been interested in managerial information processing. Economists, political scientists, statisticians, sociologists, and psychologists have all considered it from their angle. The present research applied the theory of information integration (Anderson, 1981, 1982), a theory in psychology, to managerial information processing.

This theory has had success in study of judgment and decision. Its method is so precise that it detects not only the rule of information combination but also strategies of information processing. By establishing an algebraic rule underlying judgment and decision, the theory makes study of processes of information valuation, utilization, and processing flow quite easy.

To say that managers process information in everyday life is to stress the obvious. Hardly any moment passes when managers do not gather and process information, and utilize them in their decisions. The managerial information processing has thus become a subject of interest in recent years (Rivera, Ungson, Braunstein, & Hall, 1981; Bass, 1983).
The task considered here dealt with prediction of job performance. Judges received information about motivation (effort, trying) and ability (competence, capability) of stimulus persons and predicted how well the so-described person do in the job. This task has yielded mixed results on information integration and processing in previous work. Accordingly, it was expected to detect many subtle differences in managerial information processing.

Review of Literature

Heider's (1958) suggestion that effectiveness of trying (motivation) is conditional to the ability of a person has served as the starting point for all the studies in the area of prediction of performance. Since conditional effectiveness implies a multiplying rule (Singh, 1981), it is commonly assumed that Performance = Motivation x Ability.

The quantitative test of the multiplying model had to wait for the development of the method of functional measurement (Anderson, 1981, 1982). This technique enables one to have interval scales for both stimulus and response, and thereby allows an exact test of the multiplying model. Thus, this method has been employed in all studies of prediction of performance.
Results from more than a dozen studies of this topic show that Heider's proposition is not of universal generality. Apart from multiplying, the subjects follow adding and averaging rules in integrating information about motivation and ability. Many factors, namely, nature and difficulty of tasks as well as age, culture, and role of judges seem to have affected use of integration rule. These factors were found to act individually as well as by entering in interaction relationship.

**Prediction of Performance by Managers**

Managers play an important role in society. However, researchers in social judgment have taken only passing interest in the model managers follow in prediction of performance. Although expectancy theory states that any worker consciously calculates how much effort he should put in his job (Vroom, 1964), only two studies employed managers as subjects. In both cases, the focus was on some other roles; use of managers as subjects was intended for comparison only.

In one of the experiments by Bhargava (1983), managers from a public sector organization (bank) and from a private sector textile mill participated
in the experiment along with a group of post-graduate students of management. The task was to predict the performance of management trainees given information about motivation, ability, luck, and probability of success of stimulus trainees. The first three factors were internal factors, the last one was external factor. Bhargava found evidence for an adding rule:

Managerial Performance = Motivation + Ability contrary to what Heider (1958) and Vroom (1964) propose. No difference was found in the integration rule of public and private sector managers. Managers did not differ in prediction from the post-graduate students of management either.

All the subjects of Bhargava's experiment combined the four pieces of information in a similar way. The three pieces of internal information were combined by an adding law but the fourth piece of information was assimilated in total information processing through the use of a compound adding-multiplying model.

Managers also appeared as a group of subjects in one of the experiments of Singh and Bhargava (1984a). The other subjects of that experiment were (a) second-year engineering students, (b) a mixed group of doctoral students and college teachers attending a
course, and (c) college lectures in psychology attending a course. The manager group consisted of executive engineers from Gujarat. The task for all the subjects in the experiment was to predict performance in a difficult examination of bachelor of science in chemistry honors. The prediction of examination performance was to be done on the basis of three motivation information from three different teachers and the level of I.Q of the stimulus students. This experiment demonstrated an adding model of prediction of examination performance.

Comparison of the integration behavior of managers with those of college teachers and students obtained no evidence of any difference at all. This experiment also revealed that all the subjects uniformly processed information in two stages. In the first stage, the three pieces of motivation information were combined through averaging rule, and in second stage, the averaged motivation information was added to ability information. This result was similar to Bhargava's (1983) findings.

Prediction of Performance by Teachers

The results cited above indicated that college teachers and managers followed the same rule in prediction of exam performance. Shobha (1984) undertook
a through study of prediction of performance by school teachers. In a series of four experiments, teachers were given three tasks, namely, examination performance, competition (nonacademic) performance, and life performance.

