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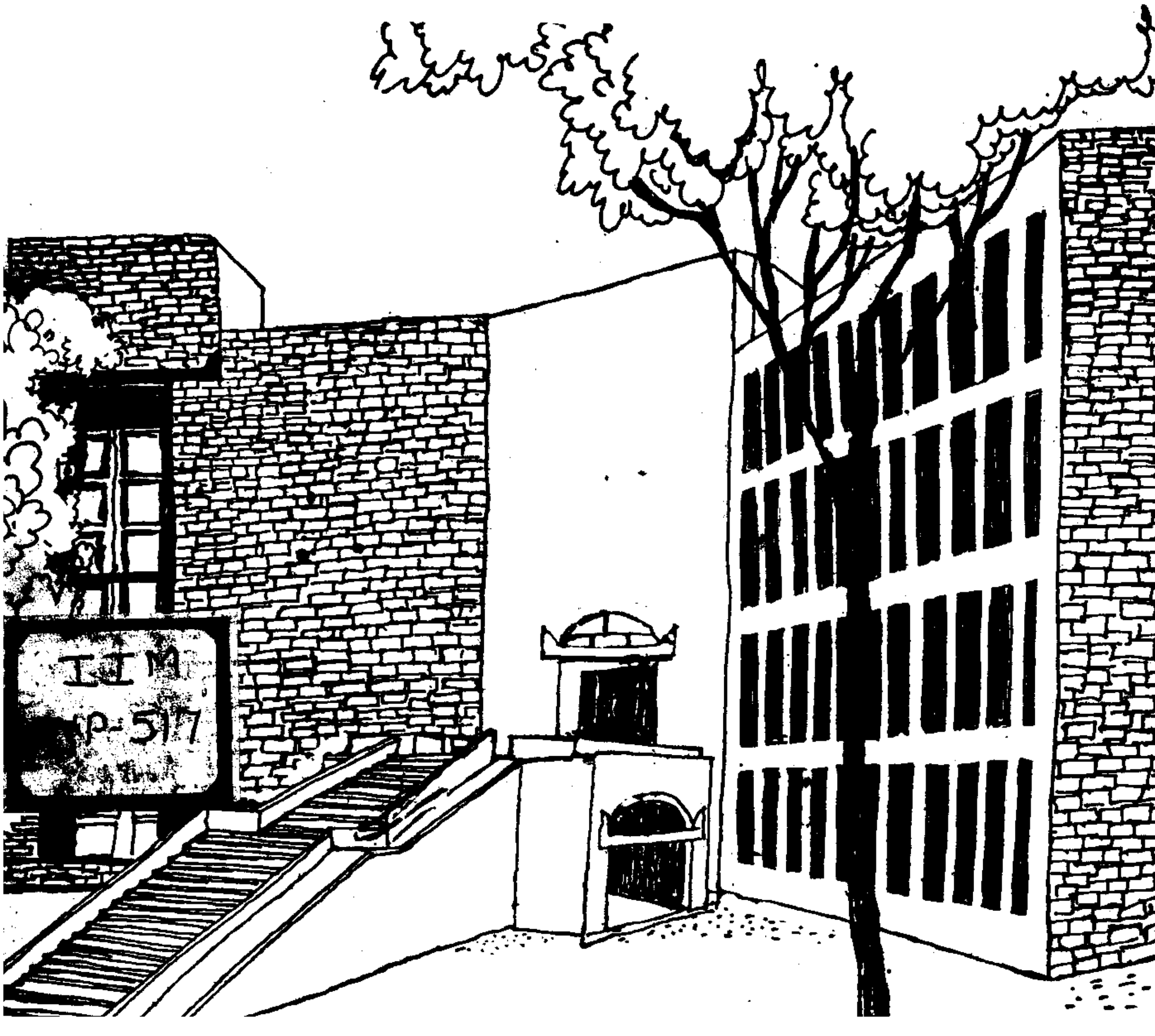

COGNITIVE ALGEBRA OF EXAM PERFORMANCE: TESTS OF HYPOTHESES OF CULTURAL DIFFERENCE, TASK DIFFICULTY, AND IMPUTATIONS

By

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Cognitive Algebra of Exam Performance: Tests of Hypotheses of Cultural Difference, Task Difficulty, and Imputations

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Abstract

In a series of six experiments, prediction of exam performance from information about motivation and ability as well as about motivation alone or ability alone of students was studied. The factorial plot of the Motivation x Ability effect always yielded the parallelism pattern with subjects from both student and nonstudent populations. Manipulation of difficulty of exam did not alter this parallelism pattern. Results agreed with the hypothesis of cultural difference between India and America but disagreed with the hypothesis of task difficulty. Distinguishing tests between the adding and constant-weight averaging rules disclosed a developmental trend: High school and undergraduate college students followed the averaging rule; postgraduate students followed the adding rule. Establishment of these rules allowed analyses of imputations about missing information. The conventional distinguishing tests which rely on just one of the two heterogeneous types of information were found to be more useful in analyses of imputation rules than in diagnosis of cognitive algebra. Manipulation of information reliability disclosed presence of two initial opinions, one about motivation and another about ability, contrary to the finding of one initial opinion in American students.

Cognitive Algebra of Exam Performance: Tests of Hypotheses of Cultural Difference, Task Difficulty, and Imputations

How do people integrate information about motivation and ability of a person when they predict his or her future performance? Heider (1958) suggested the multiplying rule: Performance = Motivation x Ability. In Anderson's (1981, 1982) theory of information integration, such a multiplying rule implies a linear fan pattern in the factorial plot of the Motivation x Ability effect.

Experimental tests of this prediction of fan pattern have yielded equivocal evidence. Some studies obtained evidence for the linear fan pattern (Anderson, 1983, pp. 73-76; Anderson & Butzin, 1974; Kun, Parsons, & Ruble, 1974; Surber, 1980); others found support for a pattern of near-parallelism (Gupta & Singh, 1981; Singh, Gupta, & Dalal, 1979; Surber, 1981a). Two hypotheses, cultural difference (Gupta & Singh, 1981; Singh et al., 1979) and task difficulty (Surber, 1981a, 1981b), have been advanced to account for the emergence of the parallelism and fan patterns in the factorial plot of the Motivation x Ability effect. The first purpose of the present research was to test plausibility of these two rival hypotheses.

Hypotheses of Cultural Difference and Task Difficulty

Since the prediction, Performance = Motivation x Ability, was clearly supported in the United States (Anderson & Butzin, 1974; Kun et al., 1974) but not in India (Gupta & Singh, 1981; Singh et al., 1979), a hypothesis of cultural difference between America and India seemed reasonable. Singh and his associates proposed, therefore, that the two cultures differ in their outlook on how motivation and ability determine performance. Americans follow the multiplying rule because of their cultural belief that effort will be more effective with persons of high than of low ability. In contrast, the adding-type rule with Indians reflects on their equalitarian belief that effort will be equally effective with persons of low as well as of high ability.

Surber (1981a) studied prediction of exam performance by American college students and obtained results identical to those of Singh et al. (1979). In her experiment, the exam was described to be of medium difficulty. She suggested, therefore, that task difficulty may determine the rule for combination of information about motivation and ability In a subsequent study, Surber (1981b) demonstrated that converging, parallelism, and diverging patterns in the Motivation x Ability effect are indeed characteristics of exams described as easy, moderately difficult, and very difficult, respectively.

If the hypothesis of task difficulty can indeed account for the failures of the linear fan pattern in Indian studies, then different patterns in the Motivation x Ability effect should be engendered by specifying the difficulty of exam. More specifically, exams described as very easy, OK, and very difficult should produce converging, parallelism, and fan patterns just as in Surber's (1981b) experiment. On the contrary, if the hypothesis of cultural difference has any merit, then Motivation x Ability effect should yield a pattern of parallelism across all levels of exam difficulty. Experiments 1, 2, and 6 tested the plausibility of these two competing hypotheses.

Diagnosis of Cognitive Algebra and Imputations

At the overt level, the parallelism and fan patterns are reflective of the adding and multiplying rules, respectively. But an averaging rule can also account for both patterns. If the weight or importance of the two types of information remain constant in all possible combinations, then averaging rule yields the parallelism pattern. But when lower values of the factors have greater weight or importance, then the very averaging operation produces a fan pattern. So the parallelism and fan patterns are always subject to alternative interpretations.

Distinguishing test based on one type of information. Singh et al. (1979), Gupta and Singh (1981), and Surber (1980, 1981b) tried to distinguish between alternative rules by asking for judgments based on information about motivation alone or ability alone. They reasoned that the curve based on just one-factor should form part of the parallelism pattern if the adding rule were operative and of the fan pattern if the multiplying rule were operative. But if the averaging rule holds, then the single-factor curve should have slope steeper than that of the two-factor curves. This prediction of the averaging model was supported in most cases. Only the adults in Surber's (1980) study followed the multiplying rule.

The distinguishing test described above rests on the assumption that only the available pieces of information control the judgment. This assumption may not be valid for the present task, for a prediction of performance cannot be made on the basis of information about motivation alone or ability alone. Since information about both motivation and ability are necessary, subjects may impute some value to the missing information to arrive at their judgment. When such imputations are allowed, the distinguishing test based on just one type of information turns out to be ambiguous.

Imputations have in fact been found in a number of information integration tasks (Lane & Anderson, 1976; Leon, 1980; Yamagishi & Hill, 1981), including prediction of performance (Anderson, 1983, pp. 73-76; Gupta & Singh, 1981; Singh et al., 1979; Surber, 1980). In a detailed study of imputations, Singh (in press) obtained judgments of gift size from information about generosity and income of the donors. He found clear evidence for the multiplying rule: Gift Size = Generosity x Income. By showing that the cognitive algebra was indeed multiplying, it was possible to detect precise forms of imputations about missing information. Missing generosity information was imputed a constant, average value, whereas the missing income information was imputed a value equal to that of the given information about generosity. As different types of information engender different forms of imputations, the averaging or multiplying interpretation of the data reported in previous work (Gupta & Singh, 1981; Singh et al., 1979; Surber, 1980, 1981b) may not be quite correct.

Distinguishing test based on information reliability. The problems connected with imputations about missing information may be avoided by employing test which includes both types of information. Surber (1981a) has performed one such test based on information reliability in order to distinguish averaging rule from multiplying rule. According to Anderson's (1981) averaging model, which was employed by Surber, the judgment of performance should be

$$\text{Performance} = \frac{\underline{w}_M M + \underline{w}_A A + \underline{w}_o I_o}{\underline{w}_M + \underline{w}_A + \underline{w}_o}, \tag{1}$$

where M, A, and I_o are the scale values of motivation, ability, and initial opinion, and $\underline{w}_M$, $\underline{w}_A$, and $\underline{w}_o$ are their respective weights. Reliability of information is assumed to affect weight parameters (Anderson, 1971). If the value of $\underline{w}_M$ is increased by varying the reliability of motivation information, then the relative weight and the relative effect of the ability information should be reduced. If motivation and ability are multiplied, however, then

$$\text{Performance} = \underline{w}_M M \times \underline{w}_A A. \tag{2}$$

In this case, an increase in $\underline{w}_M$ will also increase the effect of ability information. The two models thus make sharply contradictory predictions.

For judgment of exam performance (Surber, 1981a), this test yielded evidence for the averaging rule: The greater the reliability of one type of information, the less the effect of the other type of information. In Singh's (in press) study of judgment of gift size, however, the prediction of the multiplying rule was upheld: The greater the reliability of one type of information, the greater the effect of the other type of information.

While the two studies cited above bear upon the potential of this distinguishing test between rules, its utility is rather restricted for at least three reasons. First, it is of no use at all in study of imputations which seem to be pervasive in judgments. Second, it cannot distinguish an adding rule from a constant-weight averaging rule, both of which predict a parallelism pattern. As will be shown later, this test did not distinguish between adding and constant-weight averaging rules in Experiments 2 and 3 of the present research also. Finally, Anderson (1981, Note 4.4.3a, p. 315) has suggested that subjects may have two initial opinions, one for motivation and another for ability. With such a processing flow, reliability manipulation will affect respective initial opinion alone; weight of one type of information will have no bearing on the value of another type of information. Thus, model diagnosis will not be possible through manipulation of information reliability.

Distinguishing test based on two-operation model. A general way to attack the problem of diagnosing imputations and cognitive algebra is to use the two-operation model (Anderson, 1981), in which two pieces of information are given about motivation and one about ability. One of the motivation cues can then be omitted without creating any problem of missing information. To study imputations, judgments based on information about motivation alone and ability alone can also be obtained.

This task leads to a two-operation, averaging-multiplying model. Since the two motivation cues are qualitatively similar, previous work on person cognition implies that they will be averaged (Anderson, 1981; Singh, in press). But if Heider's (1958) multiplying hypothesis is correct, then motivation and ability should multiply. The judgment of performance would thus obey the following compound averaging-multiplying model,

$$\text{Performance} = (\text{Motivation-1} + \text{Motivation-2}) \times \text{Ability}. \qquad (3)$$

The factorial graph of the two motivation cues should exhibit the parallelism pattern, at least if the constant-weighting condition holds. However, both motivation-ability graphs (i.e., Motivation-1 x Ability and Motivation-2 x Ability) should exhibit the linear fan pattern.

The critical discrimination between the multiplying and averaging rules would come from the pattern in the combined factorial plot of the Motivation x Ability data from the three- and two-cue designs. If the multiplying rule is correct, then data from the three- and two-cue designs should form a common linear fan pattern. But if the one-operation, three-cue averaging rule is operative, then the two-cue curves would have slope steeper than the three-cue curves.

The position of the single-cue curve in the combined plot of data would further disclose the forms of imputations about missing information. If the three- and two-cue data form a common pattern, parallelism or linear fan, and the single-cue data also conform to the very pattern, then missing information was imputed a single, constant value. In contrast, if the single-cue curve crosses over the two- or three-cue curve(s), then missing information was imputed a value equal to that of the given information.

The usefulness of this two-operation model in diagnosis of cognitive algebra and imputations in causal attribution is well-documented (Singh, in press). In prediction of exam performance which has been a subject of controversy in recent years (Singh, 1981; Surber, 1981a, 1981b), however, doubt exists about the real operative rule for the reasons mentioned earlier. The second purpose of the present research was thus to assess the diagnostic power of different methods of detecting cognitive algebra, imputations, and initial opinions in prediction of performance.

Experiments 1, 2, and 3

Experiments 1, 2, and 3 had three main purposes. The first was to explicate the previous finding of parallelism pattern in the Motivation x Ability effect (Gupta & Singh, 1981; Singh et al., 1979). The second was to assess the plausibility of the hypotheses of cultural difference and task difficulty for the emergence of the parallelism and fan patterns in the Motivation x Ability effect. The final was to determine the real cognitive algebra underlying prediction of exam performance by varying reliability of information just as in the experiment by Surber (1981a) and by Singh (in press).

Method

Stimuli and designs. Experiment 1 through 3 had descriptions of high school (i.e., Standard X) students who were to take the final exam conducted by the All India Examination Board. Description of each student was typed on separate index card, and cards were presented to subjects in different shuffled orders.

