DOCUMENT RESUME

ED 065 600 TM 001 870

AUTHOR Hansen, Joe B.
TITLE An Investigation of Cognitive Abilities, State Anxiety and Performance in a CAI Task under Conditions of No Feedback, Feedback and Learner Control.
PUB DATE 72
NOTE 19p.; Paper presented at annual conference of the AERA (Chicago, Ill., April, 1972)

EDRS PRICE MF-$0.65 HC-$3.29
DESCRIPTORS Affective Behavior; *Anxiety; *Cognitive Ability; *Computer Assisted Instruction; Course Content; Factor Analysis; *Feedback; Hypothesis Testing; Memory; Multiple Regression Analysis; *Task Performance; Testing

ABSTRACT

The major objectives of this study were: to determine whether information feedback provided during a difficult task would reduce State-Anxiety (A-State) and whether learner control of feedback would lead to further reductions in A-State. Another objective was to attempt to bridge cognitive and affective domains by examining relationships of the task variables of feedback and learner control by examining the relationships of the task variables of feedback and learner control with anxiety and cognitive abilities, specifically reasoning ability (R) and associative memory (Ma). Three objective-related hypotheses were investigated. Prior to taking the CAI course, each subject received a battery of five tests administered to small groups. The course contained a series of eight sets of three examples and three test items, illustrating eight consecutive rules comprising the task. A varimax factor analysis conducted on the ability scores produced two factors, R and Ma. A second analysis of variance, multiple linear regression analysis, a two covariable analysis of covariance, and a single covariable analysis were also performed. It was found that real reductions in A-State can be obtained through increased use of feedback. While feedback generally seems to reduce A-State, high A-State appears to interfere with the learner's capacity to utilize the feedback information effectively in performing the task requirements. Learner control seems to offer definite advantages both in terms of anxiety reduction and performance. (CK)

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AN INVESTIGATION OF COGNITIVE ABILITIES, STATE ANXIETY AND PERFORMANCE IN A CAI TASK UNDER CONDITIONS OF NO FEEDBACK, FEEDBACK AND LEARNER CONTROL

Joe B. Hansen

The University of Texas at Austin

Ability by treatment interaction (ATI) research has attempted to produce ATI's through the manipulation of task variables, altering the relationship between the task and one or more specific abilities known to be important to task performance. Such studies have sought to establish principles that would lead to the development of instructional design models more sensitive to individual learner differences. A separate, equally important domain of research has dealth with motivational factors in learning as an approach to the general problem of individualization of instruction. Cattell (1966) has suggested that anxiety is a function of unresolved doubt about an expected outcome. If so, then providing feedback could reduce S's doubt about performance on the learning task and, consequently, reduce anxiety. Spence-Taylor drive theory predicts that high anxiety Ss will perform better than low anxiety Ss on simple tasks where a single habit tendency is involved, while low anxiety Ss should be superior on complex tasks where competing habit tendencies are involved.

Spielberger (1966) has drawn a distinction between Trait-Anxiety, a relatively permanent personality variable, and State-Anxiety, a transitory condition resulting from the amount of threat perceived by an individual in a particular situation. Trait-Anxiety (A-Trait) measures reflect individual anxiety proneness, or the tendency to display anxiety under conditions of stress.

This study was supported by NSF contract GJ509X

State-Anxiety (A-State) measures, on the other hand, reflect the reaction of the individual to a particular stress-inducing stimulus complex. The State-Trait Anxiety Inventory (STAI) was developed by Spielberger, Gorsuch, and Lushene (1969) as a means of measuring these two types of anxiety separately.

The major objectives of this study were: to determine whether information feedback provided during a difficult task would reduce A-State; and to determine whether learner control of feedback would lead to further reductions in A-State. Another objective was to attempt to bridge cognitive and affective domains by examining the relationships of the task variables of feedback and learner control with anxiety and cognitive abilities, specifically reasoning ability (R) and associative memory (Ma).

