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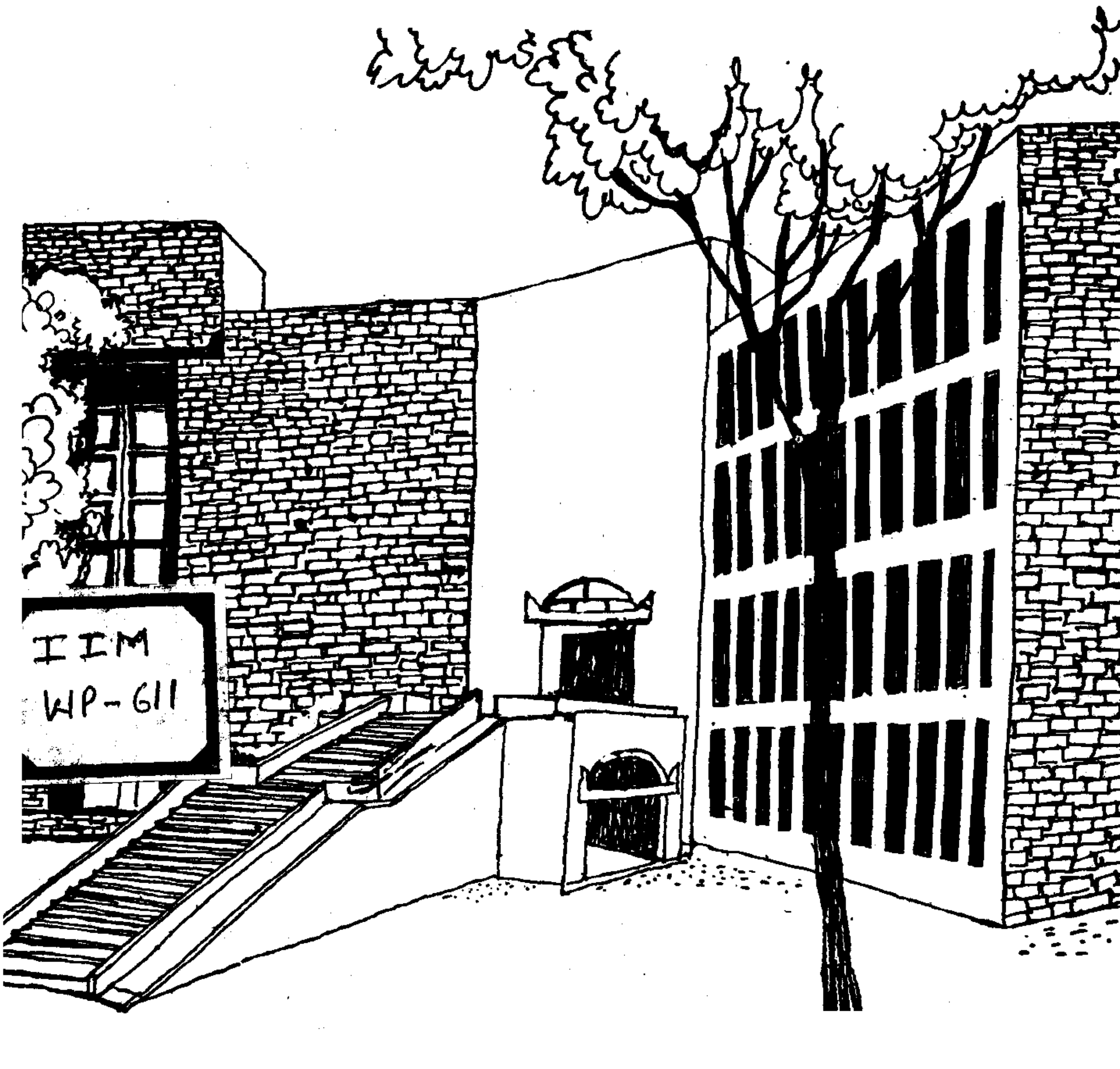

INFORMATION RELIABILITY AND PREDICTION OF PERFORMANCE: ROLE OF INITIAL OPINION IN MULTIPLYING MODEL

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Information Reliability and Prediction of Performance: Role of Initial Opinion in Multiplying Model

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Running Head: INFORMATION RELIABILITY

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Abstract

All the models of information integration predict that the greater the reliability of an information, the greater its effectiveness. However, they disagree with the relationship between reliability of information of one type and effectiveness of information of another type. The multiplying model predicts that reliability of information of one type should enhance effectiveness of information of another type; the relative-weight averaging model predicts just the opposite; and the adding and constant-weight averaging models predict that effectiveness of information of one kind is independent of the reliability of information of another kind. Experiment 1 demonstrated that Life Performance = Motivation x Ability. Experiment 2 tested the hypothesis that information reliability causes averaging of external information with the corresponding initial opinion of the judges. Accordingly, the effect of motivation information should be independent of the reliability of ability information and vice versa even within the multiplying model. Results supported the hypothesis. Implications of this finding for test of multiplying model were discussed.

Information Reliability and Prediction of Performance:

Role of Initial Opinion in Multiplying Model

Suppose you are given information, ostensibly varying in reliability, about motivation and ability of a person and asked to predict his or her life performance, how would you make the prediction? How would the reliability of information of one kind affect the effectiveness of information of another kind in your judgment?

Analysis of the effects of source credibility on communication and persuation has long been an important topic (Cohen, 1964). Only in recent years have the answers to the specific questions raised above been possible with the method of information integration theory (Anderson, 1981, 1982). The present research extends the previous work on information reliability (Singh, in press; Singh & Bhargava, 1985a; Surber, 1981a, 1984a), and illustrates the role that an initial opinion plays in multiplying model.

The reliability of information has been shown to affect weight parameters in integration models (Anderson, 1981). By establishing an integration model, it is possible to determine the precise ways in which information reliability influences prediction of performance. The available literature shows that the prediction of performance from information about motivation and ability follows multiplying rule (Anderson, 1983, pp. 73-76; Anderson & Butzin, 1974; Kun, Parsons, & Ruble, 1974; Surber, 1980), relative-weight averaging rule (Surber, 1981a, 1981b), or constant-weight averaging rule (Gupta & Singh, 1981; Singh & Bhargava, 1985a, 1985b; Singh, Gupta, & Dalal, 1979). These three models make altogether different predictions about the relationship between reliability of information of one kind and effectiveness of information of another kind.

If motivation and ability are indeed multiplied, then

$$\text{Performance} = \underline{w}_M M \times \underline{w}_A A, \tag{1}$$

where M and A are value of motivation and ability information, and $\underline{w}_M$ and $\underline{w}_A$ are their respective weights due to information reliability. This model makes three specific predictions. First, the factorial plot of Motivation x Ability effect should exhibit a linear fan pattern, that is, a systematic divergence toward right. Second, the greater the reliability of an information, the greater its effect. Finally, reliability of information of one kind should enhance the effectiveness of information of another kind.