In the first experiment, where the task was prediction in examination, the teachers followed an averaging law. The teachers' responses were not affected by set size of motivation information. There was no evidence for any imputation about the missing information either.

The task of nonacademic competitive situation of puzzle-solving, singing, and drawing-painting competition was the theme of second experiment. The finding of an averaging mode was replicated in this experiment also. The only change from the result of first experiment was an existence of a small set-size effect of positive motivation information.

Experiments 3 and 4 were concerned with life performance. They tried to differentiate between models in two ways. Experiment 3 manipulated information reliability (Surber, 1981a); Experiment 4 employed four-cue, two-cue and one-cue designs. Both the experiments confirmed the findings of earlier two experiments. In addition, Experiment 3 brought out the existence of
non-zero initial opinion about ability in teachers and Experiment 4 showed lack of any imputation about missing information.

Considered together, Shobha's results suggest that teachers have a uniform way of information integration and processing. The various roles that judges play in their life can be expected to influence information processing.

**Prediction of Performance by Students**

Much of the research in prediction of performance employed students as subjects. One reason for this was an easy availability of students as subjects. Another reason was the interest of researchers in developmental trends in information integration. Subjects of various studies ranged from kindergarten pupils to post-graduate students. These experiments considered four tasks, namely, examination performance, nonacademic competition performance, life performance, and performance in managerial profession.

**Examination performance**. The academic performance (graduate studies) was the task in the very first study by Anderson and Butzin (1974). The subjects were American college students. The factorial plot of the
Motivation x Ability effect yielded a linear fan pattern. By the logic of functional measurement, Anderson and Butzin interpreted the fan pattern as supportive of a multiplying rule.

This American result failed to be replicated with Indian subjects (Singh, Gupta, & Dalal, 1979). Experiments of the study showed parallelism in the factorial plot of Motivation x Ability effect. Judgement obtained on the basis of information about motivation alone or ability alone revealed that subjects followed a constant-weight averaging rule. This led to a formulation of the cultural difference hypothesis: American and Indian students differ in their cultural outlook as how motivation and ability determine exam performance.

This hypothesis received further support in a study by Gupta and Singh (1981) in which subjects were from Standards II, IV, VI and VIII from a school and college adults. All subjects uniformly exhibited parallelism prescribed by the equal weight averaging rule. There was no developmental change in integration rule, though children differed in their integrational ability.
Anderson (1981) replicated the earlier results of Anderson and Butzin (1974). This study employed an improved test between multiplying and different weight averaging and found support for multiplying and against averaging.

Surber (1981a) manipulated reliability of information to differentiate between multiplying and differential weight averaging rule. Her subjects were college students, and task was presented as college examination of moderate difficulty. Her results differed from the earlier American studies, as averaging rule was found to be the model of integration. Further, as in the Indian case, a pattern of slightly converging picture in Motivation x Ability plot was obtained.

Intrigued by her results and unable to answer to what extent her characterizing the task as moderately difficult was responsible for her different results, she conducted another experiment (Surber, 1981b). This experiment manipulated task difficulty. The factorial plot of Motivation x Ability effect yielded converging, parallelism, and diverging patterns for examination specified as easy, moderately difficult, and very difficult. All three
patterns were, however, consistent with the averaging rule. Accordingly, Surber questioned the cultural difference hypothesis and argued for the hypothesis of task difficulty.

Singh and Bhargava (1984a) reported results from a series of six experiments. These experiments examined hypothesis of cultural difference, task difficulty, and imputation about missing information. It was a developmental study with subjects from schools, college, and post-graduate program in management. While the school and college subjects followed averaging rule, those from the post-graduate program in management followed adding. The findings further underlined the cultural difference hypothesis. The same parallelism pattern was present across all the three levels of exam difficulty. This study examined a number of other theoretical aspects and found evidence for imputation about the missing information. The last available study in the area (Srivastava, 1984) indicated that averaging is the model of integration among the students starting from Kindergarten to Standard XI.

To sum up, there is evidence of both multiplying and averaging model of information integration.
in American college students. In case of Indian subjects, the averaging rule appears to hold good from kindergarten to college. But the Indian post-graduate students of managements were found to use adding for the task. Prediction of exam performance thus seems to be susceptible to cultural factors.