Hypotheses

The following specific hypotheses were investigated in this study. (1) Ss who receive informative feedback (FB) and Ss who have learner control (LC) over feedback would show greater reductions in A-State during a computer-assisted instruction task than would Ss who received no feedback (NF). (2) High A-State (HA) Ss would produce fewer errors under the FB condition than under the NF condition with low A-State (LA) Ss producing fewer errors under the NF than FB conditions. (3) For Ss in the NF group, the demand for both R and Ma abilities would be greater than for Ss in either the FB or LC groups. That is, the amount of change in error score per unit of increase in each of the ability scores would be greater in absolute terms for the NF Ss than for Ss in either of the other groups.

Method

Subjects

The Ss were 98 undergraduate female education majors at The University of Texas at Austin who were randomly assigned to three groups: no feedback (FB) n = 38; feedback (FB), n = 31; and learner control, n = 29.

Apparatus

The task, a computer-assisted instruction (CAI) course on the Science of Xenograde Systems (Merrill, 1964) was a revision of an earlier version described in detail elsewhere (Merrill, 1970; Bunderson & Hansen, 1972). It was presented by means of an IBM 1500 computer system in the CAI Laboratory at The University of Texas at Austin. The system has eight terminals of the cathode ray tube (CRT) type (IBM 1510). Each terminal is accompanied by an image projector (IBM 1512) for the computer-controlled presentation of 16mm transparencies. The terminals, each housed in an individual wooden carrel constructed to provide isolation and work space for each student, are all located in the same room of the CAI Laboratory.

Procedure

Approximately two weeks prior to taking the CAI course each S received a battery of five tests, administered to small groups, at the convenience of the Ss. The test battery included: the Trait scale of the State-Trait Anxiety Inventory (Spielberger, et al., 1969); Ship Destinations Test, Object-Number Test, First and Last Names Test (French, Ekstrom, & Price, 1963), and the Bi-Column Number Series Test (Merrill, 1970). Ship Destinations is a measure of general reasoning ability (R) while Bi-Column Number Series is designed as a process measure. Object Number and First and Last Names are measures of associative memory (Ma).

As each subject reported to the terminal room she was assigned to a terminal and was immediately given a 20-item paper and pencil version of the State Anxiety Inventory (SAI) (Spielberger, et al., 1969). Following the A-State measure subjects received appropriate instructions on terminal operation, followed by ego-involving stress instructions given on-line. The stress instructions implied that the task was an indicator of intelligence and that each S would be compared with other college students. Following the stress instructions a five-item version of the SAI was presented on-line, followed immediately by the first example of the Xenograde course.

The course contained a series of eight sets of three examples and three test items, illustrating eight consecutive hierarchical rules comprising the task. Following each example, three test questions designed to test the S's knowledge of the exemplified rule were presented. In the no feedback (NF) group, Ss received no feedback following their test item responses. In the feedback (FB) group, they received the words "true" or "false" as feedback following each test item, plus a statement of the rule following the ninth test item for each rule. In the learner control (LC) condition, Ss were required to type "y" to receive the true-false feedback and "n" if no feedback was desired following a test item. The LC Ss were also given the option of viewing the rule following the third test item for any example. Presentation of the rule, however, terminated the presentation of examples for that rule and resulted in immediate presentation of the first example of the next rule.

Results and Discussion

A varimax factor analysis conducted on the ability scores produced two factors, R and Ma. Factor scores expressed in Z score units were used as covariables for analyses of Ability-Treatment Interactions (ATI).

A group-by-trials ANOVA on pre- and post-stress A-State with three groups revealed that the stress instructions did indeed produce an increment in anxiety. A three-group, trials-by-subjects ANOVA using the three post-stress measures as repeated measures, yielded a significant groups-by-trials interaction. The source table for this analysis appears in Table 1. The LC group showed the greatest decline in A-State over the task, with the FB group next; the NF group remained at a relatively high level throughout. Table 2 reveals

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Insert Table 1 About Here

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the mean A-State scores for each group at each of the three points in time. Figure 1 is a graph of these data.

Insert Table 2 About Here

Insert Figure 1 About Here

A second analysis of variance was conducted to determine whether the three groups differed significantly in A-State at time 1 (post-stress instructions). While such a difference can be observed in Figure 1 and Table 1, this difference was not significant at $p < .05$. The following simple

effects were also tested: A-State at time 1 (A1) was compared with A-State at time 3 (A3) within each group. These data are reported in Table 3. Viewed collectively, these data provide strong support for the hypothesis that FB and LC result in greater A-State reductions than NF.