Model 1 is actually a four-factor multiplying model. Consequently, it predicts similar enhancement effects in all two-way, three-way, and four-way interactions. Partial support for this model has been obtained in an experiment on prediction of gift size from information about generosity and income of donors (Singh, in press).

If the averaging rule holds (Anderson, 1981; Surber, 1981a), the judgment of performance should be

$$\text{Performance} = \frac{\underline{w}_I I + \underline{w}_M M + \underline{w}_A A}{\underline{w}_I + \underline{w}_M + \underline{w}_A}, \tag{2}$$

where new terms, I and $\underline{w}_I$ are value and weight of judges' initial opinion or expectancy in the absence of any external information. Model 2 predicts the same relationship between the reliability of information and its effectiveness as does Model 1. However, Model 2 predicts that increase in reliability of information of one kind should decrease the effectiveness of information of another kind. This happens because the effective relative weight of motivation, $\underline{w}_M/(\underline{w}_I + \underline{w}_M + \underline{w}_A)$, decreases as the value of $\underline{w}_A$ increases in the denominator.

Support for this relative-weight averaging rule has been obtained in prediction of academic performance (Surber, 1981a), intuitive numerical prediction (Birnbaum, 1976), judgments of the value of used cars and likableness of persons (Birnbaum, Wong, & Wong, 1976), and attribution of ability and study time (Surber, 1984a). None of these studies, however, found the parallelism pattern in the Factor 1 x Factor 2 effect. Singh and Bhargava (1985a) suggested, therefore, that the relative-weight averaging rule is perhaps linked with nonparallelism in the Factor 1 x Factor 2 effect.

When motivation and ability information carry the same weight in all combinations (Birnbaum, 1976; Birnbaum et al., 1976), then the averaging model becomes

$$\text{Performance} = \frac{\underline{w}'_I\ (\underline{w}'_I\ I) + \underline{w}'_M\ (\underline{w}'_M\ M) + \underline{w}'_A\ (\underline{w}'_A\ A)}{\underline{w}'_I + \underline{w}'_M + \underline{w}'_A}, \qquad (3)$$

where $\underline{w}'_I$, $\underline{w}'_M$, and $\underline{w}'_A$ are weights for each of the information types independent of and not affected by information reliability. Birnbaum (1976) points out that this constant-weight averaging model is similar to the impression formation model of Rosenbaum and Levin (1968, 1969) and the <u>average of regressed values</u> model of Lichtenstein, Earle, and Slovic (1975).

This model agrees with Models 1 and 2 about the relationship between reliability of an information and its effectiveness. However, it does not specify the exact pattern in Reliability x Value effect, in that the values of I and $\underline{w}_I$ will largely determine presence of Linear x Linear or other semi-linear trends (Anderson, 1981, p. 276). More importantly, Model 3 predicts that the effect of information of one kind is independent of the reliability of information of another kind. Thus, the parallelism pattern is predicted not only for the Motivation x Ability effect but also for the Reliability of motivation x Ability and Reliability of ability x Motivation effects.

Since studies of prediction of exam performance in India always conformed to the predictions of the constant-weight averaging rule (Gupta & Singh, 1981; Singh & Bhargava, 1985b; Singh et al., 1979), Singh and Bhargava (1985a) tested the adequacy of Model 3 by manipulating the reliability of information just as in the experiment by Surber (1981a). Their results confirmed the constant-weight averaging rule but infirmed the relative weight averaging rule. Following Anderson's (1981) averaging model for source-message integration, Singh and Bhargava (1985a) also suggested a change in the structure of Model 3. In the revised model,

$$\text{Performance} = \frac{\underline{w}''_M \left[\dfrac{\underline{w}_{Im} I_m + \underline{w}_M M}{\underline{w}_{Im} + \underline{w}_M} \right] + \underline{w}''_A \left[\dfrac{\underline{w}_{Ia} Ia + \underline{w}_A A}{\underline{w}_{Ia} + \underline{w}_A} \right]}{\underline{w}''_M + \underline{w}''_A}, \qquad (4)$$

where new terms, I_m and I_a are the values of the initial opinions of motivation and ability in judges, $\underline{w}_{Im}$ and $\underline{w}_{Ia}$ are their respective weights, and $\underline{w}''_M$ and $\underline{w}''_A$, are weights for estimated values of motivation and ability from the first-stage integration with the respective initial opinion.

While Model 4 is similar to Model 3 in recognizing a two-stage integration, it differs in two respects. The first is the presence of two separate initial opinions in the judges (Anderson, 1981, p. 315). The second is the loci of the effects of information reliability. According to Model 4, manipulation of information reliability engenders averaging of external information with its corresponding initial opinion at the first stage of integration. At the subsequent stage, estimated values of motivation and ability are integrated by the constant-weight averaging rule. On the basis of existing data, it was not possible to ascertain whether subjects in experiments by Singh and Bhargava (1985a) had followed Model 3 or Model 4.

If the loci of effects of information reliability on prediction of performance hypothesized by Singh and Bhargava (1985a) are correct, then the effectiveness of information of one type should be independent of the reliability of information of another type even in a multiplying task. In such a task, the model would become

$$\text{Performance} = \underline{w}''_M \left[\frac{\underline{w}_{Im}\, I_m + \underline{w}_M\, M}{\underline{w}_{Im} + \underline{w}_M}\right] \times \underline{w}''_A \left[\frac{\underline{w}_{Ia}\, Ia + \underline{w}_A\, A}{\underline{w}_{Ia} + \underline{w}_A}\right]. \qquad (5)$$

This model predicts linear fan pattern in the Motivation x Ability effect and interactions between reliability and value of motivation as well as of ability factor. The remaining three two-way interactions are expected to exhibit parallelism pattern. See Appendix for a derivation of the conditions under which parallelism is expected.

The main purpose of the present research was to determine the plausibility of Models 1 and 5 both of which predict the same multiplicative relationship between motivation and ability but quite different relationships between reliability of information of one type and effectiveness of information of another type. The experimental task was prediction of life performance, that is, how high a person would go in chosen profession during his life. This task has been expected to obey the multiplying rule (Anderson, 1976).

Experiment 1

The chief purpose of Experiment 1 was to obtain evidence for a multiplying model, Life Performance = Motivation x Ability. The multiplying model predicts a linear fan pattern in Motivation x Ability effect. But the linear fan pattern is not unique to the multiplying rule alone. If lower values of motivation and/or ability had greater weight, then the averaging model (Anderson & Butzin, 1974; Singh et al., 1979) would also produce an approximate linear fan pattern. Three distinguishing tests between multiplying and averaging rules, as will be discussed in the results section, were thus also included.

Method

Stimuli and designs. Descriptions of high school students (i.e., Standard X) were prepared on separate index cards. Each card listed information about motivation and ability of the stimulus student.