In Experiments 1 and 2, student descriptions contained information about difficulty of the exam as well as motivation and ability (i.e., IQ) of the student. Exam was described as extremely difficult, very difficult, difficult, OK, easy, very easy, or extremely easy. Motivation was defined by one's willingness and seriousness to do well in the exam, and was described as not at all motivated, little bit motivated, below average, average, above average, very much motivated, or extremely motivated. Ability was indicated by IQ which ranged from 85 to 140.

In Experiment 1, stimulus descriptions were prepared according to a 3 x 3 x 3 (Exam difficulty x Motivation x IQ) factorial design. The three levels of exam difficulty were very difficult (VD), OK, and very easy (VE); the three levels of motivation were little bit motivated (LO), average (AV), and very much motivated (HI); and the three levels of IQ were 90, 112, and 135.

The design of Experiment 2 was a 3 x 3 x 3 x 3 (Exam difficulty x Motivation x IQ x Reliability of IQ estimate) factorial. The three levels of the first three factors were the same as in Experiment 1. Reliability of IQ estimate was manipulated by specifying the duration of the intelligence test. Tests were described to be of 1- , 5- , or 10-hour duration. This information was typed immediately below the IQ information.

Experiment 3 described the exam as OK, that is, medium in difficulty, and manipulated information about motivation, IQ, and reliability of both types of information. The first design was a 4 x 2 x 4 x 2 (Motivation x Reliability of motivation information x IQ x Reliability of IQ estimate) factorial which produced descriptions of 64 two-cue students. The motivation scale had 9 verbal labels of *not at all motivated*, *very very low*, *a little bit of*, *some*, *a moderate amount of*, *fairly much*, *a good deal of*, *a great deal of*, and *extremely motivated*. The four levels of motivation factor were *very very low* (VVL), *some* (SM), *fairly much* (FM), and *a great deal of* (GRT); the four IQ levels were 90, 105, 120, and 135. The motivation information came from a classmate who had known the student for 1 month (low reliability) or 5 years (high reliability). The IQ estimate was from a test of 1-hour (low reliability) or 10-hour (high reliability) duration.

The second and third designs of Experiment 3 were 4 x 2 factorials, one for Motivation x Reliability of motivation information and one for IQ x Reliability of IQ estimate. The levels of the factors of these two designs were identical to those in the main design. The designs generated descriptions of sixteen students, eight described with respect to motivation alone and the remaining eight with respect to IQ alone.

There were nine filler descriptions in Experiments 1 and 2 and 10 filler descriptions in Experiment 3. These were based on levels other than those used in the regular descriptions. Four of these descriptions had levels more extreme than those used in main stimuli and so they served as end anchors. In each experiment, there were 15 practice examples. These descriptions were intended to orient the subjects to use the response scale in a uniform way and to serve as end anchors (Anderson, 1982).

<u>Procedure</u>. Subjects, gathered in groups of four to six, received a typed sheet of instructions that described the nature of the task and their role as subjects. The task

was introduced as dealing with prediction of performance of some Standard X students in their forthcoming final Board examination. It was emphasized that prediction of exam performance would be based on difficulty of the paper as well as motivation and ability of the students.

In all three experiments, basis of deciding difficulty of the test paper was a distribution of scores obtained by a random sample of 10,000 students at a previous exam. In Experiments 1 and 2, the source of motivation information was a classmate who had known the student closely for at least 5 years. In Experiment 3, the classmate had known the student for 1 month or 5 years. The IQ estimates of Experiment 1 were from a test of 10-hour duration; those of Experiment 2 were from tests of 1- , 5- or 10-hour duration; and those of Experiment 3 were from tests of 1-hour or 10-hour duration. Subjects were urged to regard IQ estimates from tests of 1- , 5- , and 10-hour durations as low (LO), moderate (MOD), and high (HI) in reliability and validity.

Experiment 3 had some descriptions based on information about motivation alone or IQ alone. Subjects were told that it was not practically possible to get both types of information in all the cases. One of the two types of information would thus be missing. In those cases, judgments were to be made on the basis of whatever information was available.

After reading the instruction sheet twice, each subject worked with 15 practice examples. He read the information about each student and then indicated how that stimulus would perform at the Board exam. Prediction of exam performance was made along a 21-step ladder which had digits 1-21 written on the corresponding step.

After the practice session, the main points of the instructions were summarized to the subjects by the experimenter. All queries about the task were answered. To familiarize themselves with the nature and distribution of the descriptions, the subjects read description of at least 12 stimulus students randomly drawn from the main set of cards. Finally, each subject shuffled the main set of cards thoroughly and rated them two times in different shuffled orders. In each case, he wrote the code number of the student and his judgment of the student's performance on a response sheet supplied for this purpose. Data from both trials of judgments were coded and analyzed.

After all subjects of the group completed the task, general purpose of the research was described by the experimenter. Subjects were thanked for their cooperation in the research. In addition, each subject received 5 Rupees for his service.

Subjects. There were 20, 32, and 42 subjects in Experiments 1, 2, and 3, respectively. Subjects of Experiment 1 were second-year engineering students from the Indian Institute of Technology, Kanpur, India. They were used to replicate and extend the earlier findings from their population (Gupta & Singh, 1981; Singh et al., 1979).

Subjects of Experiments 2 and 3 were first-year students enrolled in the 2-year post graduate program in management of the Indian Institute of Management, Ahmedabad, India. These subjects were older than those in Experiment 1 by at least three years.

Results and Discussion

Parallelism pattern. The first point of interest in the data concerns the pattern in the factorial plot of the Motivation x Ability effect. Figure 1 presents such plots from the three experiments. According to the previous results (Gupta & Singh, 1981; Singh et al., 1979), the factorial plot of the Motivation x Ability effect should yield a pattern of parallelism. This is what was obtained in all three experiments.

Figure 1 about here

Statistical test of the parallelism pattern is obtained from the two-way, Motivation x Ability interaction in analysis of variance. Parallelism corresponds to statistically nonsignificant interaction. Experiments 1, 2, and 3 yielded $\underline{F}$ (4,76) = 0.69, $\underline{F}$(4,124) = 0.70, and $\underline{F}$ (9,369) = 1.16 in order. Since all three $\underline{F}$ ratios are negligible, statistical support for the parallelism pattern in the Motivation x Ability effect shown, in Figure 1 can be adjudged as quite good.

The finding of parallelism pattern indicates that subjects followed a simple integration model, adding or averaging This provides a replication of the previous finding from engineering students (Singh, et al., 1979). In addition, it shows generality of the very simple model to management students of slightly older age group.

Hypotheses of cultural difference and task difficulty. The second point of interest is in the plausibility of the hypotheses of cultural difference (Gupta & Singh, 1981; Singh 1981; Singh et al., 1979) and task difficulty (Surber, 1981a, 1981b) for the emergence of parallelism pattern. According to the former, parallelism pattern is characteristic of Indian students. In contrast, the latter hypothesis attributes parallelism to low and moderate difficult level of the task. More specifically, it specifies that tasks described as very difficult, OK, and very easy should yield linear fan, parallelism, and converging patterns, respectively.

Figure 2 plots profiles of Exam difficulty x Motivation x Ability effect from Experiments 1 and 2. The three graphs on the left have the very pattern of parallelism even though the exams were specified as very difficult, OK, and very easy. The three graphs on the right also display a similar picture. Although the fourth graph exhibits minor deviation from parallelism, there is a prevailing pattern of parallelism across all the three levels of exam difficulty. So it can be said that even explicit specification of task difficulty does not alter the parallelism pattern in India.

Figure 2 about here

It deserves mention that the hypothesis of task difficulty requires at least the first and fourth graphs to have the linear fan pattern. But the first graph has near-parallelism and the fourth one has slight convergence. Thus, there is no support for the hypothesis of task difficulty at all.

The hypothesis of task difficulty implies a three-factor interaction, Exam difficulty x Motivation x Ability in analysis of variance. This interaction was not significant in Experiment 1, *F* (8,152) = 0.88. Although it was statistically significant in Experiment 2, *F* (8,248) = 2.13, $p < .05$, the locus of this effect was strong end effect on the lower left point of the fourth graph in Figure 1. In fact, partition of the Motivation x Ability effect depicted in the fourth graph into its various trend components of Linear x Linear, Linear x Quadratic, Quadratic x Linear, and Quadratic x Quadratic by Shanteau's (1977) POLYLIN program did not yield any significant *F* ratio. The end effect interpretation for the triple interaction is thus reasonable. Results from these statistical tests are also contrary to the specifications of the hypothesis of task difficulty.

It should be noted that the failure of the exam difficulty to moderate the pattern in the Motivation x Ability effect cannot be attributed to the failure of the manipulation itself. In both experiments, the main effect of exam difficulty was substantial, *F* (2,38) = 62.74 and *F* (2,62) = 125.17. It seems that integration of information about task difficulty with information about motivation and ability of the students is also susceptible to cultural influence.

Figure 3 presents factorial plots of the Exam difficulty x Motivation and Exam difficulty x Ability effects from Experiments 1 and 2. The two graphs on the left are parallel, F (4,76) = 0.69 and F (4,124) = 1.14, so are the two graphs on the right, F (4,76) = 2.16 and F (4,124) = 1.44. This prevailing pattern of parallelism in the four graphs of Figure 3 as well as in the three Motivation x Ability plots of Figure 1 suggests that prediction of exam performance was made according to an additive model,

$$\text{Performance} = \text{Exam Easiness} + \text{Motivation} + \text{Ability}. \qquad (4)$$

Figure 3 about here

This model is in sharp contrast with the suggestions made by Kun and Weiner (1973) and by Surber (1981a, 1981b). Furthermore, it indicates that Indian college students integrate information about task difficulty, motivation, and ability in a way different than that of their American counterparts. This confirms the hypothesis of cultural difference.

Effects of information reliability. Figure 4 presents mean judgment of exam performance as a function of exam difficulty, motivation, IQ, and reliability of intelligence information. The main point of interest in the data centers around the relationship between motivation (curve parameter) and ability (listed on horizontal axis) under the three conditions of reliability of intelligence information. The effect of motivation appears to be about the same across all the three levels of intelligence reliability, for the vertical spread of curves is the same. The effect of reliability of intelligence information is on the slope of the IQ curves. The curve on the right side have steeper slope than those on the left side. This trend is present at each level of exam difficulty also. This means that reliability of intelligence information had impact on the effectiveness of IQ information alone.

Figure 4 about here

The same result emerges from the grahhs of Figure 5 which presents mean judgment of exam performance as a function of motivation, IQ, and their reliability from Experiment 3. Look at the two graphs at any level of IQ reliability. The four curves have greater spread when motivation reliability was high (right panel) than when it was low (left panel). Also, the slope of the IQ curves is constant across the two levels of motivation reliability. This means that effect of motivation reliability was confined to the motivation cue alone.

Figure 5 about here

Comparison of the upper and lower graphs of the left and right panels of Figure 5 also discloses the same trend. Although the vertical spread of the curves in the upper and lower graphs is about the same, the curves of the lower graph have steeper slope than those of the upper graph. This is because IQ reliability was high with lower graphs than with upper graphs. This comparison discloses that IQ reliability did not alter effectiveness of motivation information at all. Its effectiveness was restricted to just the IQ information.

The foregoing results are more evident from the two-way plots of Figures 6 and 7. Figure 6 presents relationship between reliability and value of an information. Consider the second graph which shows Reliability x Value of motivation information. Motivation information produced greater effect when it came from a classmate with 5-year contact (high reliability) than when it came from a classmate with just 1-month contact (low reliability). The other four graphs have the same trend: As the reliability of the information increased, the effect of the information also increased.

Figures 6 and 7 about here

That the effect of the reliability of an information was restricted to the very information alone can be seen from the parallelism pattern in the four graphs of Figure 7. These graphs display relationship between reliability of information of one type (curve parameter) and effectiveness of information of another type (on horizontal axis). All the four graphs have nice pattern of parallelism, _F_ (4,124) = 0.97 and 0.28 and _F_ (3,123) = 1.23 and 0.58 in order.

According to the relative-weight averaging model, the greater the weight of IQ information, the less the effect of the information about motivation. Thus, the slope of the two curves of the third graph from left of Figure 7 should have the crossover with _opposit_ ordering of curves in the second graph of Figure 6. There is no sign for this predicted pattern at all. The pattern in the other three graphs does not conform to the requirement of the relative weight averaging model either. On this basis, it can be said that the relative-weight averaging model cannot account for the parallelism pattern present in Figures 1 through 5. This finding casts doubt on the generality of Surber's (1981a) model for prediction of exam performance.

Evidence for two initial opinions. Results of Experiment 3 suggest a new model for the prediction of exam performance,

$$\text{Performance} = \left[\frac{\underline{w}_o M_o + \underline{w} M}{\underline{w}_o + \underline{w}} \right] + \left[\frac{\underline{u}_o A_o + \underline{u} A}{\underline{u}_o + \underline{u}} \right] . \qquad (5)$$

The M and A refer to scale values of motivation and ability information, M_o and A_o refer to initial opinion of motivation and ability, and $\underline{w}$ and $\underline{u}$ are weights for information about motivation and ability. According to this model, reliability of an information affects the effectiveness of the initial opinion about that very information alone. The information about motivation and ability are integrated by an adding-type rule at the second state of integration.

Equation 5 makes four precise predictions. First, prediction of exam performance involves subjective initial opinion of the judges. The role of such initial opinion can be seen by considering the upper-left graph and lower-right graphs of Figure 5 in which both types of information have equal reliability. The vertical separation between curves and the slope of the curves are greater in the lower-right than upper-left graph. This means that reliability of information operates on the initial opinion of the judges: Initial opinion plays greater role when information reliability is low than high.

Second, there are separate initial opinions of motivation and ability. This is illustrated by the lower-left and upper-right graphs of Figure 5. In the lower-left graph, IQ information has high reliability but motivation information has low reliability. In the upper-right graph, the reverse is true. The slope of the curves is thus steeper in the lower-left than in upper-right graph. In contrast, vertical spread of the curves is more in the upper-right than in lower-left graph. Since the vertical spread of curve is constant over two levels of IQ reliability and slope of the curves is constant across two levels of motivation reliability, it is reasonable to state that judges had separate initial opinions of motivation and ability. This confirms Anderson's (1981) suggestion that different types of information are processed separately.

Third, although the relationship between scale value and weight is multiplicative in Equation 5, integration of source and information may follow either a multiplying rule or a semilinear rule, depending upon the value of the initial opinion. For example, if $M_o = 0$ and $\underline{w}_o \neq 0$, then the left part of Equation 5 reduces to the multiplying rule

$$\text{Performance} = [\underline{w}/(\underline{w}_o + \underline{w})]M. \qquad (6)$$

Thus, interaction between reliability and value of motivation information will reside in just the Linear x Linear trend. However, if $M_o \neq 0$, then some higher-order trends will also be present. Trend analyses of the data shown in the first three graphs of Figure 6 from left yielded good evidence for the third prediction. The Reliability x IQ effects had semilinear trends in both Experiments 2 and 3; the Reliability x Motivation effect had only Linear x Linear trend. These results suggest that initial opinions of motivation and ability had different values.