Insert Table 3 About Here

Multiple Linear regression analysis (Bottenberg & Ward, 1963) was used to test the hypothesis that HA Ss would perform better than LA Ss under FB while the opposite results would occur under NF. The regression of error rate on mean A-State scores produced an interesting, though non-significant anxiety by treatment interaction [$F(1/65) = 2.69$, $p < .11$]. These results are shown in Figure 2. The results for the NF group conformed very well to predictions while the FB group produced results almost opposite those predicted.

Insert Figure 2 About Here

In order to test the hypothesis that for each unit of change on each of the ability scores, the amount of change in posttest scores would be greater for the NF than for either of the other conditions, a two covariable analysis of covariance was conducted, using program COVAR2[1]. In this analysis the two ability scores were covaried simultaneously, while posttest scores served as the dependent variable.

This analysis revealed no interaction between covariables. It also failed to produce the predicted interaction between the treatment conditions and the two covariables combined. A significant interaction did occur, however,

between the treatments and the R factor scores. This interaction; $F(2/91) = 3.15$, $p < .05$, is illustrated in Figure 3. Although statistically significant, the results were once again virtually opposite to the direction predicted.

Insert Figure 3 About Here

The FB condition produced the strongest relationship between R ability and performance, with NF showing the weakest relationship. Reasoning ability seems to be of greater value when feedback is present after every problem than when feedback is absent or under learner control. A single covariable analysis using mean errors per problem as a dependent variable and R factor scores as the covariables produced highly similar results, $F(2/92) = 7.27$, $p < .01$.

That FB and LC resulted in reductions in A-State not obtained under NF seems clear. Some of the decrease in A-State probably resulted from adaptation to the task and the CAI medium. However, the crossing of the FB and LC groups over the NF group as shown in Figure 1 suggests that the treatments were effective in reading anxiety.

Spielberger, O'Neil, and Hansen (1970) found that high A-State Ss performed more poorly under conditions of informative feedback than did low A-State Ss, but that high A-State Ss showed a decrease in mean number of errors per problem over the course. The A-State performance data in the present study seems to support those earlier findings.

These results run counter to Campeau's (1968) finding of superior performance for HA girls under the FB as opposed to the NF condition. These results might be partially explained by the "response inteference hypothesis"

of the Drive Theory. Spence and Spence (1966) suggest that stress induced anxiety results in an increase in drive (D) and drive stimulus (S_D). The effect of increased S_D is to elicit competing responses which may interfere with task performance. The Xenograde task can be characterized as an hypothesis-formation, hypothesis-testing task. If the Ss' response pattern can be defined in terms of an hypothesis-formation, hypothesis-evaluation, rejection cycle, then individual hypotheses about what consitutes an appropriate rule can be thought of as individual covert mediating responses to example displays, which then lead to overt attempts to solve the ensuing problems, the attempted solution, providing a basis for rejection or acceptance of the hypothesis in question. In such a situation then, high anxiety could result in the generation of a greater number of competing erroneous hypotheses. In order to test these hypotheses, S must utilize information available in the problem displays or present in the form of feedback. If we can assume a limit on the amount of information an S can process, i.e., channel capacity, as suggested by Miller (1956), then it seems reasonable to speculate that increased information input input in the form of feedback could contribute to an increase in the proportion of incorrect hypotheses, thereby producing a loss of efficacy in the hypothesis formation-evaluation process. This could account for the greater number of errors per problem under the FB condition for high A-State Ss, as shown in Figure 5. To summarize, it seems plausible that increased anxiety produces a greater number of competitive responses in the form of erroneous hypotheses. Given an upper limit on information processing capacity, S must now evaluate a higher proportion of erroneous hypotheses. Feedback information further adds to the information processing

burden, resulting in reduced efficiency and an increase in the error-problem ratio. Although highly speculative, such reasoning implies the need for further studies, where the effects of high A-State on information processing variables can be more carefully examined.