Motivation was defined by the frequency of serious effort that the stimulus student put in on any assigned task. Ability was defined as the student's intelligence. Both kinds of information were specified by verbal labels of extremely low, very much below average, below average, average, above average, very much above average, and extremely high. This allowed use of a comparable scale for both kinds of information.

Stimulus descriptions were prepared according to four designs. Design 1 was a 2 x 3 x 3 (Number of average motivation information x Motivation x Ability) factorial. The three levels of motivation and ability factors were extremely low (EL), average (AV), and extremely high (EH). The number of average pieces of motivation information in a description was either none (0) or two(2). Descriptions with one piece of motivation and ability information will be referred to as two-cue and those with three pieces of motivation information, including two average pieces, and one ability information will be referred to as four-cue. Design 1 generated 9 two-cue and 9 four-cue descriptions.

Design 2 was a 2 x 3 x 3 (Set size of motivation information x Motivation x Ability) factorial. The levels of motivation and ability were identical to those in Design 1. The size of the descriptive sets was manipulated by including 1 or 3 exactly same piece of information about motivation. This design required 18 descriptions, 9 of which were already present in Design 1. Therefore, only 9 new descriptions were prepared.

Designs 3 and 4 had information about motivation alone and ability alone, respectively. The levels of the two factors were identical to those in Designs 1 and 2.

There were 4 end anchor descriptions based on motivation information from four sources and one piece of ability information. The 12 practice examples included these 4 end anchors plus 8 other descriptions from the set of 33 descriptions of the four designs. A total of 49 (37 main and 12 practice) descriptions were thus made.

Procedure. Subjects, gathered in groups of four to six, received a typed sheet of instructions that described the nature of judgment and their role as subjects. The task was introduced as dealing with prediction of life performance of some Standard X male students. Subjects were urged to assume that each student would enter to a profession, and that life performance would mean how high the student would go in that profession during life time.

It was emphasized that prediction of life performance would be made on the basis of whatever was presently known about the motivation and ability of the stimulus student. Subjects were told that information about motivation and ability of the stimulus students came from teachers who had known them for at least 5 years. In addition, motivation information came from 1 to 4 teachers and so their opinions were to be treated as equally important and valid. In cases where either motivation or ability was not known, subjects were asked to rely their prediction on only the given piece of information.

Subjects were also informed that each of the stimulus students had all opportunity available for growth. This information came from a teacher who had known student's family and other conditions (e.g., socio-economic status; physical, social, and educational facilities; and scope for doing whatever one wishes to) for at least 5 years.

After reading the instruction sheet twice, each subject worked with 12 practice examples. He(she) read the information typed on card and predicted how high the stimulus person would go in his profession during his life. This prediction was made along a 21-step ladder which had digits 1-21 written on the corresponding step.

Before the actual data collection, the main points of the instructions were summarized to the subjects by the experimenter. All queries about the task were answered. Finally, each subject rated the main set of cards one by one over three trials of judgment in different shuffled orders. In each case, the subject wrote the code number of the stimulus person and the judgment of life performance on a response sheet supplied for this purpose. Data from all three trials of judgment were analyzed.

After collection of data, the general purpose of the research was described to the subjects by the experimenter. Subjects were thanked for their cooperation in the research.

Subjects. The subjects were 25 male and 3 female students from a course on personal and interpersonal dynamics for the first year of the 2-year post-graduate program in management of the Indian Institute of Management, Ahmedabad, India. Each subject received 5 rupees for participation in the experiment.

Results and Discussion

Models and predictions. Since Designs 1 and 2 varied the number of pieces of motivation information along with just one piece of information about ability, the multiplying model assumes a two-stage, averaging-multiplying operation. The qualitatively similar pieces of motivation information will first be averaged together (Anderson, 1981, 2.4; Singh, in press); the estimated value of motivation will then be multiplied with ability. This two-stage model for Design 1 could be written as

$$\text{Performance} = \underline{w}''_M \left[\frac{\underline{w}_{Im}\, Im + \Sigma\, \underline{w}_M\, M}{\underline{w}_{Im} + \Sigma\, \underline{w}_M} \right] \times \underline{w}''_A\, A. \qquad (6)$$

For Design 2 which varied number (n) of isovalent pieces of motivation information, the model would be

$$\text{Performance} = \underline{w}''_M \left[\frac{\underline{w}_{Im}\, Im + n\, \underline{w}_M\, M}{\underline{w}_{Im} + n\, \underline{w}_M} \right] \times \underline{w}''_A\, A. \qquad (7)$$

The left part (i.e., terms in brackets) of Equation 6 is identical to Anderson's (1965) averaging model which predicts that addition of neutral pieces of information to the low and high values of the same information will reduce extremity of both values. The left part (i.e., terms in brackets) of Equation 7 is Anderson's (1967) set-size model which predicts that adding more information of equal value makes a more polarized response. In this way, both Equations 6 and 7 imply that various pieces of motivation information will be averaged together.

The first purpose in data analysis was to test the averaging rule for integration of information about motivation. Of immediate interest are the first and second graphs of Figure 1 from left. In the leftmost graph, the solid curves with open-circles are based on one piece of motivation information listed on the horizontal axis; the solid curves with filled-circles are based on the same piece of motivation information plus two additional pieces of average motivation information. At each of the three levels of ability, the filled-circle curve has a shallower slope than the open-circle curve. In the overall analysis of variance, this crossover pattern was statistically significant, $F(2, 54) = 95.82$, $p < .0001$. Accordingly, the hypothesis that various pieces of motivation information are averaged has received good support in Design 1.

Figure 1 about here

The second graph from left illustrates the standard set-size effect: Sets having 3 similar pieces of motivation information have produced a more polar response than those having just 1 piece of motivation information. This crossover of the solid curve with open-circles (i.e., Set size = 1) by the solid curve with squares (i.e., Set size = 3) was also statistically significant in the overall analysis of variance, $F(2, 54) = 36.66$, $p < .0001$. This means that the first part of Equation 7 represents the judgment well.

The second, and more important, purpose in data analysis was to demonstrate the linear fan pattern in the common factorial plot of the Motivation × Ability effect from the two-cue and four-cue descriptions of the two designs. These factorial plots are shown in the two graphs on the right side of Figure 1. Both graphs have the predicted pattern of linear fan, and data from the two-cue and four-cue descriptions fit well within the same fan pattern.

Statistical analyses of the data shown in the two graphs on right side of Figure 1 basically confirmed the above interpretation of the linear fan pattern. In the 6 x 3, Motivation x Ability analyses of variance, the interaction terms were statistically significant, $F(10, 270) = 2.86$ and 4.89,

$p < .01$, which implies that both graphs depart from parallelism. The multiplying model further requires a significant Linear x Linear component and nonsignificant Linear x Quadratic, Quadratic x Linear, and Quadratic x Quadratic components in each interaction effect. The corresponding tests yielded F (1, 27) = 4.94, 0.11, 0.26, and 0.83 for Design 1 and F (1, 27) = 8.59, 0.02, 2.30, and 0.07 for Design 2. Since only the Linear x Linear trend is present in each interaction, these quantitative tests provide solid confirmation of the multiplying rule for integration of information about motivation and ability.