Finally, Equation 5 predicts parallelism pattern in the Motivation x Ability effect. This was clearly supported in all three experiments (see Figure 1).

Considered together, results from the manipulations of information reliability in Experiments 2 and 3 disclose an altogether different manner of information processing in Indian subjects. Furthermore, they illustrate weakness in diagnostic power of this test between integration rules. The parallelism pattern shown in Figure 1 may be due to an adding rule or a constant-weight averaging rule.

Distinguishing test based on one type of information. A distinguishing test between the adding rule and the constant-weight averaging rule can be made by comparing the slope of the motivation-only or ability-only curve with that of curves based on information about both motivation and ability. If the adding rule is correct, the motivation-only and IQ-only curves would form part of the parallelism pattern. But if the constant-weight averaging rule is correct, then both the motivation-only and IQ-only curves would cross over the two-cue curves.

Figure 8 displays four graphs from Experiment 3. The two-cue data from the main four-way design have been plotted in both IQ x Motivation and Motivation x IQ formats to provide a clear comparison between slopes of two-cue (solid) and single-cue (dashed) curves. The motivation-only curves of the two graphs on left have slope steeper than that of two-cue curves. This is consistent with the constant-weight averaging rule. However, the IQ-only curves in the two graphs on right plot close to the two-cue curve based on some motivation. This agrees with the adding rule but infirms the constant weight averaging rule. Considered together, the single-cue distinguishing tests do not provide clear diagnosis of the cognitive algebra of exam performance.

Figure 8 about here

Imputation hypothesis. The inconsistency in results yielded by the motivation-only and ability-only tests may be resolved by assuming that subjects imputed some value to the missing information. The equivalence of the dashed curve and the second solid curve from below in the two graphs on right of Figure 6 reflects that subjects imputed a single, constant value of some motivation when IQ alone was given. However, the steeper slope of the motivation-only curve suggests that subjects imputed value to the missing IQ information as a positive function of the value of the information given about motivation. When such imputations are allowed, the results do not seem contradictory. Nevertheless, the possibility of imputations casts doubt on the diagnostic power of distinguishing tests based on just one type of information (Gupta & Singh, 1981; Singh et al., 1979; Surber, 1980, 1981b).

Experiment 4

The chief purpose of Experiment 4 was to resolve the ambiguity just noted in the diagnosis of cognitive algebra. This was done by pairing the ability information with either one or three similar pieces of information about motivation. This avoided the problem of missing information. If the averaging rule holds, then the curves from the two-cue design will cross over those from the four-cue design. But if motivation and ability are added together, then prediction of performance will obey the two-operation, averaging-adding model. The various pieces of motivation information will first be averaged and then the averaged motivation will be added to ability. In this case, therefore, the curves from the two-cue and four-cue designs will form a common parallelism pattern.

A second purpose of Experiment 4 was to obtain further evidence of the operation of imputations. Accordingly, judgments of performance were taken from information about motivation alone as well as ability alone.

Method

Stimuli and designs. Descriptions of stimulus students were prepared in much the same way as in the previous experiments. Motivation and ability were specified by verbal lavels of *extremely low*, *very much below average*, *below average*, *average*, *above average*, *very much above average*, and *extremely high*. This allowed use of comparable levels for the two factors.

Stimulus descriptions were prepared according to three designs. Design 1 was a 2 x 3 x 3 (Set size of 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 size of the descriptive sets was manipulated by including one (1) and three (3) similar pieces of motivation information. This design generated 18 descriptions - nine two-cue and nine four-cue.

Designs 2 and 3 had information about motivation alone and ability alone, respectively. Each design had the same three levels as of the motivation and ability factors in Design 1.

There were 12 end anchor and filler descriptions. The end anchor descriptions had motivation information from four sources; the filler sets had levels from the entire 7-point information scale described earlier. The 12 practice examples included two end anchors, five single-cue descriptions, three four-cue descriptions, and two two-cue descriptions. A total of 49 (37 main and 12 practice) descriptions were thus prepared.

Procedure. The general procedure was the same as in the previous experiments. Subjects were told that information about motivation and ability of the stimulus students came from teachers who had known them for at least five years. Furthermore, information about motivation came from one to four teachers and so opinions from two or more teachers were to be treated as equally important and valid. In cases where either motivation or ability information was not known, subjects were asked to rely their ratings on only the given information. The main set of 37 cards were rated over three separate trials of judgments in different shuffled orders. Data from all three replications were analyzed.

Subjects. The subeects were 20 male and four female students from the same population as in Experiments 2 and 3. Each subjects spent around one hour on the experimental task and received 5 Rupees for his or her service.

Results and Discussion

Two-operation model. Design 1 paired one or three similar pieces of motivation information with one piece of ability information. If all pieces of information available for judgment are averaged simultaneously as Equation 1 implies, then impact of the number of pieces of motivation information would be identical on the effectiveness of motivation as well as ability factor. Moreover, curves from the two-cue descriptions would cross over those from the four-cue descriptions in the combined factorial graph of the Motivation x Ability effect.

According to the hypothesized two-operation model, prediction of performance of a stimulus student of Design 1 would follow the compound averaging-adding model. The motivation cues will be averaged first and then averaged motivation will be added to ability information. Judgment of expected performance would thus be

$$\text{Performance} = \left[\frac{k\underline{w}\ M + M_o\ (1-\underline{w})}{k\underline{w} + (1-\underline{w})} \right] + \underline{u}A, \qquad (7)$$

where M, A, and M_o are motivation, ability, and initial opinion about motivation, $\underline{w}$, 1-w, and $\underline{u}$ are weight of motivation, initial opinion, and ability, respectively, and k is the number of pieces of motivation information of equal value. The first part of Equation 5 is identical to Anderson's (1967) set-size equation which predicts that adding more information of equal value makes a more polarized response.

Like Equation 1, this model predicts impact of set-size of motivation information on effectiveness of motivation factor. But unlike Equation 1, this model predicts no impact of set-size of motivation information on effectiveness of ability information. In the combined factorial plot of Motivation x Ability data, therefore, the expected pattern is parallelism, not the crossover interaction.

Figure 9 presents three two-way factorial plots of Set-size x Motivation, Set-size x Ability, and Motivation x Ability effects. The left graph illustrates the standard set-size effect: Sets having three similar pieces of motivation information produced much stronger effect than those having one motivation information. This agrees with previous findings of set-size effect in person cognition (Anderson, 1981, 2.4), and further extends its generality to integration of cues about motivation of a person.

Figure 9 about here

The center graph of Figure 9 provides a distinguishing test between one-operation and two-operation model. The two set-size curves are parallel; they do not exhibit a crossover pattern as in the left graph. Parallelism reflects that effect of ability information is independent of the effect of the set-size of motivation information. This agrees with the two-operation, averaging-adding model but rejects the one-operation averaging model.

Further evidence for the two-operation model comes from the right graph of Figure 10 which plots data from both set-sizes in the Ability x Motivation format. At each level of ability, similar set-size effect is present. This indicates that motivation cues were averaged in line with the first part of Equation 7.

Figure 10 about here

Both the adding and averaging rules require the right graph of Figure 10 to have a pattern of parallelism. The three graphs are nearly parallel, although there is an end effect on the upper right point. This deviation is minor; hence, the parallelism pattern can be accepted.

The left graph of Figure 10 shows the common factorial plot for Motivation x Ability effect. What is interesting is that the pair of two set-size curves is almost parallel at each level of motivation. This disagrees with the averaging rule but agrees with the adding rule. Although end effects are noticeable in this graph also, the overall picture that emerges from this combined factorial plot is parallelism, It may be said, therefore, that information about motivation and ability were added together.

A striking evidence for adding and against averaging rule is present in the pattern displayed by the pair of middle solid curves in the left graph. The solid curve with open-circle and with filled-circle are based on the three levels of ability listed on the horizontal axis plus one or three pieces of average motivation information, respectively. According to the averaging rule, the solid curve with open-circle should cross over the curve with filled-circle. This would happen because averaging of three moderate pieces of motivation information with the levels of ability factor 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 the prediction of the averaging rule, the two curves are parallel.

This parallelism supports the adding rule. It should be emphasized that these two curves are free from the problems connected with missing information. Nevertheless, they yield clear evidence for adding rule. The graphs of Figures 9 and 10 are thus in excellent agreement with the prescriptions of the compound averaging-adding model.

Detailed statistical analyses basically collaborated the above interpretations. The Set-size x Motivation effect was statistically significant, $\underline{F}$ (2,46) = 10.32, but the Set-size x Ability effect was nonsignificant, $\underline{F}$ (2,46) = 0.76. This establishes the crossover effects in the left graph and the parallelism pattern in the center graph of Figure 7. The Motivation x Ability effect which is required to be nonsignificant was significant, $\underline{F}$ (4,92) = 4.26, due to the end effects noted earlier. However, the Set-size x Motivation x Ability effect was absent, $\underline{F}$ (4,92) = 0.43, which indicates that the effect of ability information was independent of the set-size of motivation information. In other words, the slope of the curves for two set-sizes was identical.[1] It may be concluded, therefore, that subjects indeed obeyed the compound averaging-adding model in prediction of exam performance.

Imputations. Because the adding rule has been established, it is possible to show that subjects made imputations about missing information. Two rules of imputations must be considered, one for ability, the other for motivation.

When information about motivation alone was given, subjects imputed a fixed value to the missing ability information and added the given motivation and imputed ability values together. This interpretation comes from the dashed curve of the right graph in Figure 8. The dashed curve which is based on information about motivation alone plots similar to the solid curve with filled-circle, F (2,46) = 0.95, as well as with open-circle, F (2,46) = 1.05. Since the solid curves have the same average level of ability, it is reasonable to say that subjects imputed average value to the missing ability information.

If subjects made no imputation at all, then the slope and elevation of the dashed curve would be hard to understand. On the other hand, if subjects imputed a nonconstant value of ability, one that depended on the given value of motivation information, then the dashed curve would have had variable slope and crossed over the solid curves.

A different imputation rule seems to have been utilized when information about motivation was missing. In this case, subjects imputed a motivation value that is direct function of the given ability information. Evidence for this interpretation is present in the left graph of Figure 10, which plots the data from the two set-sizes in the form of two-way, Motivation x Ability format. The two solid curves are perfectly parallel, F (2,46) = 0.01, which was the basis of accepting the adding rule and rejecting the averaging rule earlier. But the dashed curve based on information about ability alone clearly crosses over the solid curves, F (4,92) = 11.37. This crossover does not establish the averaging rule, for the distinguishing test which avoided the problems connected with imputations supported the adding rule.

The steeper slope of the dashed curve based on ability information can be explained by the imputation hypothesis. It seems that subjects assumed a direct correspondence between ability and motivation: Students who are more capable have more motivation also. In other words, subjects imputed a value to the missing information in direct relation to the given ability information and added the imputed and given values to arrive at their judgments.

The foregoing results of imputations indicate that there is an assymmetry in the imputation rules for the two types of information. Although the levels used in the description of motivation and ability factors were identical, the two types of information resulted in different patterns of imputations. Statistical test of the interaction between type and value of given information was thus significant, <u>F</u> (2,46) = 6.45.

Considered together, data from the single-cue sets clearly illustrate the operation of imputations in prediction of exam performance. In addition, they demonstrate an asymmetry in the imputation rules for the two types of information. An unambiguous test between rules has, therefore, to avoid the problems associated with missing information just as Design 1 of the present experiment did.

Experiment 5

Experiment 5 had two intents. One was to check on the generality of the two-operation, averaging-adding model evinced by post-graduate students to high school and undergraduate college students who have been found to follow the one-operation averaging rule (Gupta & Singh, 1981; Singh, et al., 1979). Another was to examine whether the asymmetry in imputations about missing information pertaining to motivation and ability could be eliminated by asking subjects to develop their "own strategy of dealing with missing information".

Method

Stimuli and designs. There were nine stimulus designs. The first was a four-way factorial with three motivation factors and one ability factor. Each motivation factor was defined by the opinion of a different teacher: Teacher 1 (bottom most, average, and top most); Teacher 2 (very much below average, and very much above average); and Teacher 3 (quite below average and quite above average). The ability information came from a teacher and the three levels were very much below average, average, and very much above average These levels of the two factors of motivation and ability were taken from a 11-point scale: Top most, very much above average, quite above average, fairly above average, little bit above average, average, little bit below average, fairly below average, quite below average, very much below average, and bottom most.

The second design was a three-way factorial using the three motivation factors already mentioned. Designs 3, 4, and 5 were two-way factorials that paired one of three motivation factors with the ability factor. Designs 6, 7, and 8 had information about motivation alone. Their levels were identical to those of three motivation factors. Design 9 had information about ability alone with the same levels as in the four-way design.

These nine designs yielded descriptions of 79 stimulus students. In addition, 11 end anchor and filler descriptions were prepared. They were based on extreme levels and on levels different than those used in the construction of 79 stimulus students. Of these 11 descriptions, four had four cues, one had three cues, two had two cues, and the remaining four had only one cue. There were 15 practice examples taken from the set of 90 descriptions already mentioned.

Procedure. The general procedure was the same as in the previous experiments. Subjects were told that information about motivation and ability (i.e., intelligence) of the stimulus students came from teachers who had known them for at least two years. Furthermore, motivation information came from one to three teachers. Whenever more than one piece of motivation information were available, they were to be treated as equally important and valid. When information about either motivation or ability was not known, subjects were urged to develop their "own strategy of dealing with missing information". After practice session, the main set of 90 cards were rated over two trials of judgment in different shuffled orders. Data from both trials were analyzed.

<u>Subjects</u>. Forty-eight high school and 24 undergraduate college students who came from populations comparable to those studied earlier (Gupta & Singh, 1981; Singh et al., 1979), served as subjects. School students were from Standards IX and XI of the Central School, Shahibaugh, Ahmedabad, India. The college students were in the second year of their 4-year bachelor of technology program at the Indian Institute of Technology, Bombay, India. There were 12 males and 12 females in each group of school students. The college students were all male. The age ranges for the three groups of subjects were 13 years and 6 months to 14 years and 8 months, 15 years and 7 months to 16 years and 8 months, and 18 years and 4 months to 19 years and 7 months, respectively.

Results and Discussion

Two-operation versus one-operation model. To establish the two-operation model, it is first necessary to demonstrate a pattern of parallelism in the Motivation x Ability effect from the two-cue and four-cue designs separately. Figure 11 presents factorial plots of these effects. In the left panel, three solid curves with open-circle are from the two-cue, Motivation-1 x Ability design. The corresponding curves in the center and right panels are from the similar two-cue designs, Motivation-2 x Ability and Motivation-3 x Ability, respectively. All three sets of curves show the parallelism pattern.

Similar parallelism pattern is also present in the data from the four-cue design. The two-way graphs of these data are shown in each panel of Figure 11 by the solid curves with filled-circle. All three sets of these curves also show perfect parallelism. The first requirement of the two-operation model is thus satisfied.

The critical discrimination between the two-operation, averaging-adding model and the one-operation averaging model comes from comparison of the curves from the two-cue and four-cue designs. The two-operation model requires a parallelism pattern in the common factorial plot of the two-cue and four-cue data; the one-operation model, in contrast, requires serious violations of the parallelism pattern.