**Competition performance.** There are four studies of prediction of competition performance. Three had American students as subjects. The very first experiment on Heider's proposition (Anderson and Butzin, 1974) had prediction of athletic performance, and results were in agreement with predicted fan pattern.

Kun, Parsons, and Ruble (1974) did a developmental study, using subjects from kindergarten to college. The task in the experiment was predicting performance on puzzles. While children below Standard II exhibited parallelism; subjects from all other standards gave evidence of a linear fan pattern.

The third study (Surber, 1980) had the task of predicting performance in a weight lifting contest. The subjects were from kindergarten to college. The results of earlier experiments could be replicated only with college students, rest of the subjects gave evidence for averaging.
Srivastava (1984) undertook a comprehensive developmental study of integration rule in children. She used puzzle and music competitions as tasks and subjects were from kindergarten to Standard XI. The result of this study was found to be quite at variance with the earlier studies with American subjects. Children upto Standard VI obeyed multiplying rule; the older subjects displayed existence of an adding rule. The first experiment by Srivastava had asked children to predict examination performance. This experiment had no evidence of any developmental shift in data. So she concluded that integration rule depends upon age, task, and culture of the subjects.

**Life performance.** Two studies considered prediction of life performance. In Singh and Bhargava (1984b), the subjects were post-graduate students of management, and they followed a multiplying rule. It may be recalled that the similar subjects in Singh and Bhargava (1984a) had exhibited adding rule in prediction of examination performance. Both groups were similar, however, with respect to two initial opinions.

The second study by Bhargava (1983) was developmental, with subjects taken from standards V, VII, IX,
XI of a school, from first-year of a college, and from post-graduate course of a management school. Subjects up to the college level followed the averaging rule; the post-graduate management students used the multiplying rule.

**Managerial performance.** This area is not so well researched, for there is only one study to date (Bhargava, 1983). It is understandable because managerial performance as a task does not have much relevance to students in general. However, this task is of relevance to the post-graduate students of management, future managers, who formed subjects for experiment of the study. They used addition as a rule to combine information. It is interesting to compare the integration rule for the same group for different task. They were found to display multiplying rule in case of prediction of life performance (Bhargava, 1983) but adding rule in case of prediction of examination and managerial performance (Bhargava, 1983; Singh & Bhargava, 1984a). It appears that prospective managers are flexible in their integration rule.
Summary

Indian managers use adding rule to predict exam and managerial performance. There is no difference between public and private sector managers. College teachers also use adding rule in examination performance. School teachers, on the contrary, uniformly use averaging for exam performance, competitive performance, and life performance. Management students followed adding rule for exam and managerial performance but multiplying rule for life performance.

College students in America followed multiplying rule in some studies and averaging in others for exam performance. In case of averaging, the exam difficulty affected the pattern in Motivation x Ability effect in a systematic way. The Indian studies of exam performance have been mostly developmental and have shown averaging being followed by subjects up to college level. But management students gave evidence for adding rule. Indian students, unlike their American counterparts, had two initial opinions, one each for motivation and ability.

In the task of puzzle competition, students from Standard II to college in America followed multiplying but in weight lifting task only college level subjects
used multiplying rule. Indian subjects up to standard VI used multiplying rule, higher standard school students gave evidence of averaging. It can thus be said that cognitive algebra of task performance is highly complex.

Models and Methods

From the survey of literature on performance prediction, it is clear that subjects use three types of integration rule, namely, adding, averaging, and multiplying. Let $M$, $A$, and $P$ represent scale values of motivation, ability and performance, and $w_M$ and $w_A$ as the weights for motivation and ability. The three basic models can be written as follows:

Adding:

$$\text{Performance} = M \cdot w_M + A \cdot w_A, \quad (1)$$

Averaging:

$$\text{Performance} = \frac{w_M \cdot M + w_A \cdot A}{w_M + w_A}; \quad (2)$$

$$\left( w_M + w_A = 1.0 \right)$$

Multiplying:

$$\text{Performance} = M \cdot w_M \cdot A \cdot w_A. \quad (3)$$
The adding and averaging models differ in their constraint on weights. The former does not put any restriction on weight, the latter requires weights to sum up to unity. There are two variations of Equation 2, depending on the pattern of weights. In case \( w_M \) and \( w_A \) are fixed, we have the case of equal weight averaging. When \( w_M \) changes with the level of \( M \), the \( w_A \) also changes for different levels of \( M \), we have the case of differential weight averaging model. Under the condition of equal weighting, Equation 2 predicts parallelism in Motivation x Ability effect just as Equation 1 does. With differential weighting, Equation 2 predicts a fan pattern in Motivation x Ability plot just as Equation 3 does.