Averaging rule. Had subjects integrated information about motivation and ability according to the differential-weight averaging rule, there could have been serious violations of the linear fan pattern in the two graphs on the right side of Figure 1. In addition, the effect of motivation or ability information presented alone (i.e., dashed curve in the second and fourth graphs of Figure 1) could have been greater than that of motivation and ability presented together (Singh et al., 1979; Surber, 1981a, 1981b).

There is no evidence of the predictions of the averaging model (i.e., Equation 2) at all. As already noted, the combined factorial plot of Motivation x Ability effect from the two-cue and four-cue descriptions conformed precisely to the linear fan pattern contrary to the prescription of the averaging model. More importantly, the dashed curves of the second and fourth graphs differ from the solid curve with open-circles only in elevation, F (2, 54) = 24.98 and 17.84, $p < .001$, and not in slope, F (2, 54) = 2.99 and 2.16. It appears that subjects imputed a constant value of slightly below average to the missing ability and motivation information (Singh, in press).

A striking evidence against the averaging rule and for the multiplying rule is present in the pattern displayed by the pair of middle solid curves in the rightmost graph of Figure 1. The solid curves with circles and squares are based on the three levels of ability listed on the horizontal axis plus one and three similar pieces of average motivation information, respectively. According to the averaging rule, the curve with circles should crossover the curve with squares. This should happen because averaging of three moderate pieces of motivation information with the values of ability information would reduce the difference between ability levels much more than the averaging of just one moderate piece of motivation information (Anderson, 1965, 1981, 2.3.2). Contrary to this averaging prediction, the two curves show a mild divergence. This divergence agrees with the multiplying rule, for the values of motivation are different for the two curves.

Discussion. The first theoretical implication of the foregoing results is that various pieces of motivation information are averaged with the initial opinion of the judges. This averaging result agrees with the previous findings that qualitatively similar pieces of information are averaged in person cognition (Anderson, 1981, 2.3 - 2.4, 1983; Singh, in press).

The second theoretical implication concerns the linear fan pattern in the Motivation x Ability effect. On the basis of previous work (Anderson, 1983; Singh, in press), it was hypothesized that motivation cues are first averaged and this average is then multiplied into the ability cue. This prediction was clearly supported. Accordingly, it may be stated that prediction of life performance indeed follows the multiplying model, Life Performance = Motivation x Ability.

Experiment 2

The success of the multiplying model in Experiment 1 shows that the prediction of life performance could be a useful task for analyzing effects of information reliability. Experiment 2, therefore, manipulated reliability of motivation and ability just as in Surber's (1981a) experiment and examined the plausibility of Models 1 and 5 both of which predict the linear fan pattern in the Motivation x Ability effect but different effects of information reliability.

Method

Stimuli and design. Descriptions of stimulus students were prepared according to a 3 x 3 x 3 x 3 (Motivation x Reliability of motivation information x Ability x Reliability of ability information) factorial design. All the 81 stimulus persons were described to have all opportunity for growth just as in the previous experiment.

Both motivation and ability of stimulus students were defined as in Experiment 1. However, frequency of serious effort, an index of student's motivation, was described as never, very rarely, once in a while, sometimes, quite often, very often, and always. The three levels of motivation were very rarely (LO), sometimes (MOD), and very often (HI); the levels of ability were very much below average (VBA), average (AV), and very much above average (VAA). Information about motivation and ability were obtained from different teachers who had known the stimulus students for 1-week, 1-year, or 5-year. This manipulation of length of contact between stimulus person and source of information was intended to ostensibly vary the reliability of information.

In addition to the main set of 81 descriptions, nine filler and 15 practice descriptions were also constructed. They were based on levels more extreme and other than those used in the regular descriptions already mentioned.

Procedure. The general procedure was same as in Experiment 1. Subjects made prediction of life performance of male stimulus students from information about student's motivation, source of motivation information, ability, and source of ability information. Subjects were instructed that teachers supplying motivation and ability information were different, and that information coming from teachers having contact of 1-week, 1-year, and 5-year with the stimulus students should be treated as low, moderate, and high in reliability, respectively. Each subject rated the main set of 81 cards and nine fillers one by one over two trials of judgment in different shuffled orders. Data from both trials were analyzed.

Subjects. The subjects were 28 male and 4 female students from the same population as in Experiment 1. Each subject received 5 rupees for participation in the experiment.

Results and Discussion

Linear fan pattern. A complete overview of the results is given in Figure 2, which plots the mean life performance from all 81 cells of the design. There are nine graphs for each of the nine combinations of reliability of information about motivation and ability. Each graph has motivation as curve parameter and ability on the horizontal axis. Every graph has the linear fan pattern predicted by Models 1 and 5.

Figure 2 about here

These results provide strong support for the multiplying model, and trend analyses further supported the interpretation of linear fan form. Partition of the overall Motivation x Ability effect, F (4, 124) = 17.92, $p <$ .001, shown in the fifth graph from left in Figure 3, into Linear x Linear, Linear x Quadratic, Quadratic x Linear, and Quadratic x Quadratic components yielded F (1, 31) = 30.09, 0.11, 0.42, and 0.74, respectively. The Linear x Linear component is highly significant, and the linear-quadratic components are all nonsignificant, just as predicted by the multiplying model. This provides an independent replication of the fan pattern found in Experiment 1.

Effects of information reliability. The effects of the manipulation of information reliability are in accord with the predictions of Model 5. The greater the reliability of the information, the greater its effectiveness. More importantly, the effectiveness of information of one kind is independent of the reliability of information of another kind.

These results can be seen in Figure 2. Look at the three graphs at the top layer of Figure 2 which has ability information from highly reliable source. The three curves have greater vertical spread when motivation reliability is high (right panel) than when it is low (left panel). However, the slope of the ability curves are virtually the same across all three levels of motivation reliability.

Comparison of the top, center, and bottom layer graphs in the right side of Figure 2 also discloses the same trend in the effects of ability reliability. As the reliability of ability information increases from the bottom to top layers, the slopes of the curves increase. But the vertical spread of the curves which indicates effect of motivation remains constant.

The foregoing trends stand out more clearly from the two-way plots of data in Figure 3. The first two graphs from the left show the relationship between the reliability and value of information. It is evident that the effect of information is greater when it is of high than of low reliability. This trend is predicted by both Models 1 and 5.