Figure 11 about here

The three graphs of Figure 11 have no indication for the parallelism pattern in the common factorial plot. All the solid curves with open-circle have markedly steeper slope than those with filled-circle. This result casts serious doubt on the generality of the two-operation model followed by postgraduate students. However, it establishes the one-operation model in which all pieces of information available about the stimulus students were averaged simultaneously. It may be concluded, therefore, that the two-operation model is not applicable with high school and undergraduate college students.

For completeness, the statistical analyses are given in Table 1, which presents tests of interaction effects from separate analyses of variance of the two-cue and four-cue data as well as from the combined analyses of variance for the two corresponding factors. The nonsignificance of the two-way interaction tests in separate analyses confirms the earlier interpretation of parallelism in the graphs.

The three highly significant F ratios listed in the last column of Table 1 show that the common factorial plot of the data from the two-cue and four-cue designs differ significantly from the parallelism pattern predicted by the adding rule. Since the two-cue curves have slope steeper than the four-cue ones, this deviation is in excellent agreement with the one-operation averaging rule. These quantitative tests provide strong support for the averaging rule but eliminates the adding rule. It may be concluded, therefore, that high school and undergraduate college students indeed follow the constant-weight averaging rule found by Gupta and Singh (1981) and Singh et al. (1979).

Table 1 about here

Imputations. When information about motivation or ability of the stimulus students was not known, subjects were urged to develop their "own strategy of dealing with missing information". This allowed them to handle the missing information in any way they wished. The dashed curves of Figures 9 and 10 indicate that subjects followed one imputation rule: Missing information was assigned value in direct relation to the value of given information. This interpretation comes from the positive slope of the ability-only curve in the left panel of Figure 11 and the motivation-only curves in the three panels of Figure 12.

Figure 12 about here

The single-cue curves cross over the four-cue curves (i.e., solid curve with filled-circle) convincingly and show a steeper slope than the two-cue curves (i.e., solid curve with open-circle). An averaging interpretation which does not allow any imputation (Anderson, 1981) is also possible. But if subjects rendered their judgments on the basis of only given information, then the averaging rule would make the dashed curves cross over the middle solid curve with open-circle. There is no indication of such crossover in Figure 11 or 12. All the four dashed curves end at the average level of the missing information. This means that the maximum value imputed to the missing information was average.

Further evidence for the interpretation just made is present in Figure 13 which presents data from the four-way design in the Ability x Motivation format. The 12 conditions of the three motivation factors were reduced to eight by virtue of identical functional values; hence, there are only eight levels on the horizontal axis. The dashed curve is based on data from the three-way, Motivation-1 x Motivation-2 x Motivation-3 design. Since this design did not have any information about ability, its slope is as useful in diagnosing the imputation rule as were the slopes of the three motivation-only curves in Figure 12.

Figure 13 about here

Although the dashed curve of Figure 13 has slope steeper than the middle solid curve, there is no indication for any crossover at all. In fact, the dashed curve ends at the average level of ability similar to the three motivation-only curves of Figure 12. This indicates that the missing information was indeed handled in precisely the same way in both the single-cue and three-cue designs.

The foregoing results show that missing information is not ignored while rendering judgments. When subjects are asked to develop a way of dealing with missing information they impute value to the missing information in direct relation to the value of known information. The highest imputed value does not exceed the average level. These results cannot be accounted for by the averaging rule which does not allow imputations. However, if imputations are allowed, the averaging rule can give a good account for the crossover interaction between two-cue and four-cue curves as well as for the failure of the single-cue curve to cross over the two-cue curves.

It should also be noted that the asymmetry in imputation rules for missing ability and motivation information found in Experiments 3 and 4 as well as in the experiments by Singh et al. (1979) and Gupta and Singh (1981) seems to be attributable to their requirement that judgments be made on the basis of only the given information. When subjects are instructed to develop a method of dealing with missing information, they use one imputation rule.

Developmental differences. There was not any developmental differences in integration or imputation rule in the overall analyses of variance of the various designs. However, perceived effectiveness of ability steadily increased over the three age levels. The Age group x Ability effect was thus statistically significant in Designs 1, 3, and 4, F (4,138) = 7.79, 3.81, 2.67.

Experiment 6

Experiment 1 through 5 clearly showed that prediction of performance in high school examination by school and college students obeys the parallelism pattern prescribed by the cultural difference hypothesis (Gupta & Singh, 1981; Singh, 1981; Singh et al., 1979). The chief purpose of the sixth and final experiment was to assess the generality of the parallelism pattern to prediction of performance in college examination, using subjects from student and non-student populations.

Method

Stimuli and design. Descriptions of stimulus students were prepared according to a four-way, 2 x 2 x 3 x 3 (Motivation-1 x Motivation-2 x Motivation-3 x IQ) factorial design. Each motivation factor was defined by the opinion of a different teacher: Teacher 1 (*very much below average* and *very much above average*); Teacher 2 (*quite below average* and *quite above average*); and Teacher 3 (*little bit below average*, *average*, and *little bit above average*). These levels were taken from the 11-point scale of motivation used in Experiment 5. The three IQ levels were 90, 105, and 135. There were thus 36 main stimulus persons.

There were 15 filler and 15 practice descriptions as well. The filler descriptions had levels more extreme and different than those used in the main descriptions. The practice descriptions were taken from the set of 51 descriptions already listed.

Procedure. The general procedure was similar to that in the previous experiments. Subjects read information about motivation and IQ of each student and predicted his performance in a bachelor of science examination in chemistry honors at a major university. It was emphasized that the chemistry department of the university is well-known for its standard and rigor in the nation, that chemistry honors program uses recent textbooks of highest quality, and that getting honors degree from the department is extremely difficult. These specifications were made to present the exam as extremely difficult. After practice session, subjects rated the set of 51 cards over two trials of judgment in different shuffled orders.

Subjects. There were four groups of subjects. The first group consisted of 18 students from the same population as in Experiment 1. The second group of 16 male and 2 female students were enrolled in a course on research methods at the Indian Institute of Management, Ahmedabad. Nine were college teachers attending the faculty development program; the remaining nine were in the first year of their 4-year fellow program in management. The third group of 13 male and 5 female college lecturers in psychology were attending a workshop on instrumentation in psychology at the Gujarat University, Ahmedabad. The fourth and final group consisted of 18 male executive engineers who were attending a course on project implementation at the Staff Training College, Gandhinagar, Gujarat, India. The age ranges for the four groups of subjects were 18 years and 5 months to 20 years and 2 months, 23 years and 8 months to 38 years and 4 months, 28 years and 5 months to 49 years and 3 months, and 45 years and 7 months to 52 years and 9 months.

Subjects, who were run in small groups of 6-9 at a time, spent 70-90 minutes on the judgmental task. Each subject of the first group received 5 Rupees for his service. Subjects from the other three groups volunteered to participate in the experiment at the request of the course coordinator.

Results and Discussion

Parallelism pattern. The main goal of Experiment 6 was to yield evidence for the parallelism pattern in Motivation x Ability effect on prediction of performance in an extremely difficult college exam. Figure 14 presents six two-way factorial plots for the four factors of the design. According to the cultural difference hypothesis, the three right graphs, which are for Motivation-1 x IQ, Motivation-2 x IQ, and Motivation-3 x IQ effects, should be parallel, as in fact they are. This shows that prediction of performance in college exam also conforms to the same parallelism pattern, which characterized prediction of performance in high school exam. This provides greater generality of the cultural difference hypothesis.

Figure 14 about here

It deserves emphasis that Surber (1981b), who described college exam as most difficult in much the same way as in the present experiment, obtained the linear fan pattern in the Motivation x Ability effect. While her result agrees with results from previous American studies (Anderson, 1983, pp. 73-76; Anderson & Butzin, 1974), it is not generalizable to the present groups of subjects. Even though the college exam was introduced as extremely difficult, the pattern of parallelism emerged in the Motivation x Ability effect similar to the result of Experiments 1 and 2 described earlier. This finding confirms the hypothesis of cultural difference but questions the applicability of Surber's hypothesis of task difficulty with Indian subjects.

On the basis of the results of Experiment 5, the three pieces of information about motivation were expected to be integrated by the constant-weight averaging rule. Thus, the three left graphs of Figure 14 were expected to have a pattern of parallelism. While the first two graphs have the parallelism pattern, the third one has mild convergence. This means that opinion of the second teacher carried less weight when opinion of the third teacher was high than low. The deviation from the parallelism is minor, however. Accordingly, success of the equal-weight averaging rule for integration of information about motivation can be accepted.

Statistical analyses. Tests of two-way interaction between factors shown in the six graphs of Figure 12 yielded F (1,68) = 0.18, F (2,136) = 1.93, 3.02, 1.92, 1.10, and F (4,272) = 0.61 in order. Of the six F ratios, only the third for the third graph is statistically significant for the reason already mentioned. These statistical tests thus provide strong support to the interpretations made earlier.

The results were readily generalizable to all groups of subjects. Tests of interaction between subject groups and the two factors listed in each of the six graphs of Figure 14 yielded only one triple interaction effect: Subject groups x Motivation-1 x IQ effect, F (6,136) = 2.16, $p < .05$. Examination of the Motivation-1 x IQ effect in each of the four groups of subjects disclosed that the subjects of the second and third groups had mild divergence in their Motivation-1 x Ability effect, F (2,34) = 2.91 and 3.43. Partitioning of these two interaction effects in their Linear x Linear and Linear x Quadratic trends did not, however, yield significant F ratio for the Linear x Linear trend, *F* (1,17) = 2.38 and 1.92, contrary to the requirement of the linear fan pattern (Anderson, 1982). It can be concluded, therefore, that subjects from all four groups followed the same integration rule.

General Discussion

Cultural Difference in Cognitive Algebra

Cultural-difference hypothesis. Results of the present set of six experiments show that prediction of exam performance from information about motivation and ability of stimulus students obeys the parallelism prediction of the cultural-difference hypothesis. Singh et al. (1979) and Gupta and Singh (1981), who studied prediction of performance in engineering institute exam and in elementary school exam, respectively, suggested that Indian students believe that effort is equally effective with students of low and of high ability. In the present research, exams were of high school (Experiments 1 through 5) and college (Experiment 6) levels and subjects were from both the student and nonstudent populations. Nevertheless, the results are identical to those obtained by Singh and his associates. This indicates that the parallelism pattern in the Motivation x Ability effect is indeed robust across types of exam and subject populations.

At a more micro level, the parallelism pattern appears to have been caused by the constant-weight averaging rule or by adding rule. High school and undergraduate college students followed the constant-weight averaging rule (Experiment 5); the postgraduate students of management followed the adding rule (Experiment 4). Perhaps the adding rule develops out of the averaging rule in this task in India.

In the United States, the developmental trend noted in prediction of performance is different. Prediction of exam performance has been found to conform to the requirements of the multiplying rule (Anderson, 1983; Anderson & Butzin, 1974), relative-weight averaging rule (Surber, 1981a), and differential-weight averaging rule (Surber, 1981b) at the level of adults. In addition, multiplying rule has been found to develop out of the adding rule (Kun et al., 1974) or constant-weight averaging rule (Surber, 1980) at a quite early age (e.g., Standard II). These differences between students of India and the United States suggest that prediction of performance is indeed a powerful cognitive task for analyses of cross-cultural differences.

Gupta and Singh (1981) had emphasized that the constant weight averaging rule for India and the multiplying rule for the United States were not uniquely restricted to each culture. Some subcultures or subgroups within each country would be expected to obey these rules, for rules people use reflect on their causal schemata. Evidence for the relative-weight averaging rule, differential-weight averaging rule, and multiplying rule in the United States and the present finding of constant-weight averaging rule and adding rule in India suggest that the two cultures differ in the variety of rules they employ in prediction of performance. In addition, origin of the rule and developmental trends in utilization of rules also seem to be culture-linked.

Considered together, it may be said that the hypothesis that Indian and American cultures differ in their outlook on how motivation and ability determine exam performance is indeed correct. Whereas Indian subjects follow the parallism pattern; American subjects follow the fan, parallelism, and converging patterns. Thus, there is a greater homogeneity in the causal conceptions of Indians than of Americans. This difference calls attention to the importance of cultural factors in social cognition.

Hypothesis of task difficulty. According to Surber (1981a, 1981b), the linear fan pattern in the Motivation x Ability effect is characteristic of an extremely difficult task. Tasks of low and medium difficulty yield the parallelism pattern. Hence, the hypothesis of cultural difference can be replaced by the hypothesis of task difficulty.

One of the goals of the present research was to assess the plausibility of Surber's explanation for the failure of the linear fan pattern in Indian studies (Gupta & Singh, 1981; Singh et al., 1979). Thus, Experiments 1 and 2 had exams of low, medium, and high difficulty; Experiments 3 and 6 had exam of medium and extremely high difficulty, respectively; and Experiments 4 and 5 did not explicitly specify the difficulty of exam. Inspite of these variations across the six experiments, the result from each experiment was basically the same as in the experiments by Singh et al. and by Gupta and Singh. It may be concluded, therefore, that Surber's hypothesis of task difficulty is not applicable in India.

In Experiments 1 and 2, difficulty of exam affected the origin of the scale. In other words, subjects predicted higher performance on an easy exam than on a difficult exam. Moreover, factorial plots of Task difficulty x Motivation and Task difficulty x Ability effects also conformed to the parallelism pattern. This means that task difficulty played an additive role in prediction of performance. This finding also emphasizes importance of cultural variables in social cognition.

Other alternative hypotheses. Can the parallelism pattern in the Motivation x Ability effect of the Indian studies be explained in ways other than the cultural difference hypothesis? At least two other hypotheses may be suggested. First, the adding and constant-weight averaging rules are perhaps used to predict performance on tasks which are familiar to the subjects. Second, the parallelism pattern is characteristic of academic tasks. Prediction of performance on nonacademic tasks may yield the linear fan pattern just as in the American studies. Let us examine the plausibility of these alternatives to the cultural difference hypothesis.

There is no doubt that all subjects of the present work had some familiarity with exam situations. But the levels of familiarity were not the same for all subjects. In Experiment 5, for example, subjects from Standard XI and college had successfully passed the Board exam of Standard X but those from Standard IX were to take the exam after two years. Similarly, psychology lecturers of Experiment 6 have had no familiarity with the bachelor of science exam in chemistry honors. Nevertheless, results from all subjects conformed to a common parallelism pattern. How can the hypothesis of task familiarity account for similarity in mod used by subjects varying in task familiarity?

All Indian studies were confined to prediction of exam performance, whereas the American studies considered both the academic and nonacademic tasks. It is possible, therefore, that nature of task may account for the discrepant results. Two lines of evidence suggest the promise of this hypothesis. First, subjects from the same population followed the constant-weight averaging rule in prediction of exam performance (Singh, et al., 1979) but the multiplying rule in a conceptually similar task, Gift Size = Generosity x Income (Singh, in press). Second, Surber (1978) found the linear fan pattern in prediction of performance in weight-lifting contest but the convergence pattern in prediction of performance in a math test of elementary school with the same group of subjects.