Diagnosis of the underlying model for the parallelism and patterns has thus been a subject of controversy.

Diagnosis of Integration Rule

The factorial plot of Motivation x Ability is commonly done by taking values of ability along the horizontal axis and motivation as curve parameter. For fixed level of motivation, say \( M = m_1 \), the Equation 1 and 3 take the shape of equation of straight lines, \( P = m_1 w_M + A w_A \) and \( P = m_1 w_M x A w_A \). In both the cases, the variables are \( P \) and \( A \), but the slope and
intercept are $m_1 w_M$ and $w_A$ in the former and $0$ and $m_1 w_M w_A$ in the latter. When these lines are plotted for different values of $M$, we get a set of parallel lines in the former case and set of diverging curves resembling a fan in the other case. These two patterns are referred to as the parallelism and fan patterns.

Both parallelism and fan patterns are consistent with more than one rule. A major preoccupation of researchers has thus been to diagnose between adding and equal weight averaging in case of parallelism and between multiplying and differential weight averaging in case of fan pattern. Three methods have been used for this purpose.

**One-Cue Approach**

Four studies (Singh et al., 1979; Gupta & Singh, 1981; Surber, 1980, 1981b) have used this device. This method of rule differentiation contains design with motivation alone and ability alone apart from the design when both motivation and ability information are present. It was argued that the single-cue curves would form part of parallelism or linear fan depending on adding or multiplying rule. However, if the subjects use equal weight averaging, there would be a crossover in the parallelism graph. Similarly, in
The above prediction is understandable. In both fixed weight and differential weight averaging, the weight factor of ability will make the slope of the curve less than that of the one-cue curve. For judgments based on information about ability only, the model is

\[ \text{Performance} = A W_A \]  

(4)

The same holds good for motivation only curve when plotted in a diagram with ability as curve parameter and motivation along abscissa.

The above technique fails to give results in situation of judgment when both the informations are considered necessary by the subjects. When one of the two information is found missing, subjects may impute a value for it. The phenomenon of imputation is well documented for wider issues (Lane & Anderson, 1976; Leon, 1980; Yamagishi & Hill, 1980) and also for prediction of performance (Anderson, 1983, pp. 73-76; Gupta & Singh, 1981; Singh et al., 1979; Surber, 1980; Singh, in press). If subjects assume a constant value for the missing information, the one-cue curve forms plot of the parallelism and fan patterns. Thus it becomes difficult to
detect the underlying rule. Singh (in press) has documented this problem and has argued that single-cue design is better suited for studying imputations than rule diagnosis.

### Information Reliability Approach

This method avoids the problem of imputation about missing information found in single-cue approach. Reliability of information is manipulated along with information (Surber 1981a). If the averaging model is correct, then

\[
\text{Performance} = \frac{(w_M M + w_A A + w_O I_O)}{(w_M + w_A + w_O)},
\]

where \( I_O \) is initial opinion and \( w_O \) is its weight. If the multiplying rule is correct, then Equation 3 will apply. Both averaging and multiplying models predict a multiplicative relationship between value and reliability of an information. It is assumed that reliability affects weight.

The two models, however, predict different relationship between reliability of one information and value of another information. The averaging rule predicts that increase in reliability of ability information will decrease effectiveness of motivation. Similarly, increase in reliability of motivation information will decrease effectiveness of ability
information. But the multiplying rule predicts that reliability of an information will have similar effect on the other pieces of information. Thus, two models make sharply contradictory predictions.