Figure 3 about here

The third and fourth graphs from left in Figure 3 show the independence of the effectiveness of motivation information from the reliability of ability information and of ability information from the reliability of motivation information. Both graphs exhibit a pattern of parallelism demanded by Model 5. According to Model 1, the third and fourth graphs should have the same pattern as have the first and second graphs contrary to the results. Accordingly, Model 1 is rejected but Model 5 is retained.

In the statistical analyses of the data shown in the first four graphs from left in Figure 3, clear support is present for the two interpretations mentioned above. As is evident in Table 1, Motivation reliability x Motivation and Ability reliability x Ability effects concentrate in just the Linear x Linear trend but Ability reliability x Motivation and Motivation reliability x Ability effects have perfect parallelism.

Table 1 about here

Model 5 also predicts that Motivation reliability x Ability reliability, shown in the rightmost graph of Figure 3, and all higher order interactions should be nonsignificant. In the overall analysis of variance, however, one three-way effect, Motivation reliability x Motivation x Ability reliability was statistically significant, F (8, 248) = 4.16, $p < .001$. This unexpected interaction seems to be attributable to the lack of distinction between low and moderate levels of motivation reliability when ability reliability was low. This effect did not reappear in subsequent work which also obtained evidence for Model 5 (Upadhyaya, 1985). Therefore, it does not require any serious qualification on Model 5.

Two separate initial opinions. Model 5 recognizes the presence of two separate initial opinions, one about motivation and another about ability. The two crossover interactions shown on the left side of Figure 3 bear upon the validity of this interpretation. The crossover interactions arose due to averaging of the external information with the corresponding initial opinion.

Had subjects simply multiplied the value and reliability of information, the three curves of each graph would have shown the linear fan form, not the crossover. To account for the crossover interactions, the multiplying model would require negative values of motivation and ability information which were not present.

Response scale validity. An alternative interpretation of the linear fan pattern in Motivation x Ability effect is possible. If subjects followed a constant-weight averaging rule but reproduced their response using an exponential function (Surber, 1984b), then the multiplying interpretation of the fan pattern is incorrect. Such a response reproduction interpretation would account for the independence between the effectiveness of information of one kind and reliability of information of another kind, for the underlying model is assumed to be a constant-weight averaging rule (Singh & Bhargava, 1985a).

If this response reproduction interpretation is correct, then the fan pattern should be present not only in the Motivation x Ability effect but also in the Motivation reliability x Ability, Ability reliability x Motivation, and Motivation reliability x Ability reliability effects. Figure 3 and Table 1 show that this requirement is not fulfilled at all. The third, fourth, and sixth graphs of Figure 3 are parallel, as they are demanded to be by Model 5. The pattern of parallelism in these graphs indicates that subjects used an equal-interval scale (Anderson, 1981, 1982; Graesser & Anderson, 1974; Singh, in press) in rendering their judgments. It may be concluded, therefore, that subjects indeed multiplied motivation and ability information in prediction of life performance.

Discussion

The two hypotheses that information reliability causes averaging of external information with corresponding initial opinion of subjects, and that motivation multiplies ability in prediction of life performance received reasonably good confirmation in the present research. The success of the two hypotheses shows that the effect of information of one kind is independent of the reliability of information of another kind not only in constant-weight averaging model (Singh & Bhargava, 1985a) but also in the multiplying model. Implications of these findings are discussed below.

Role of Initial Opinion

Theoretical considerations. Much of the research performed within the information integration paradigm has centered around the notion that there is only one initial opinion in the judges which they average with given information. This position has been extremely useful in accounting for effects of set size of information (Anderson, 1981, 2.4), source credibility (Anderson, 1981, 4.4.3), and individual differences between subjects (Anderson, 1981, 4.3). But the judgmental tasks have mainly been forming impressions of personality from qualitatively similar pieces of information. The present work suggests that judgmental tasks consisting of qualitatively different inputs require separate initial opinions for each distinct cognitive unit. This seems to hold for motivation and ability in the present task and would be predicted for generosity and income in the prediction of gift size (Graesser & Anderson, 1974; Singh, in press).

What are the implications of accepting separate initial opinion for each cognitively distinct unit of information? Three points deserve consideration. First, it will enable a multiplying model to account for independence of effectiveness of information of one type from the reliability of information of different type which has so far been a prescription of only the constant-weight averaging model (Birnbaum, 1976; Birnbaum et al., 1976; Singh & Bhargava, 1985a). This would also help account for the effect of set size of an information on that very information alone (e.g., Design 2 of Experiment 1).

Second, both the independence of effectiveness of first factor from the reliability of the second factor and the enhancement of effectiveness of second factor by the reliability of first factor are possible within the same experiment. The first situation can be explained by assuming the presence of initial opinion of second information; the second can be explained by the absence of an initial opinion of the first information. In Singh's (in press) experiment on gift size, reliability of income enhanced the effectiveness of generosity information, but reliability of generosity did not enhance the effectiveness of income information. Perhaps judges had much higher initial opinion of generosity than of income. In fact, the crossover interaction between generosity reliability and generosity was much stronger than that between income reliability and income.

Finally, the distinction between Models 1 and 5 is valid only when the initial opinions are present. When both initial opinions are absent, Model 5 automatically reduces to Model 1. This means that the multiplying model for a two-factor task predicts an enhancing effect of information reliability when initial opinions are absent but independence of the effectiveness of one factor from the reliability of another when the initial opinions are present. In this way, the present research extends the predictive power of the multiplying model.

It should be emphasized that Singh and Bhargava (1985a) had suggested the possibility of two initial opinions, one of motivation and one of ability, in even the constant-weight averaging model. Findings of the present research indicate that the structure of their constant-weight averaging model (i.e., Equation 4) is more meaningful psychologically than that of the model (i.e., Equation 3) proposed by Birnbaum (1976) and by Birnbaum et al. (1976). It may also be noted that the relative-weight averaging does not appear to be necessarily linked with nonparallelism in the Motivation x Ability effect contrary to what Singh and Bhargava (1985a) had suggested.

Methodological considerations. Tests of multiplying models have often faced difficulties. In two-factor studies, some subjects had unexplained deviations from the bilinear trend (Lopes, 1976; Shanteau & Nagy, 1879). In three-factor studies, one of three two-factor interactions had parallelism and the three-factor interaction failed to show a trilinear component (Klitzner & Anderson, 1977; Norman, 1977; Shanteau & Anderson, 1972). These deviations from the predictions of the multiplying model have been attributed to low statistical power of the tests (Klitzner & Anderson, 1977), to no identifiable reasons (Shanteau & Nagy, 1979), or to task simplification (Shanteau & Anderson, 1972; Slovic & Lichtenstein, 1968).

Results of the present research suggest that the initial opinions of the subjects may make the tests of multiplying model more difficult. Consider an experiment with motivation, ability, and external opportunity as factors. Even if care is taken to ensure that the levels of each factor represent the entire stimulus scale, the real psychological values of the levels of each factor may change contingent upon the weight of the initial opinion of each factor. If subjects give low, equal, and high weights to the respective initial opinion of motivation, ability, and opportunity, then the levels of each of the three factors would represent different portions of the stimulus continuum. At the second stage of integration, therefore, the multiplication of three stimulus values may not produce unambiguous evidence for the multiplying model.