Inspite of its promise, the hypothesis of nature of task cannot account for all the existing data. Two questions remain unanswered. The first is why did American studies of academic tasks yield evidence for linear fan, parallelism, and converging patterns but the Indian studies yield just the parallelism pattern? The second is why did nonacademic tasks, such as performance on puzzles (Kun et al., 1974) and in weight-lifting contest (Surber, 1980), yield both the fan and parallelism patterns in American studies? It appears that cognitive algebra of task performance depends upon age and culture of subjects as well as nature and difficulty of task. Accordingly, future research should consider all these factors together to bring orderliness in the extant literature.

Cultural Difference in Processing Flow

Surber (1981a) demonstrated that American students have one general initial opinion and that manipulation of information reliability produces configural effect. Experiments 2 and 3 of the present research yielded evidence for the presence of two initial opinions--one for motivation and another for ability. Furthermore, information reliability was averaged with its respective initial opinion. Thus, reliability of information of one type had no effect on contribution of information of another type in judgment. These results illustrate a cultural difference in processing flow of information.

The present finding of two initial opinions is based on one judgmental task. Further work is needed using different tasks. If the finding will remain robust, basic differences in information processing by Indian and American students will be established.

Imputations about Missing Information

Findings of Experiments 3, 4, and 5 illustrate operation of imputations about missing information. When needed motivation or ability information was missing, subjects imputed its value in two ways. First, missing information was imputed a single, constant value, independent of the value of the given information. Evidence for this strategy was present with imputations about motivation in Experiment 3 and about ability in Experiment 4. Second, missing information was imputed value in direct relation with the value with given information. This happendd with missing ability information in Experiment 3 and with missing motivation information in Experiment 4.

If it is assumed that subjects rendered their judgments on the basis of only the given information, then it would be difficult to account for the failure of the single-cue curve to cross over the two-cue curves. In addition, it would not be possible to reach definitive conclusion on the cognitive algebra underlying parallelism pattern. The crossover by the single-cue curve would imply the operation of the averaging rule; the near-parallelism of the single-cue and two-cue curves would imply the operation of the adding rule. Such interpretations of the single-cue curves can be quite misleading, as the results of Experiments 3 and 4 showed.

The present research shows that single-cue descriptions are useful for studying imputations about missing information but not the model diagnosis. When problems connected with imputations were removed by the logic of two-operation model (Anderson, 1981; Singh, in press), the cognitive algebra of exam performance turn out to be a clear adding rule at the level of postgraduate students and a clear constant-weight averaging rule at the level of others. But data of single-cue descriptions were not useful in discriminating the adding rule from the averaging rule in either Experiment 3 or 4 as already noted. This suggests that model diagnosis has to rely on both types of information, and that imputations about missing information can be detected through establishment of the cognitive algebra.

Establishment of the adding rule in Experiment 4 and of averaging rule in Experiment 5 has been useful in enriching our understanding of imputation rules in three ways. First, there is an asymmetry in imputation rules for missing motivation and missing ability information. Sometimes the missing information was imputed a single, constant value, and sometimes a value in direct proportion to the value of the known information. Second, if subjects are encouraged to develop a strategy of dealing with missing information, the asymmetry in imputation rules may be avoided. However, it is not clear why does such an asymmetry occur when subjects are asked to make judgments on the basis of only the given pieces of information. Finally, imputations about missing information are not restricted to only the multiplying rule (Singh, in press). Even when subjects follow adding rule as in Experiment 4 or averaging rule as in Experiment 5, they impute value for the missing information. What do they impute and how do they impute are possible to analyze by correct diagnosis of the cognitive algebra underlying judgments.

One implication of the finding of imputations in cognitive algebra is that the conventional tests which rely on one of the two types of heterogeneous information are ambiguous about the operative rule. This applies to tests between multiplying and differential-weight averaging rules (Lampel & Anderson, 1968; Surber, 1980, 1981b) as well as to tests between adding and averaging rules (Lane & Anderson, 1976; Leon, 1980; Yamagishi & Hill, 1981). In diagnosis of the real operative rule, the design and approach developed in Experiments 4 and 5 of the present research will be more useful.

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Footnote

1. Because of the problem of end effects, statistical test of the parallelism pattern in the combined 6 x 3 analysis of variance becomes ambiguous. The general trend in data is, however, for the adding rule and against the averaging rule.

Table 1

F Ratio for Motivation x Ability Effect in Two-Cue and Four-Cue Designs Separately and in Combined Analyses

Interaction	df	Two-cue	Four-cue	df	Combined
Motivation-1 x Ability	4,276	1.62	0.35	10,690	5.02*
Motivation-2 x Ability	2,138	0.44	0.12	6,414	12.92*
Motivation-3 X Ability	2,138	1.15	0.93	6,414	5.54*

Header "Analyses" spans the Two-cue through Combined columns.

* $p < .01$

Figure Captions

Figure 1. Mean exam performance as a function of motivation and IQ of the stimulus students. Data from Experiments 1, 2, and 3. Levels of motivation are listed as curve parameter: LO = little bit motivated; AV = average motivation; Hi = very much motivated; VVL = very very low motivation; SM = some motivation; FM = fairly much motivation; GRT = a great deal of motivation.

Figure 2. Factorial plots of Motivation x Ability effect across three levels of exam difficulty. Data from Experiments 1 and 2. The abbreviations VD, OK, and VE refer to very difficult, okay, and very easy exam; respectively.

Figure 3. Factorial plots of Exam difficulty x Motivation and Exam difficulty x Ability effects from Experiments 1 and 2.

Figure 4. Mean judgment of exam performance as a function of exam difficulty, reliability of IQ information, motivation, and IQ. Data from Experiment 2.

Figure 5. Mean judgment of exam performance as a function of motivation and IQ under four conditions of reliability of two types of information. Data from Experiment 3.

Figure 6. Factorial plots of Reliability x Value of information effects from Experiments 2 and 3. The abbreviations LO, MOD, and Hi refer to low, moderate, and high reliability of information listed as the curve parameter.

Figure 7. Factorial plots of Reliability of information of one type x Value of another type of information from Experiments 2 and 3.

Figure 8. Factorial plots of Motivation x Ability effects and Ability x Motivation effects under conditions of low and high reliability of information listed on the horizontal axis. The dashed curve is based on information listed on the horizontal axis alone.

Figure 9. Three two-way factorial plots for Set-size x Motivation, Set-size x Ability, and Motivation x Ability effects from Experiment 4. The abbreviations EL, AV, and EH refer to extremely low, average, and extremely high levels of motivation and ability factors.

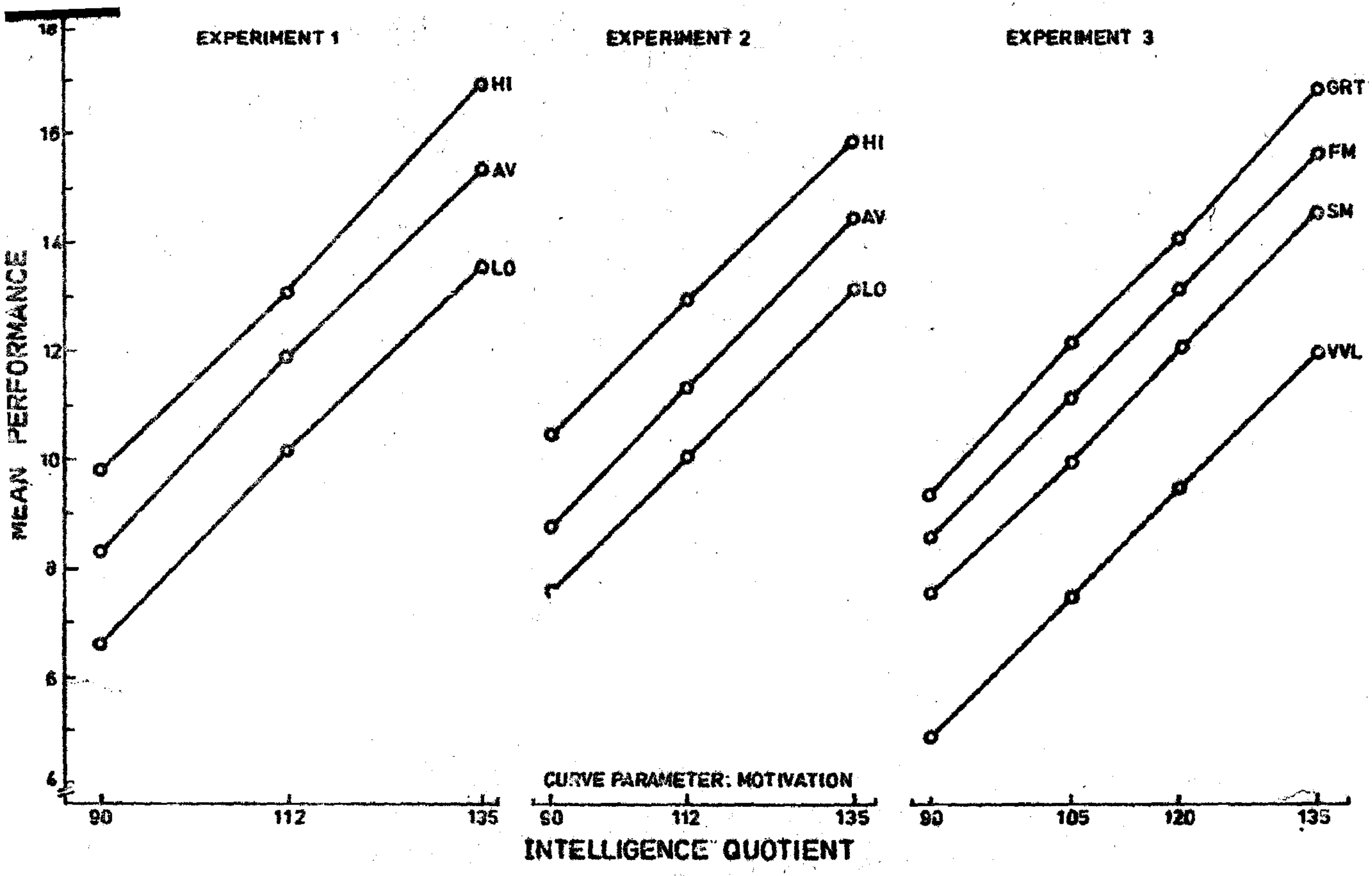
Figure 10. Common factorial plot of Motivation x Ability effect (left panel) and Ability x Motivation effect (right panel) from both set sizes. The dashed curve is based on information listed on the horizontal axis alone.

Figure 11. Factorial plots of Motivation-1 x Ability, Motivation-2 x Ability, and Motivation-3 x Ability effects from the main four-cue design (solid curve with filled-circle) and from corresponding two-cue design (solid curve with open-circle). The dashed curve is based on information about ability only. Data from Experiment 5.

Figure 12. Factorial plots of Ability x Motivation-1, Ability x Motivation-2, and Ability x Motivation-3 effects from the four-cue and two-cue designs. The dashed curves are based on the information about motivation alone listed on the horizontal axis.

Figure 13. Mean exam performance as a function of ability and motivation information. The levels of motivation information are according to their functional measure ment values in the main four-cue design. The dashed curve is based on information about motivation only from Motivation-1 x Motivation-2 x Motivation-3 design.