Surber (1981a) obtained support for the averaging rule and against the multiplying rule. Singh and Bhargava (1984a, 1984b), however, noted that such a manipulation cannot diagnose a model if the subjects have separate initial opinions about M and A. In prediction of exam performance, for example, they found evidence of the following model.

\[
\text{Performance} = \left[ \frac{w_o M_o + w M}{w_o + w} \right] + \left[ \frac{u_o A_o + u A}{u_o + u} \right]. \tag{6}
\]

In prediction of life performance, the rule was multiplicative. However, presence of two initial opinions did not allow clear diagnosis of the rule. Singh and Bhargava (1984a, 1984b) have argued, therefore, that manipulation of information reliability is good for analyzing information flow. It cannot be expected to give clear diagnosis of rule in all the cases.

**Two-Operation Approach**

Experiments based on this approach had multiple designs. The main design had 3 pieces of motivation
information paired with ability information. Other designs had one of the three motivation information paired with ability. There were also designs based on one information alone. The logic behind this test is that pieces of motivation information, being qualitatively similar, will be averaged and then added or multiplied with the ability information. The models for such compound averaging-adding and averaging-multiplying are shown below.

Averaging-adding:

\[
\text{Performance} = \left[ \frac{w_1 M_1 + w_2 M_2 + w_3 M_3}{w_1 + w_2 + w_3} \right] + A w_A, \quad (7)
\]

Averaging-multiplying:

\[
\text{Performance} = \left[ \frac{w_1 M_1 + w_2 M_2 + w_3 M_3}{w_1 + w_2 + w_3} \right] \times A w_A. \quad (8)
\]

If all the pieces of information available for judgment are averaged together, then the model becomes

\[
\text{Performance} = \frac{w_1 M_1 + w_2 M_2 + w_3 M_3 + w_4 A}{w_1 + w_2 + w_3 + w_4}. \quad (9)
\]

The essential argument of this approach is that if the hypothesis of adding rule is to be accepted, the common plot of Motivation - \( M_1 \) \( \times \) Ability from Equation 1 and 7 must show parallelism.
Similarly the results are said to support the multiplying hypothesis if the common plot of Motivation-1 x Ability from four-cue and two-cue designs show a linear fan. Similar analysis must be carried out with the plot of Motivation-2 (M2) x Ability and Motivation-3 (M3) x Ability. When the above prediction fails to materialise, it is hypothesised that averaging is the model of information integration.

Another method of rule differentiation falling in the category of two stage information processing is through the manipulation of set-size of motivation information. The logic behind this method is that adding more information of equal value causes more polarized response. To operationalize this concept as a tool of rule diagnosis, the same experiment carries two designs. In one, the stimuli are prepared with k > 1 pieces of similar motivation information and ability information. In other design, the stimuli consists of only one piece of motivation information clubed with ability information. The performance (P) for (k + 1)-cue and 2-cue designs for three integration rules are given below.

Adding:

\[(k + 1)\text{-cue : Performance} = \left[ \frac{k w_M M + w_O I_O}{k w_M + w_O} \right] + A W_A \] \hspace{1cm} (10)

\[\text{2-cue : Performance} = \left[ \frac{w_M M + w_O I_O}{w_M + w_O} \right] + A W_A \] \hspace{1cm} (11)
Averaging:

\[(k + 1)\text{-cue} : \text{Performance} = \frac{k \frac{w_M}{w} M + w_A A + w_o I_o}{k \frac{w_M}{w} + w_A + w_o}, \quad (12)\]

\[2\text{-cue} : \text{Performance} = \frac{w_M M + w_A A + w_o I_o}{w_M + w_A + w_o}, \quad (5)\]

Multiplying:

\[(k + 1)\text{-cue} : \text{Performance} = \left[ \frac{k \frac{w_M}{w} M + w_o I_o}{k \frac{w_M}{w} + w_o} \right] \times A \frac{w_A}{w}, \quad (13)\]

\[2\text{-cue} : \text{Performance} = \left[ \frac{w_M M + w_o I_o}{w_M + w_o} \right] \times A \frac{w_A}{w}. \quad (14)\]

Combined factorial plots of data from designs varying in set-size of motivation yields definitive information about the model. If the underlying model is adding, the combined plot of Motivation x Ability from Equation 10 and 11 shows common pattern of parallelism. When the underlying model is multiplying, the combined plot of Motivation x Ability from Equation 13 and 14 shows a common linear fan. But in case the subjects follow averaging model, the plots of Motivation x Ability from Equation 12 and 5 does not conform to the pattern of parallelism or linear fan.