There is no way to judge to what extent problems raised above complicated the tests of multiplying models in the studies cited earlier. Nevertheless, it is clear that presence of separate initial opinions is likely to create ambiguity in tests of multiplicative models.

Performance = Motivation x Ability

Previous studies of the prediction of performance from information about motivation and ability invariably obtained evidence for the parallelism pattern in India (Gupta & Singh, 1981; Singh & Bhargava, 1985a, 1985b; Singh et al., 1979). Results of the present research suggest that one reason for the failure of the linear fan pattern in these studies could have been the presence of two initial opinions in Indian subjects. The averaging of initial opinion with supplied information may have restricted the range of stimulus information and hence reduced the possibility of fan form in Motivation x Ability effect.

Although this possibility cannot be ruled out completely, the constant-weight averaging model considered by Singh and his associates seems to be defensible. In these studies, levels of motivation and ability varied widely, and none of the 18 groups of subjects, including school children, had any indication for the fan pattern.

The interpretation favored by Singh and associates is one of cultural difference between America and India in the outlook on how motivation and ability determine performance. The multiplying rule for Americans implies an elitist, individualistic belief that effort is more effective with persons of high than of low ability. In contrast, the constant-weight averaging rule for Indians reflects on an egalitarian, collectivistic belief that effort is equally effective with persons of low and high ability. The present finding of linear fan pattern qualifies the cultural difference hypothesis, as do the failures of the linear fan pattern in American studies (Surber, 1981a, 1981b, 1985).

Perhaps the cognitive algebra of task performance is linked with the nature of task (Singh & Bhargava, 1985b; Surber, 1984b). The multiplying rule is employed in prediction of performance on nonacademic tasks (Kun et al., 1974; Surber, 1980); the academic tasks follow both averaging (Surber, 1981a, 1981b, 1985) and multiplying (Anderson, 1983; Anderson & Butzin. 1974) rules contingent upon their difficulty.

It should, however, be emphasized that present finding of the linear fan pattern is not just a task effect. Bhargava (1983) repeated the present experiment on children of Standard V, VII, IX, and XI of a school and on undergraduate and postgraduate college students of business administration. He found evidence for the multiplying rule only at the level of postgraduate students, a group comparable to the one used in the present research. Subjects from other groups followed the constant-weight averaging rule. Accordingly, Bhargava claimed that the fan pattern in prediction of life performance in an Age x Task effect.

To the above, it may be added that the multiplying rule is employed by American children of Standard II (Kun, et al., 1974) but only later by Indian subjects (Bhargava, 1983). Furthermore, exam difficulty moderates the pattern in Motivation x Ability effect in the United States (Surber, 1981a) but not in India (Singh & Bhargava, 1985b). All these results cannot be explained fully by any one of the hypotheses of cultural difference, task difficulty, and nature of task. Perhaps cognitive algebra of task performance depends upon the nature and difficulty of task as well as upon the age and culture of judges.

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Table 1

F Ratios for Overall Interaction Effect and for Four Trend Components

Effect	Overall (4,124)	Trend Components L x L (1,31)	L x Q (1,31)	Q x L (1,31)	Q x Q (1,31)
Motivation reliability x Motivation	81.99*	20.06*	4.02	0.12	0.33
Ability reliability x Ability	52.10*	13.16*	0.07	1.71	0.02
Ability reliability x Motivation	0.37	0.02	0.04	0.10	0.18
Motivation reliability x Ability	2.36	0.01	0.71	1.80	0.00
Motivation reliability x Ability reliability	1.54	3.35	1.52	2.79	1.24

Note. Letters L and Q refer to linear and quadratic components, respectively. The figures in parentheses are *dfs* for each *F* test.

* $p < .001$

Appendix

The presence of nonzero interaction terms in the two-stage averaging-multiplying model expressed in Equation 5 depends on values of parameters. In this section, the theoretical expressions for the interaction terms are derived.

First, the two-stage model in which motivation information is averaged with an initial impression for motivation and ability information is averaged with an initial impression for ability will be rewritten in a simpler form. Without loss of generality, let $\underline{w}''_M = \underline{w}''_A = 1$ and let $\underline{w}_{Im} = (1 - \underline{w}_M)$ and $\underline{w}_{Ia} = (1 - \underline{w}_A)$. Then,

$$R = [(1 - \underline{w}_M)\ Im + \underline{w}_M\ M] \times [(1 - \underline{w}_A)\ Ia + \underline{w}_A\ A], \quad (1)$$

where R is predicted performance, M and A are the scale values for motivation and ability, $\underline{w}_M$ and $\underline{w}_A$ are their respective weights, and Im and Ia are the respective values of the initial impression. Multiplying the equation through,

$$R = (1 - \underline{w}_M)\ (1 - \underline{w}_A)\ Im\ Ia + \underline{w}_M\ (1 - \underline{w}_A)\ Ia\ M$$
$$+ \underline{w}_A\ (1 - \underline{w}_M)\ Im\ A + \underline{w}_M\ \underline{w}_A\ MA. \quad (2)$$

The presence of interactions may be determined by the method of taking partial derivatives. It will be shown that this model predicts nonzero interactions between M and A, $\underline{w}_M$ and M, and $\underline{w}_A$ and A; and it will be shown that under normal conditions it predicts zero interactions between $\underline{w}_M$ and A, $\underline{w}_A$ and M, and $\underline{w}_M$ and $\underline{w}_A$.

Partial derivatives of R with respect to two variables indicate if the response is affected by the joint combination of those two variables. The following are the partial derivatives for the first three combinations listed above:

$$dR/dMdA = \underline{w}_M \, \underline{w}_A , \quad (3)$$

$$dR/d\underline{w}_M \, dM = (1 - \underline{w}_A) \, Ia + \underline{w}_A \, A, \quad (4)$$

$$dR/d\underline{w}_A \, dA = (1 - \underline{w}_M) \, im + \underline{w}_M \, M. \quad (5)$$

Equation 3 indicates that a nonzero interaction is predicted between M and A as long neither $\underline{w}_M$ nor $\underline{w}_A$ are zero. Equations 4 and 5 indicate interactions between $\underline{w}_M$ and M and between $\underline{w}_A$ and A. Furthermore, these interactions should be confined to the bilinear component.