Figure 14. Six two-way factorial plots for the four factors of the design. Data from four groups of subjects of Experiment 6.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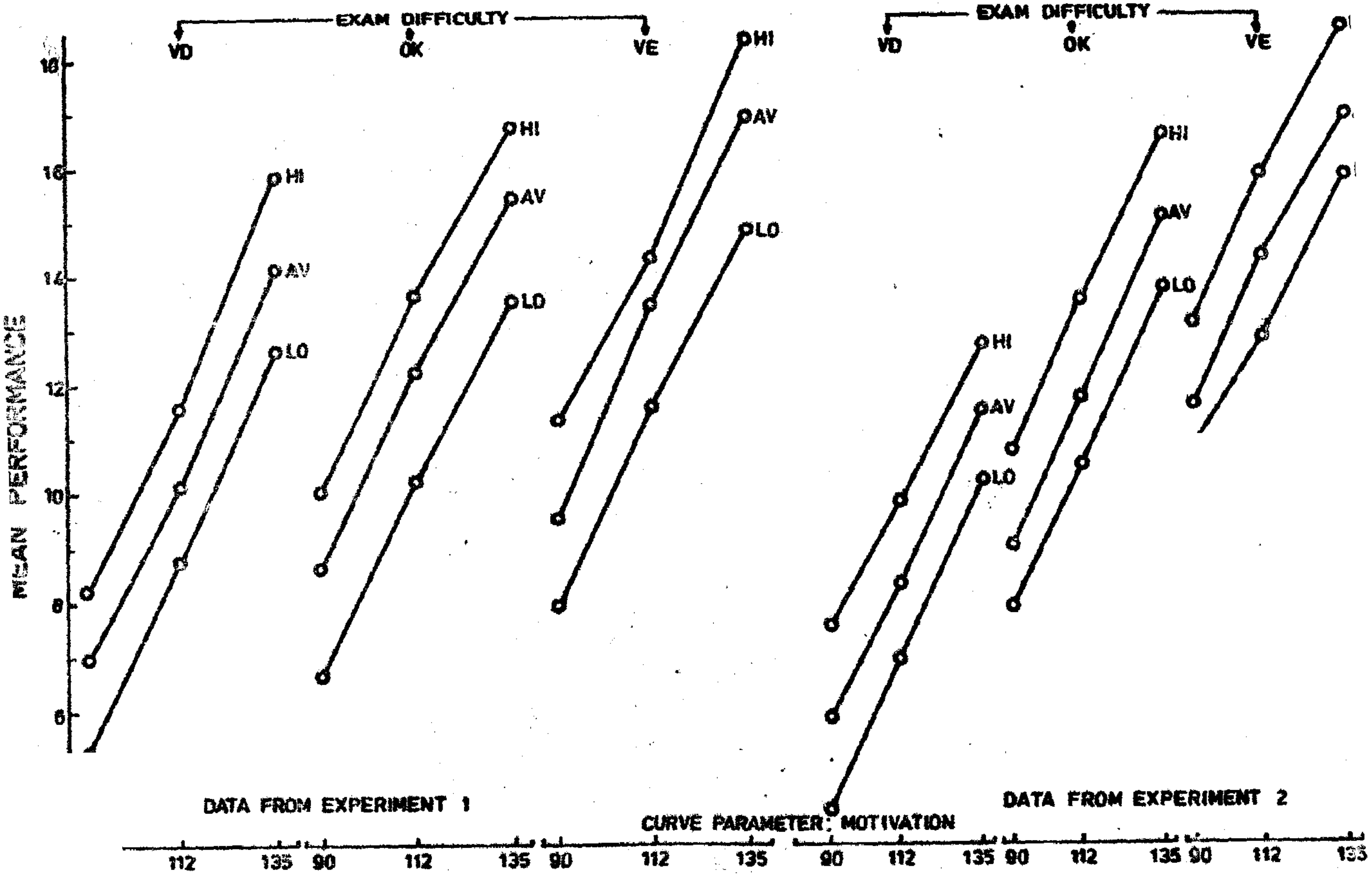
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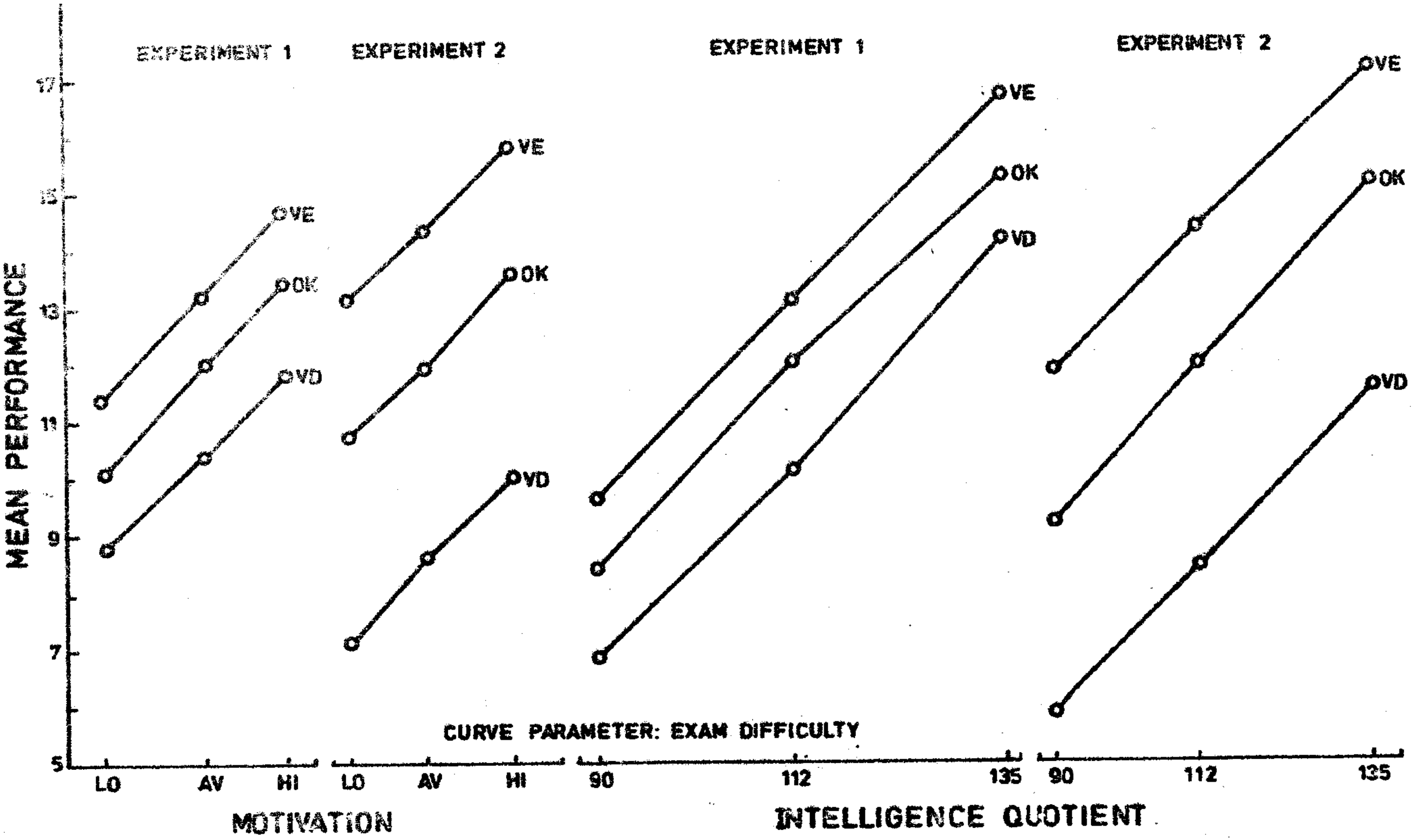
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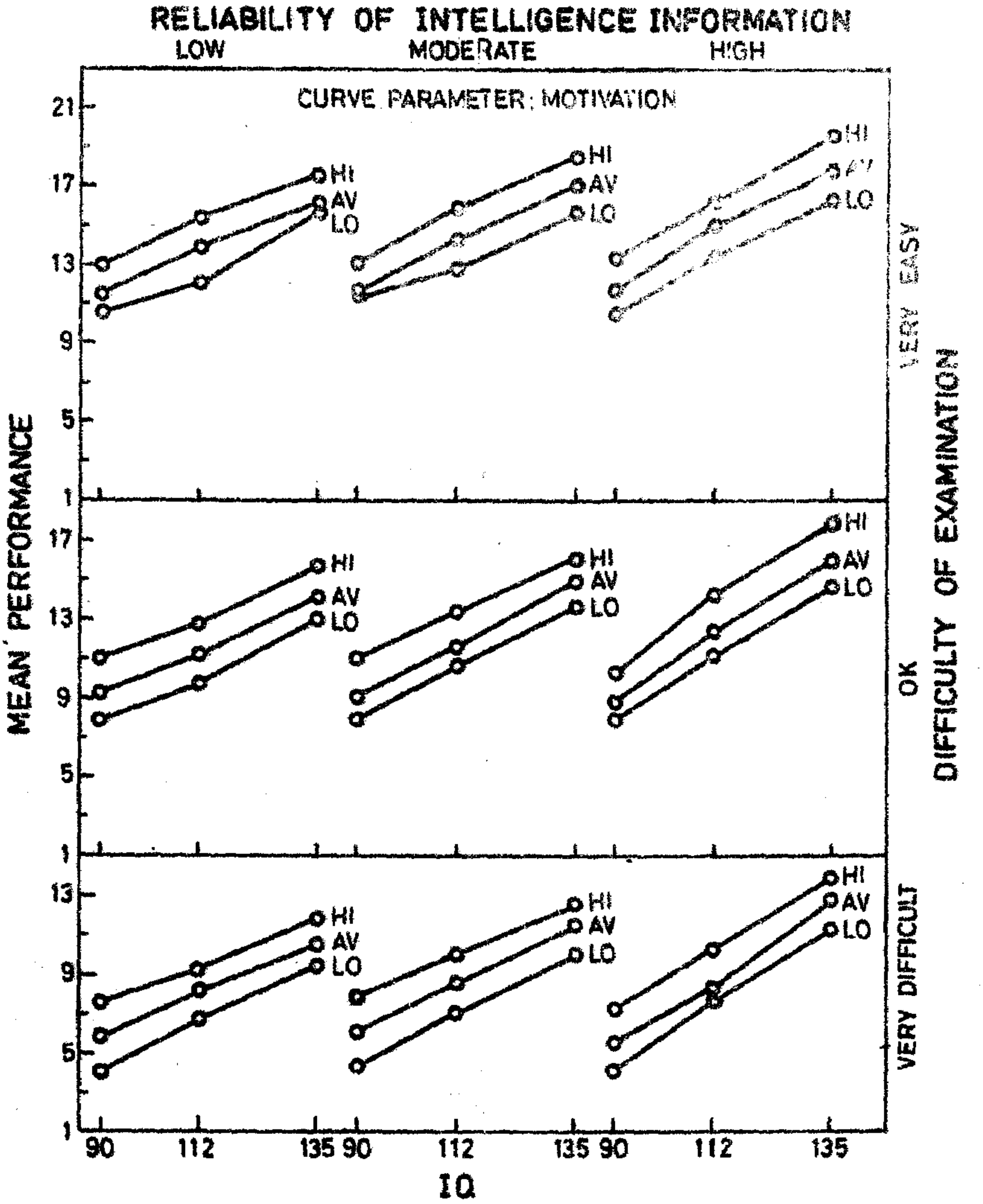
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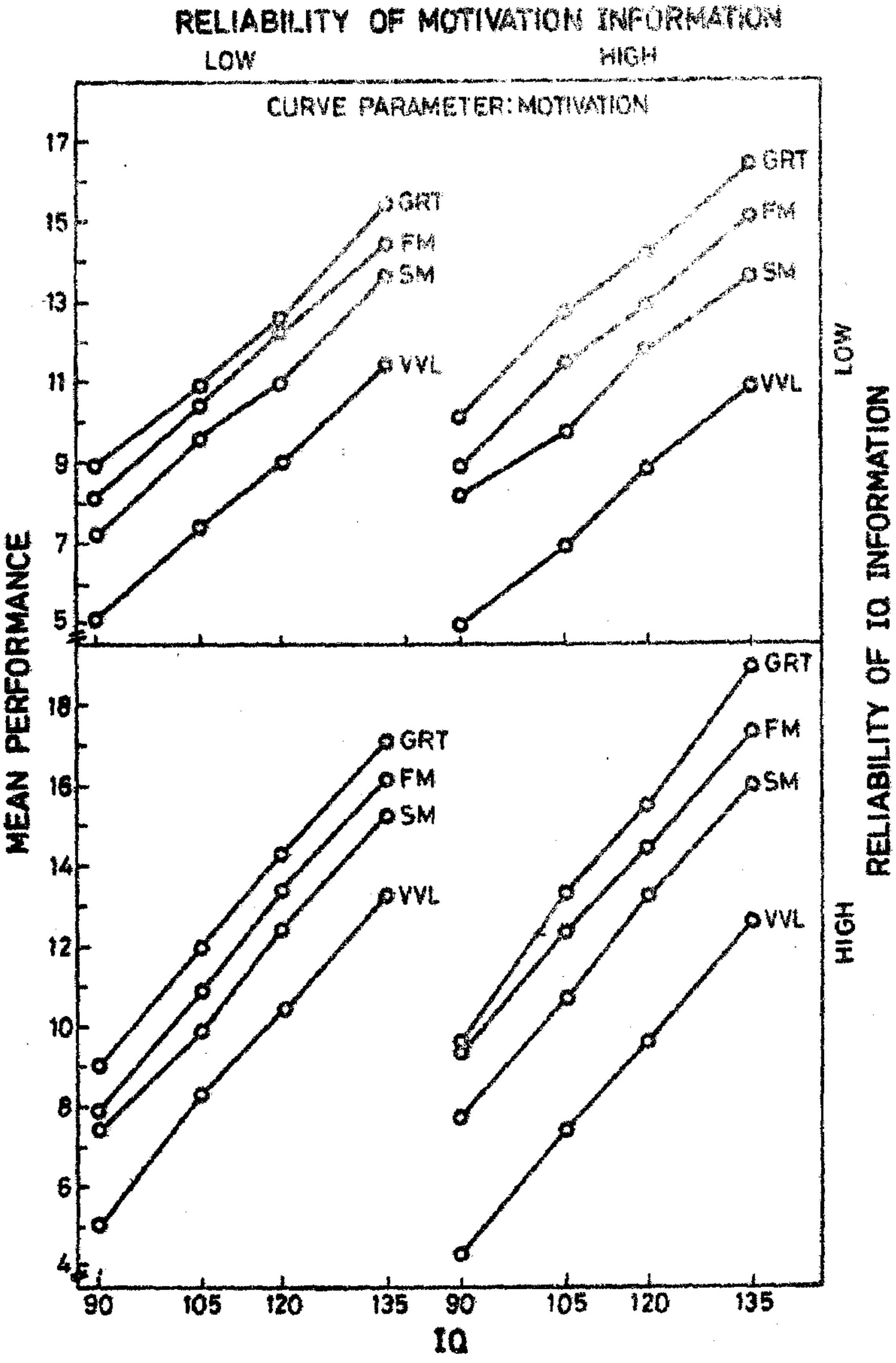
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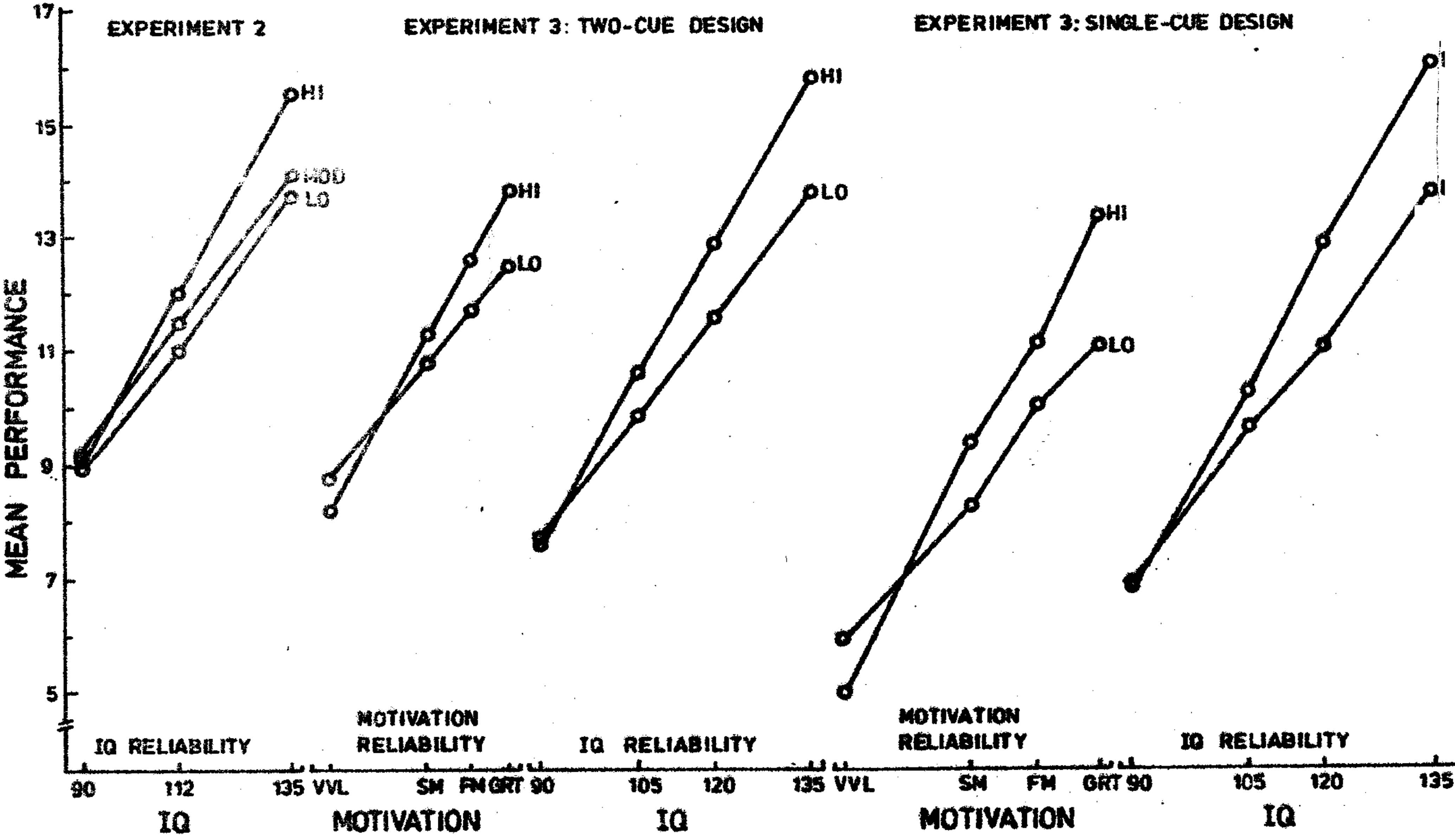
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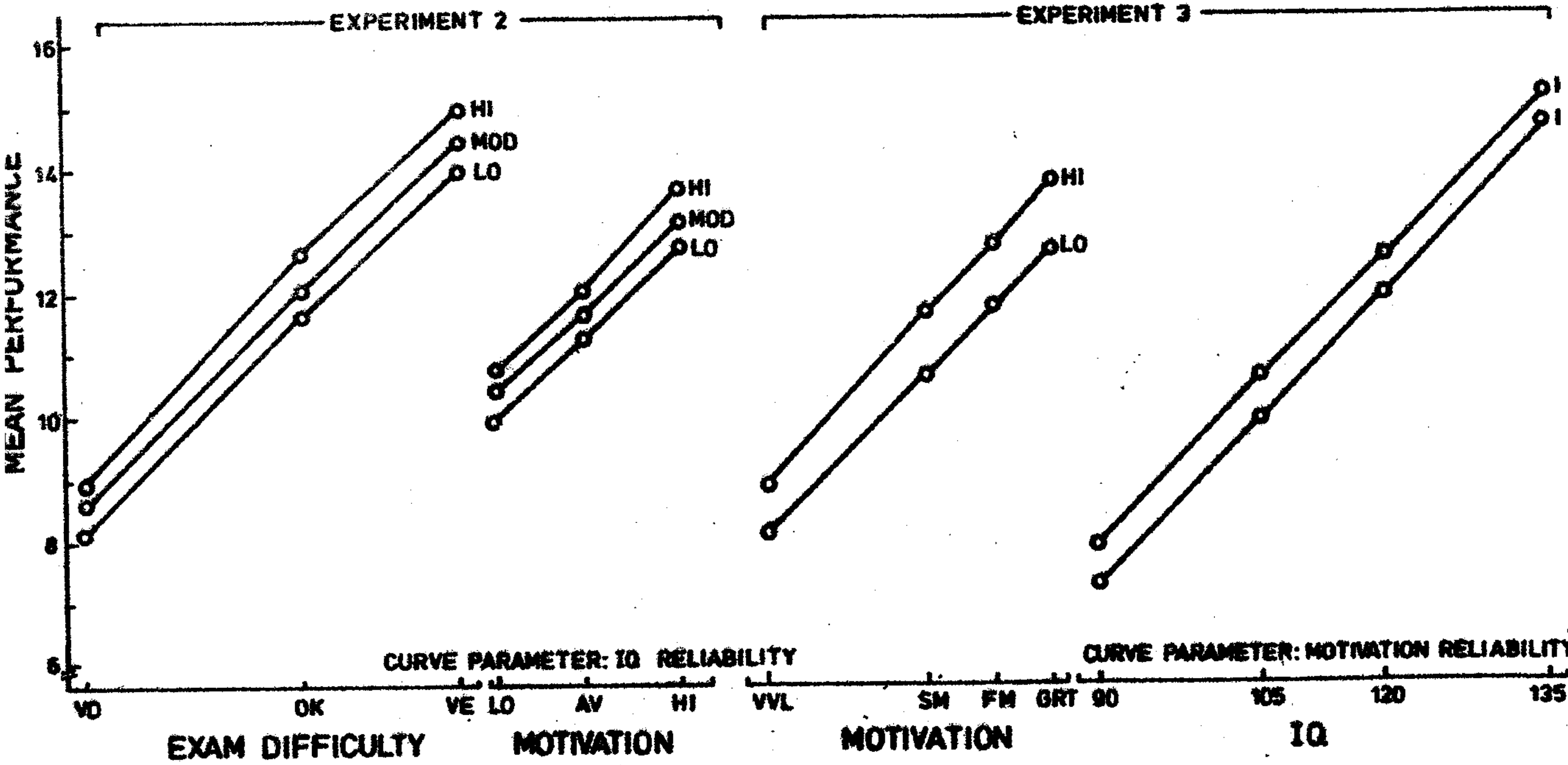