While the first two of the above predictions are obvious, the third is also not very difficult to see. Assuming fixed weight averaging, even if \(w_M\) and \(w_o\) arc
equal in Equation 12 and 5, the very logic of restrain on weights will make \( w_A \) unequal in the two equations, thus prevent a parallelism to emerge in the common plot of Motivation x Ability effect.

In case of variable weight averaging, to bring Equation 12 in a form comparable to Equation 5 will involve transformation of \( P \) in former with respect to both origin and scale. Even then for different levels of \( M \), the two equations will have different intercepts and slopes. It is quite unlikely, therefore, that the common plot will give a linear fan.

Yet another variant of two-stage information processing is to add two pieces of neutral motivation information to the information about motivation and ability. This method rested on the logic that if averaging in motivation information takes place, then three-cue motivation curve will be crossed over by the single-cue motivation curve. However, the common plot of Motivation x Ability from 4-cue and 2-cue designs will show parallelism or fan depending on the integration rule followed.

The two-stage approach to diagnose the integration rule has been successfully used by many researchers (Bhargava, 1983; Shobha, 1984; Singh & Bhargava, 1984a; Singh, in press). Bhargava (1983), by manipulating the set-size and number of neutral motivation information, showed that students from
Standards V to college followed averaging rule for life performance; management students followed multiplying.

Information Processing

Under this generic heading, the researchers in the field of performance prediction have studied two aspects of information processing: (a) Stages of information processing and (b) imputations about missing information. A broad review of these developments is given below.

Stages of Processing

The two approaches to rule discrimination, namely, manipulation of cues and manipulation of set-size of motivation information mentioned earlier provided an opportunity to see how subjects processed heterogeneous information in prediction of performance. As predicted by earlier work on person cognition, the similar pieces of motivation information were combined in the first stage by averaging process. At the second stage, this averaged information was combined with ability information through an appropriate algebraic rule. Success of the compound averaging-adding and averaging-multiplying models testifies the operation of two-stage information
processing in Indian subjects (Singh & Bhargava, 1984a, 1984b; Singh, in press).

The general formulation of averaging model, as given in Equation 5, contains one generalised initial opinion. Manipulation of information reliability for rule diagnosis with Indian subjects yielded existence for two initial opinions, one for motivation and one for ability. This can be seen in Equation 6 which has two initial opinion terms. It was noted by Singh and Bhargava (1984a) that information reliability alters its initial opinion with respect to component at the first stage. The scaled values are integrated at the second stage.

While existence of two initial opinion is not ruled out, it cannot be said to hold true for all subjects and all tasks. Shobha (1984), for example, found that teachers have non-zero initial opinion for ability.

Imputation

Imputation about missing information is a common phenomena in judgmental tasks. The two stage experiments showed that judgments based on just one of the
two necessary inputs rely on imputed value of the missing information. Detailed study of imputations by Singh (in press) indicates that subjects sometimes assume a constant value and sometimes a value as a direct function of the value of the given information. Singh and Bhargava (1984a, 1984b) have further shown that imputations about missing information are more pervasive than what has been assumed to be.

Recent work by Shobha (1984), however, shows lack of imputation about missing information by teachers. She suggests that imputations are perhaps characteristics of college students. Whether imputations are present or absent is a trivial question. What is more important is that functional measure detects how judges handle missing information.

The Present Research

Literature reviewed in the previous section shows that many factors, namely, role, age, task, and culture play an important role in the choice of integration rule as well as in processing of information. Furthermore, there exists a conspicuous gap on the topic of model of information combination for performance prediction by managers. Since role played by a
group of people is naturally reflected in their integration rule in predicting performance (Shobha, 1984), this research studied the integration model of managers for predicting the job performance. The following questions were raised:

1. What is the algebraic rule followed by managers in predicting performance on job of their subordinates?

2. Is the rule followed by managers unique to them?

3. Do managers predict job performance of their fellow members in a way different from that of their subordinates?

4. How managers process information when provided with more than one pieces of motivation information and a piece of ability information? Are the results of research in person cognition generalizable to prediction of job performance?

5. Do managers have one initial general opinion or two initial opinions, one for motivation and one for ability?

6. Do managers make imputation about missing information in predicting job performance?