The following are the partial derivatives for the last three combinations:

$$dR/d\underline{w}_M \, dA = \underline{w}_A \, (M - Im), \quad (6)$$

$$dR/d\underline{w}_A \, dM = \underline{w}_M \, (A - Ia), \quad (7)$$

$$dR/d\underline{w}_A \, d\underline{w}_M = (M - Im) \, (A - Ia). \quad (8)$$

When averaged across factors not partialled, the equations become:

$$d\bar{R}/d\underline{w}_M \, dA = \underline{w}_A \, (\bar{M} - Im), \quad (9)$$

$$d\bar{R}/d\underline{w}_A \, dM = \underline{w}_M \, (\bar{A} - Ia), \quad (10)$$

$$d\bar{R}/d\underline{w}_A \, d\underline{w}_M = (\bar{M} - Im) \, (\bar{A} - Ia), \quad (11)$$

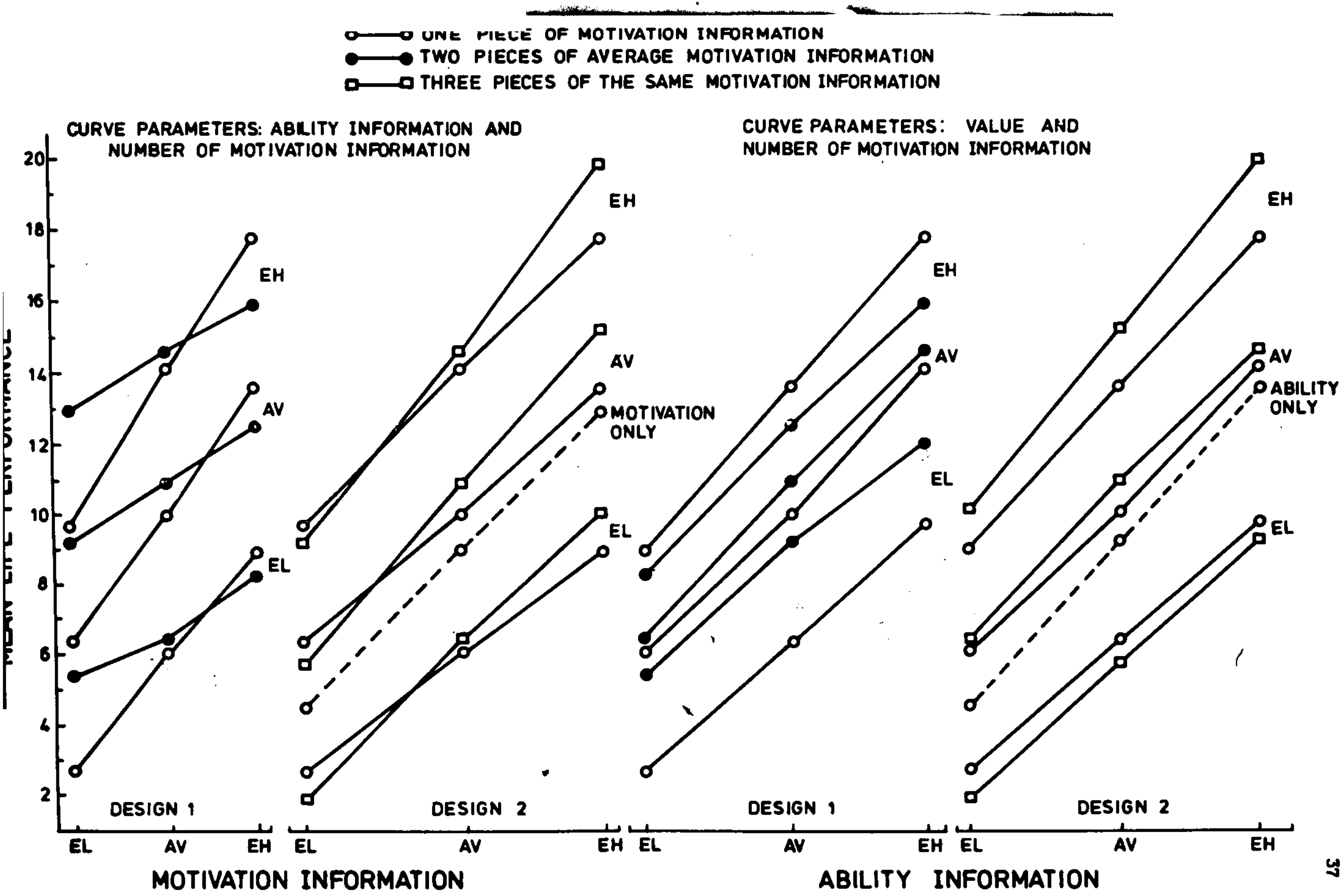
where $\bar{M}$ and $\bar{A}$ are the means of the scale values for levels of motivation and ability respectively. Consequently, when the mean of the scale values of M and the value of the initial opinion Im are equal, no interaction is predicted between $\underline{w}_M$ and A nor between $\underline{w}_A$ and $\underline{w}_M$. Similarly, when the mean of the scale values of the initial impression Ia are equal, no interaction is predicted between $\underline{w}_A$ and M nor between $\underline{w}_A$ and $\underline{w}_M$. Under normal circumstances, $\bar{M}$ will be equal to Im and $\bar{A}$ will be equal to Ia; hence, these interactions should be zero.

Figure Captions

Figure 1. Factorial plots of Ability x Motivation and Motivation x Ability effects from the two designs of Experiment 1.

Figure 2. Mean life performance as a function of motivation and ability under the nine combinations of information reliability.

Figure 3. Six two-way factorial plots of data from the four-way Motivation x Motivation reliability x Ability x Ability reliability design.