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CURVE PARAMETER: IQ
RELIABILITY
CURVE PARAMETER: MOTIVATION RELIABILITY
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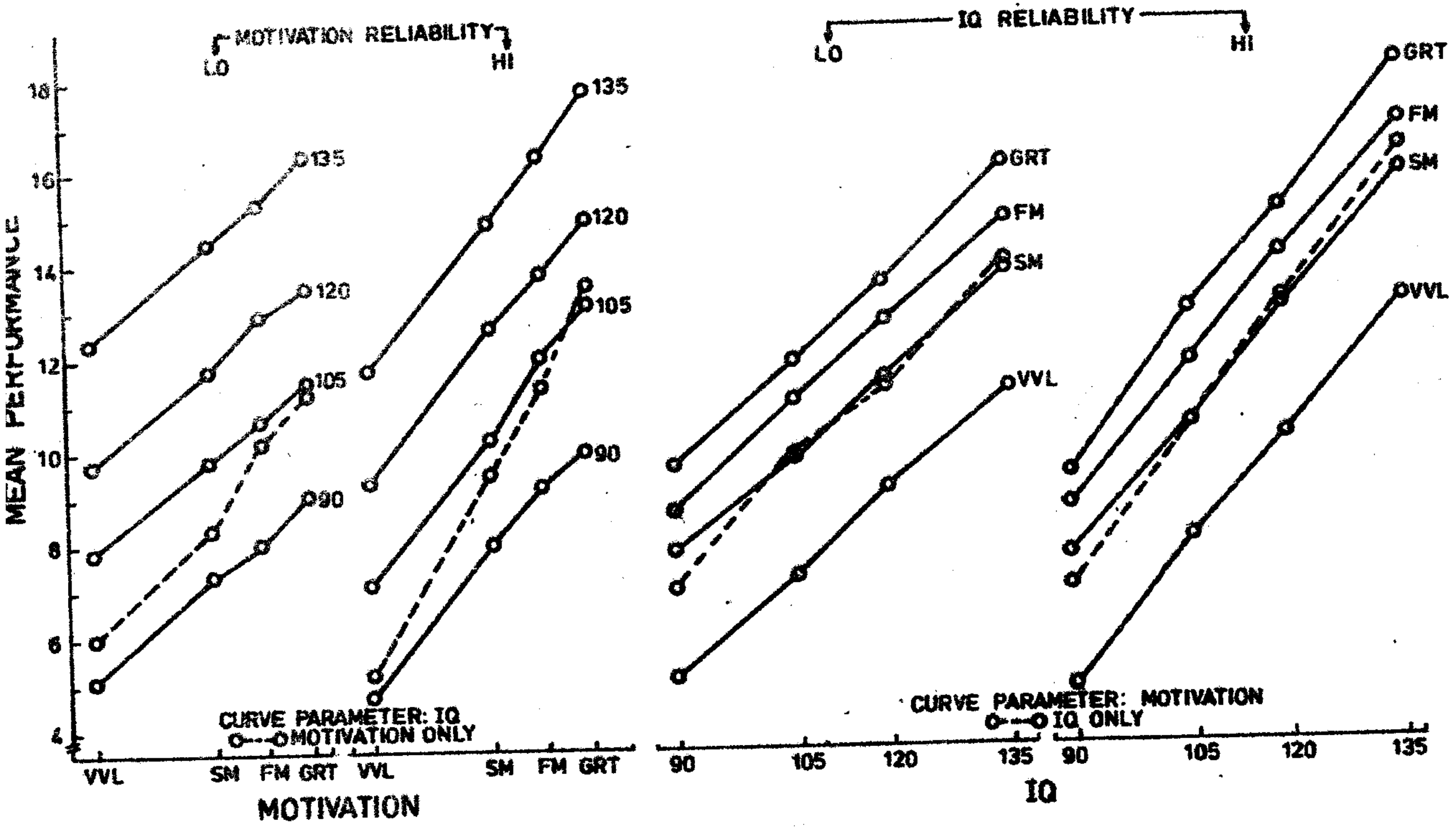
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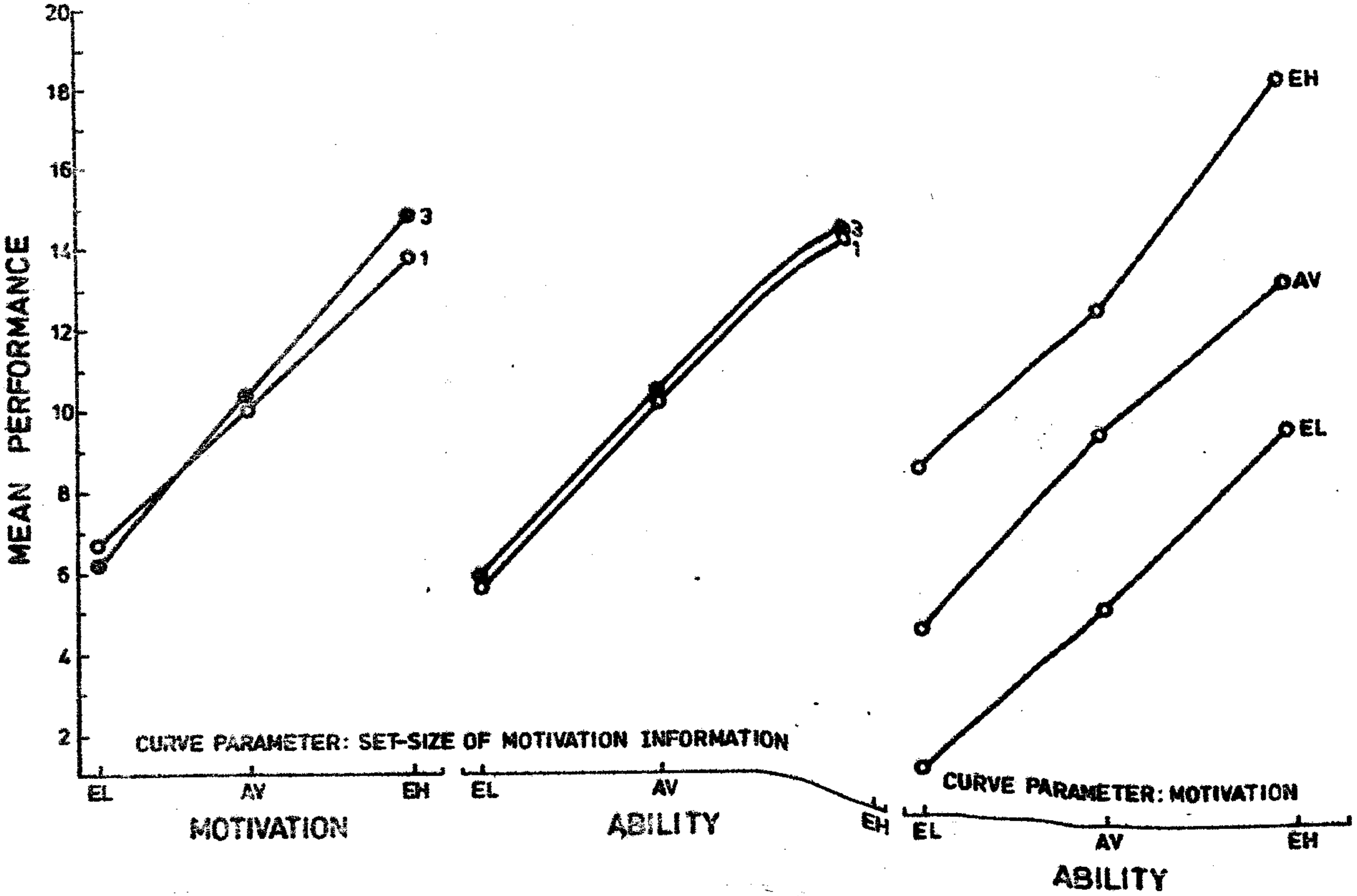
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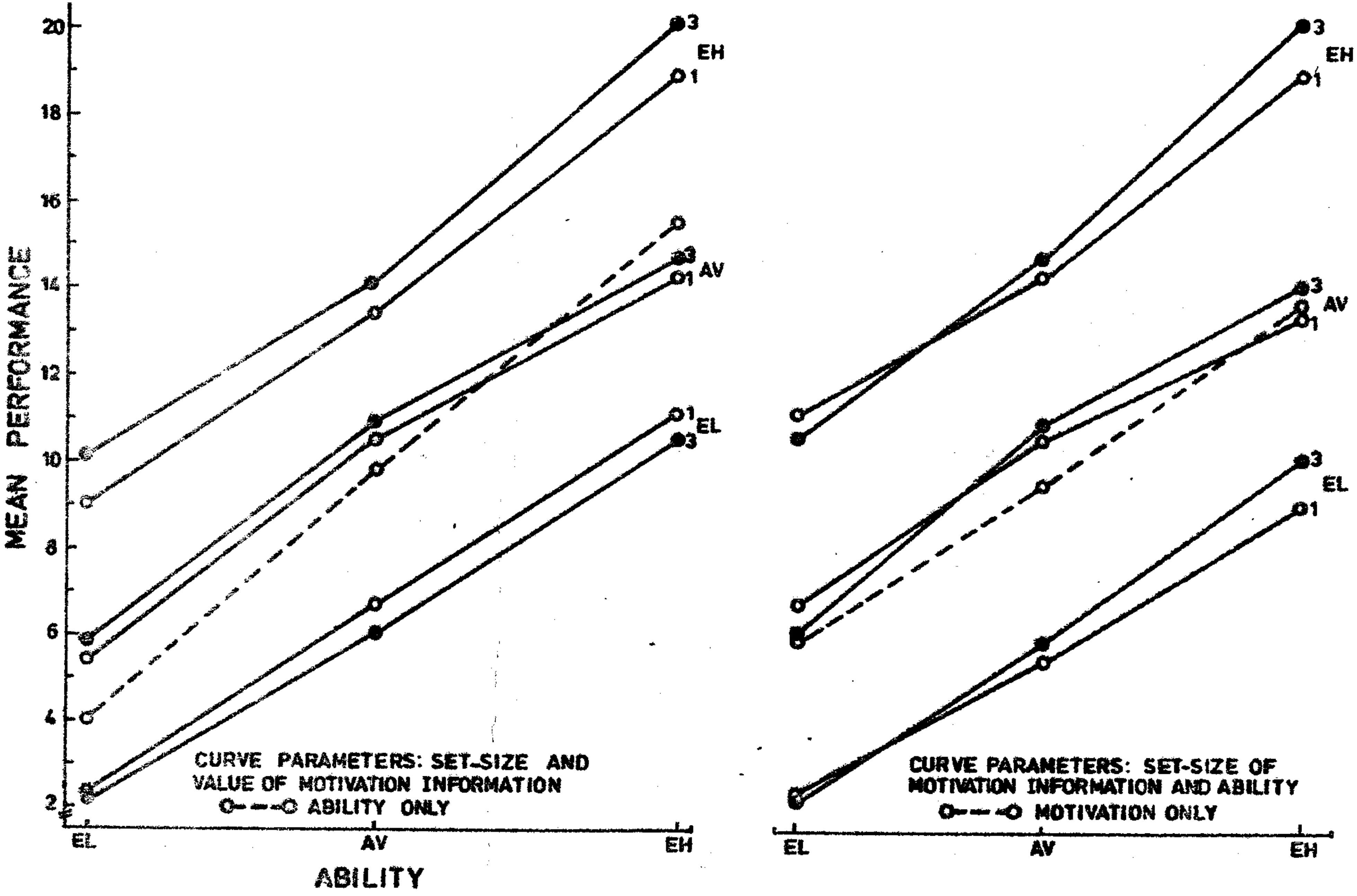
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CURVE PARAMETERS: SET-SIZE AND VALUE OF MOTIVATION INFORMATION
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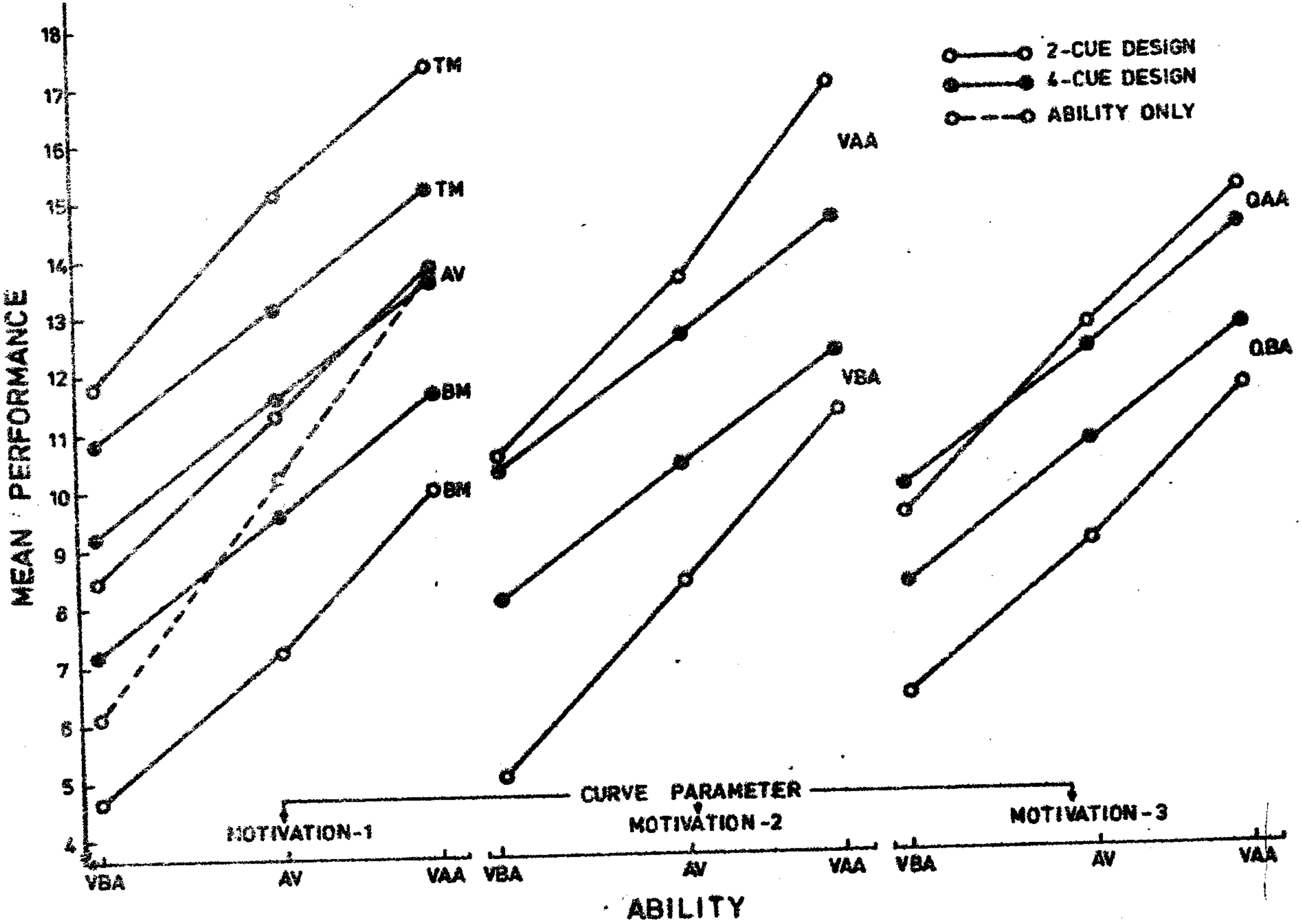
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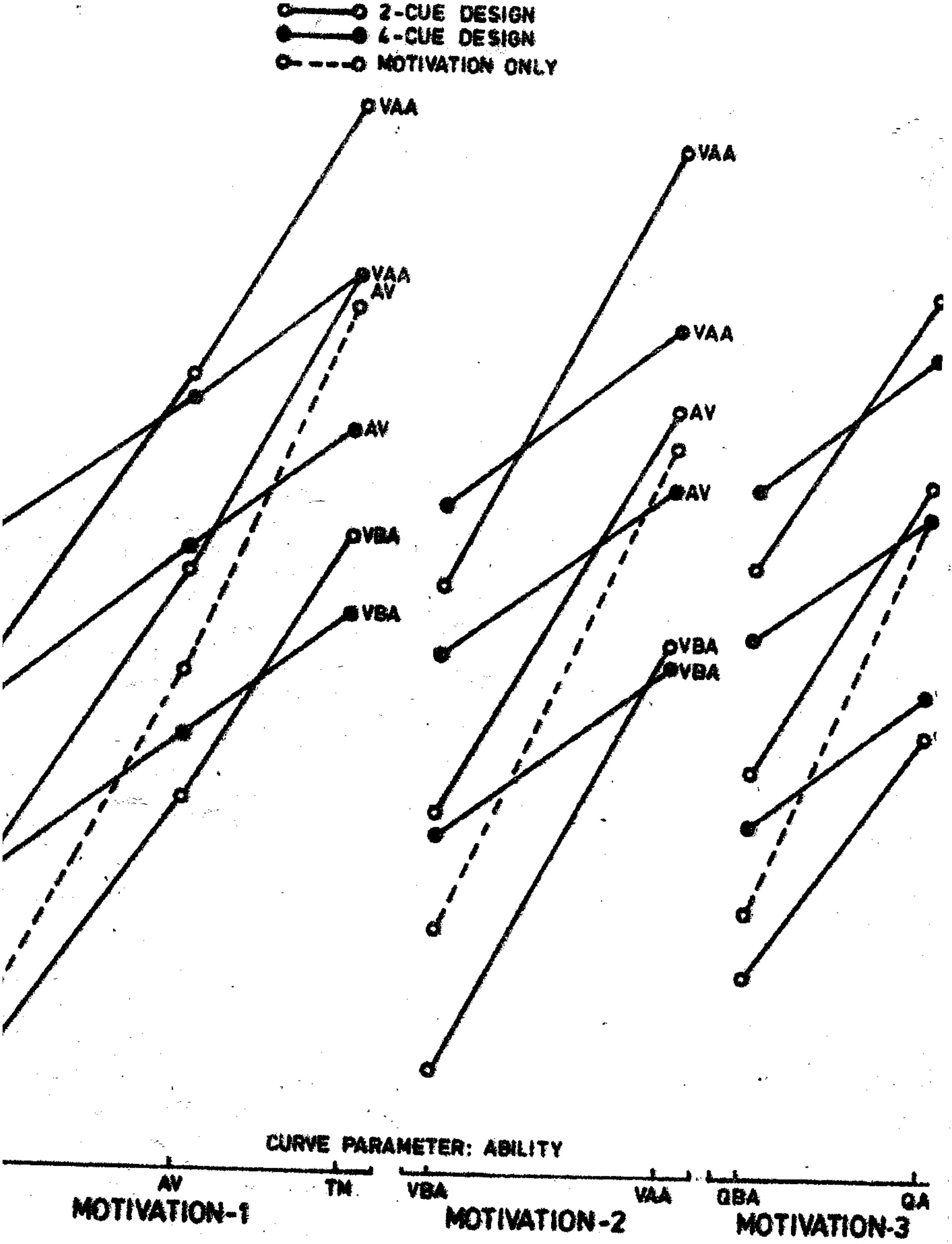