ONE PIECE OF MOTIVATION INFORMATION
TWO PIECES OF AVERAGE MOTIVATION INFORMATION
THREE PIECES OF THE SAME MOTIVATION INFORMATION
CURVE PARAMETERS: ABILITY INFORMATION AND NUMBER OF MOTIVATION INFORMATION
CURVE PARAMETERS: VALUE AND NUMBER OF MOTIVATION INFORMATION
MEAN LIFE PERFORMANCE
20
18
16
14
12
10
8
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4
2
EH
AV
EL
MOTIVATION ONLY
ABILITY ONLY
DESIGN 1
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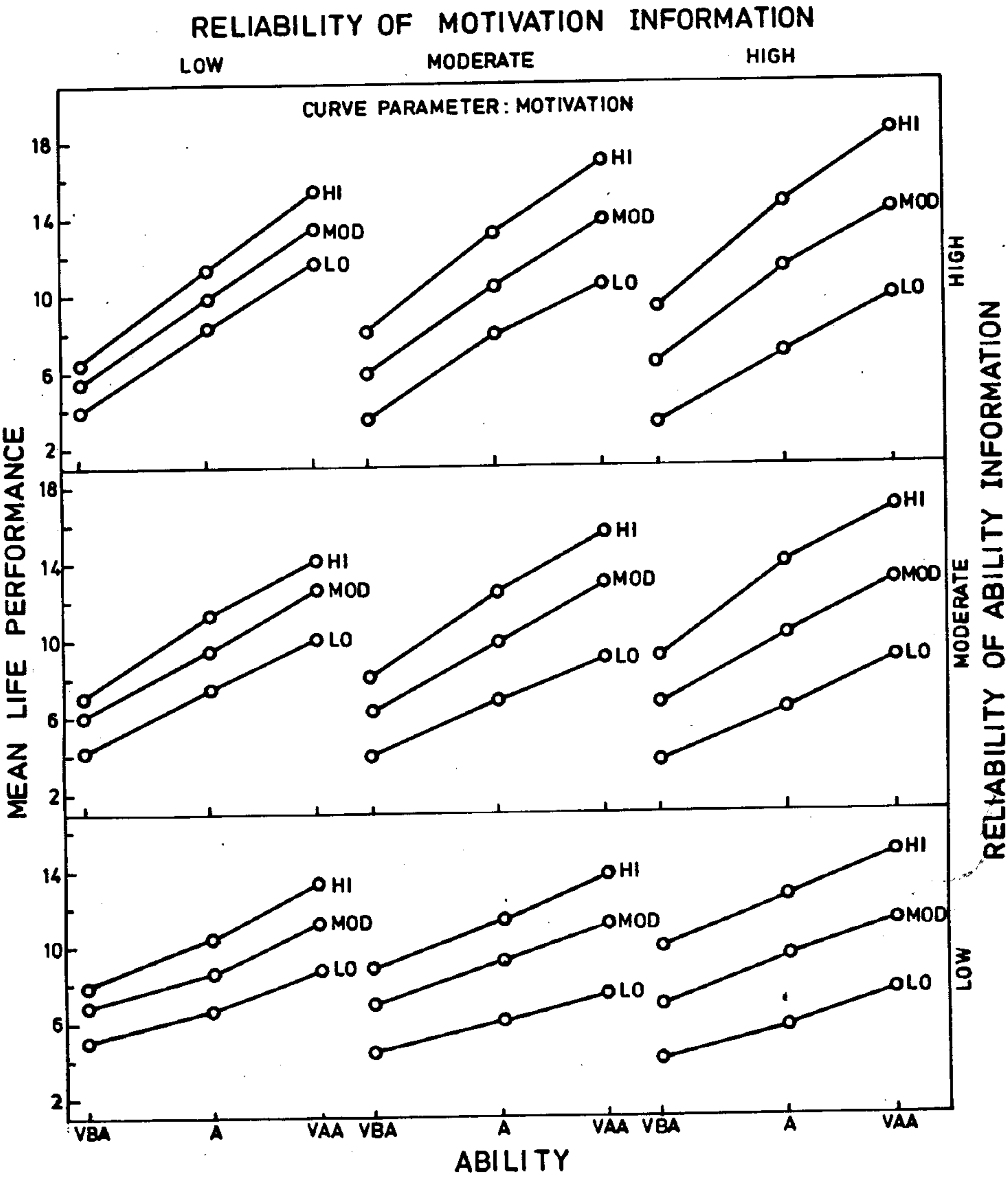
RELIABILITY OF MOTIVATION INFORMATION
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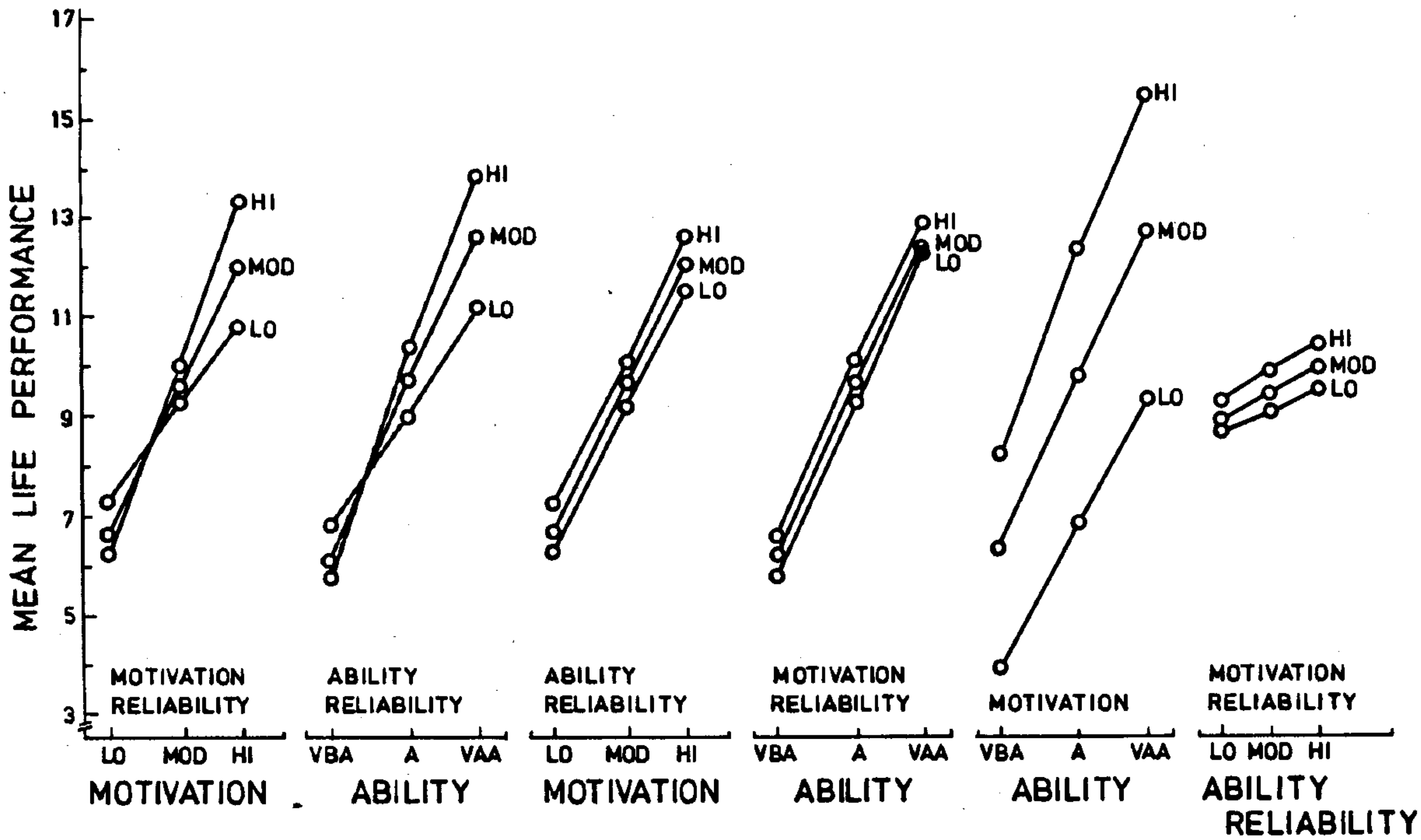
MEAN LIFE PERFORMANCE
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