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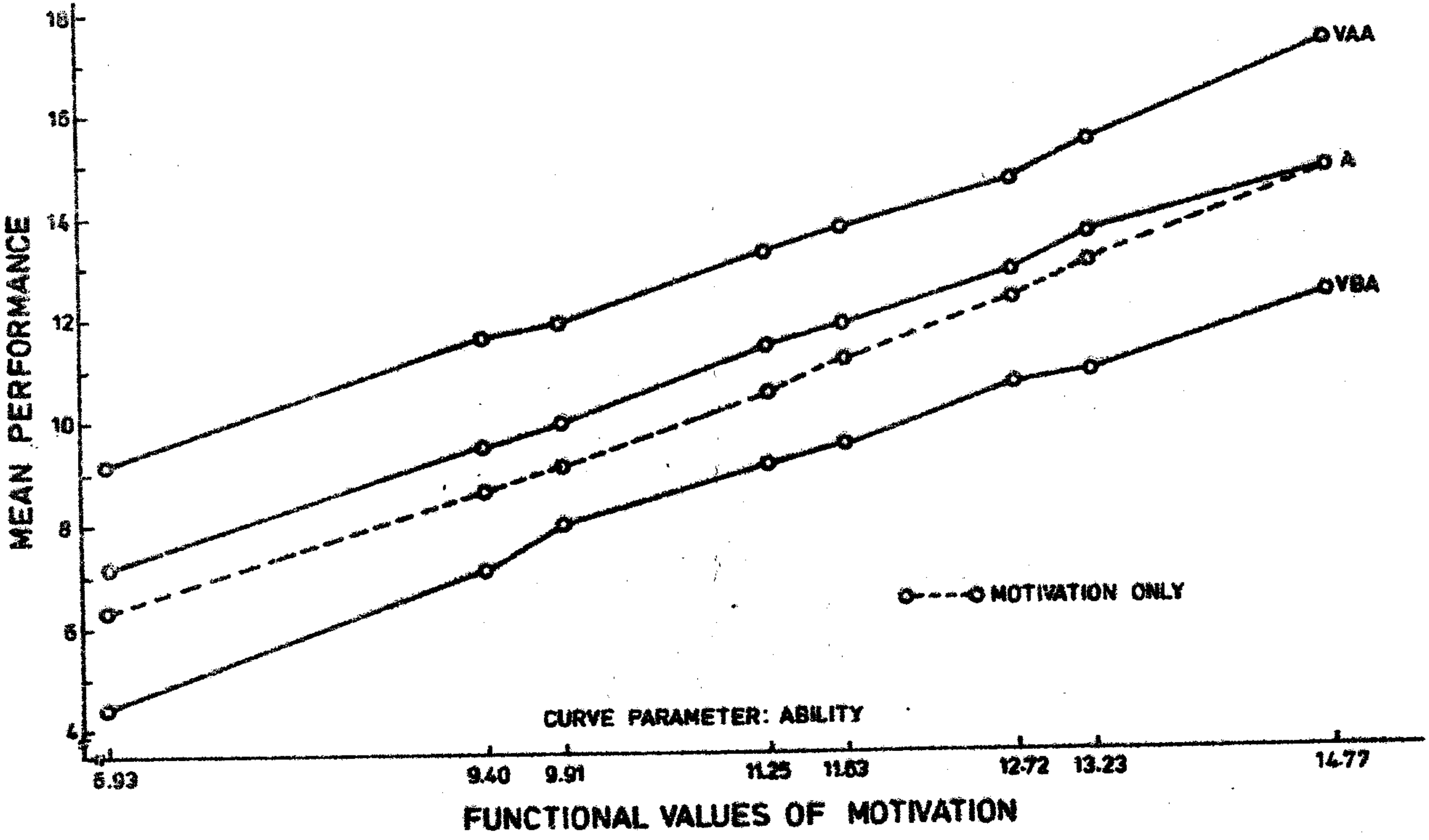
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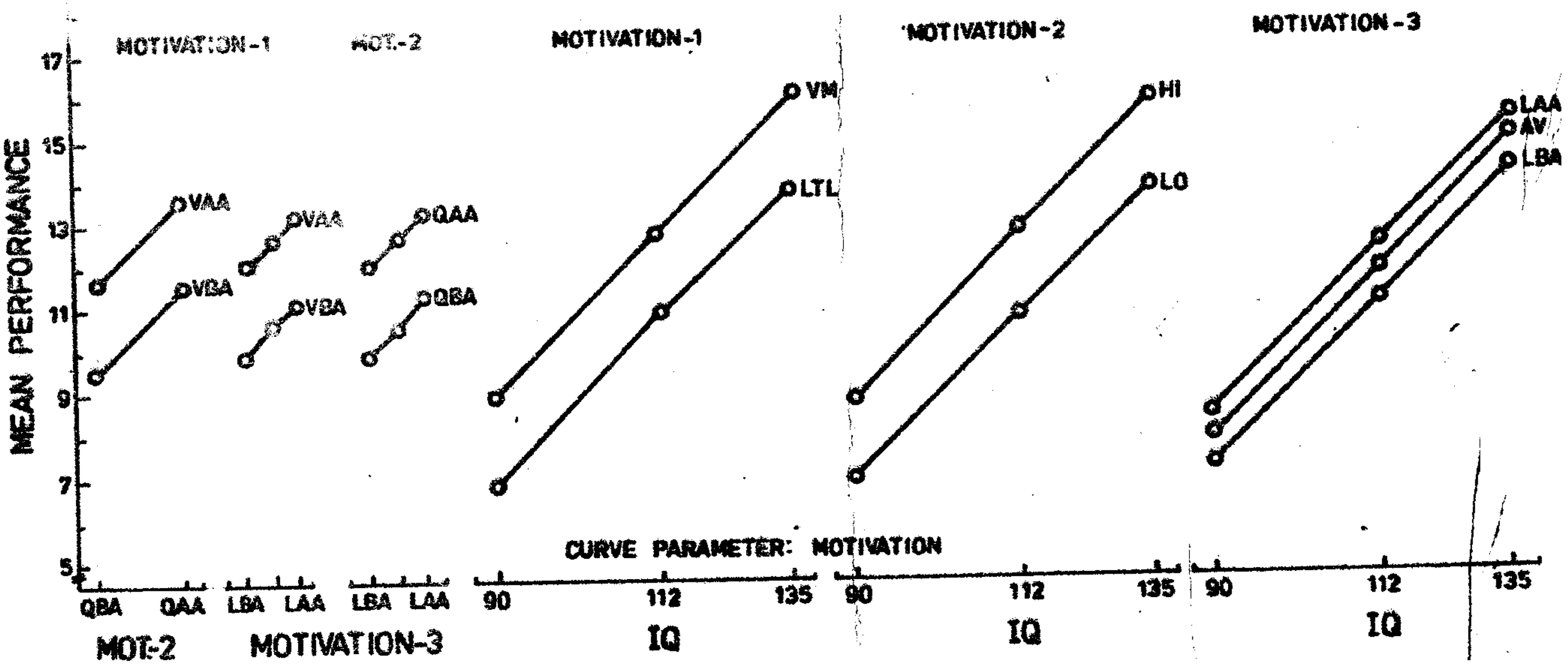
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CURVE PARAMETER: MOTIVATION