Summary and Conclusions

Several tentative conclusions can be drawn from the results of this study, regarding the effects of feedback on A-State, and the relationships among A-State, ability, and performance. With respect to the effects of information feedback on state anxiety, it appears that real reductions in A-State can be obtained through increased use of feedback. Whether or not this results in higher levels of performance or improved learning depends on other factors, particularly on ability factors that are known to be important to the task. Feedback seems to help persons with high reasoning ability, while hindering the performance of those with low R ability, suggesting a positive relationship between R and information processing capacities.

While feedback generally seems to reduce A-State, high A-State appears to interfere with the learner's capacity to utilize the feedback information effectively in performing the task requirements. Learner control, although defined here in a limited manner, also seems to offer definite advantages both in terms of anxiety reduction and performance. While the LC condition was equally effective with the FB condition in reducing anxiety, it resulted in a substantial reduction in the amount of work required to complete the task.

Suggested Further Research

The suggested relationships among the variables of A-State, information processing, and learning indicate a need for further research. Costello and Dunham (1971) have described a methodology, in the form of a model which they have tentatively dubbed the "Approach Model," which offers promise for the investigation of the relationships between two classes of variables, those relating to task performance and those relating to cognitive processes. The procedure embodied by the approach model typically involves the administration of tests of a mental ability on which there is some general consensus of acceptance, such as induction (R) or associative memory (Ma). It also involves the administration of a learning problem, usually a concept learning task, the task being selected for its suspected ability requirements. The ability tests are then submitted to a "rational information processing analysis," and further tests are developed. These new tests are expected to be tests of the specific information processing variables that are inherent in the ability tests. An example appropriate to the R ability factor might be hypothesis generation, or hypothesis evaluation, or both of these. A separate set of tests is developed from a rational information processing analsyis of the task requirements. A factor analysis of the two sets of derived test scores will reveal, through common factor loadings, factors that are inherent to both the task and the ability in question.

The applicability of the Approach Model is limited to investigation of cognitive processes and therefore would not be of value in investigating the relationship between cognitive and affective processes. It should, however, provide a sound methodology for investigation into the relationship

between R and information processing variables. By introducing varied feedback information content into the task as an independent variable, one might hypothesize differential factor structures under different feedback conditions. Such an approach would help to explicate the relationships between feedback and performance for Ss of differential abilities suggested in this study. The inclusion of A-State measures in the learning task might provide a means of determining more precisely the nature of the relationship between A-State and information processing ability as a function of differential feedback.

FOOTNOTE

1. Written by Dr. E. E. Jennings, The University of Texas at Austin.

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TABLE 1

Source Table for Groups by Trials ANOVA

for Hypotheses 2.b. and 2.c.

Source	Mean Square	d.f.	F ratio	p.
Total	12.3959	293		
Between	24.6254	97		
Groups	4.7401	2	.189	.8294
Error (G)	25.0441	95		
Within	6.3435	196		
Trials	96.0000	2	18.586	.0000
GXT	17.4860	4	3.385	.0107
Error (T)	5.1652	190		

TABLE 2

Mean A-State Scores by Group and by Trial

Group	A-State (Trials)		
	A1	A2	A3
No Feedback	$\overline{X}$ = 10.89 s.d. = 2.82 n = 38	$\overline{X}$ = 9.87 s.d. = 3.85 n = 38	$\overline{X}$ = 10.24 s.d. = 4.53 n = 38
Feedback	$\overline{X}$ = 11.03 s.d. = 2.68 n = 31	$\overline{X}$ = 9.90 s.d. = 3.29 n = 31	$\overline{X}$ = 8.77 s.d. = 3.37 n = 31
Learner Control	$\overline{X}$ = 11.79 s.d. = 2.88 n = 29	$\overline{X}$ = 10.21 s.d. = 3.70 n = 29	$\overline{X}$ = 8.45 s.d. = 3.05 n = 29

TABLE 3

Comparison of A1 and A3 Mean A-State Scores by Group

Group	Mean Comparison	F	df	p.
NF	A1 v. A3	.77	1/37	.39
FB	A1 v. A3	18.38	1/30	< .01
LC	A1 v. A3	36.55	1/28	< .01

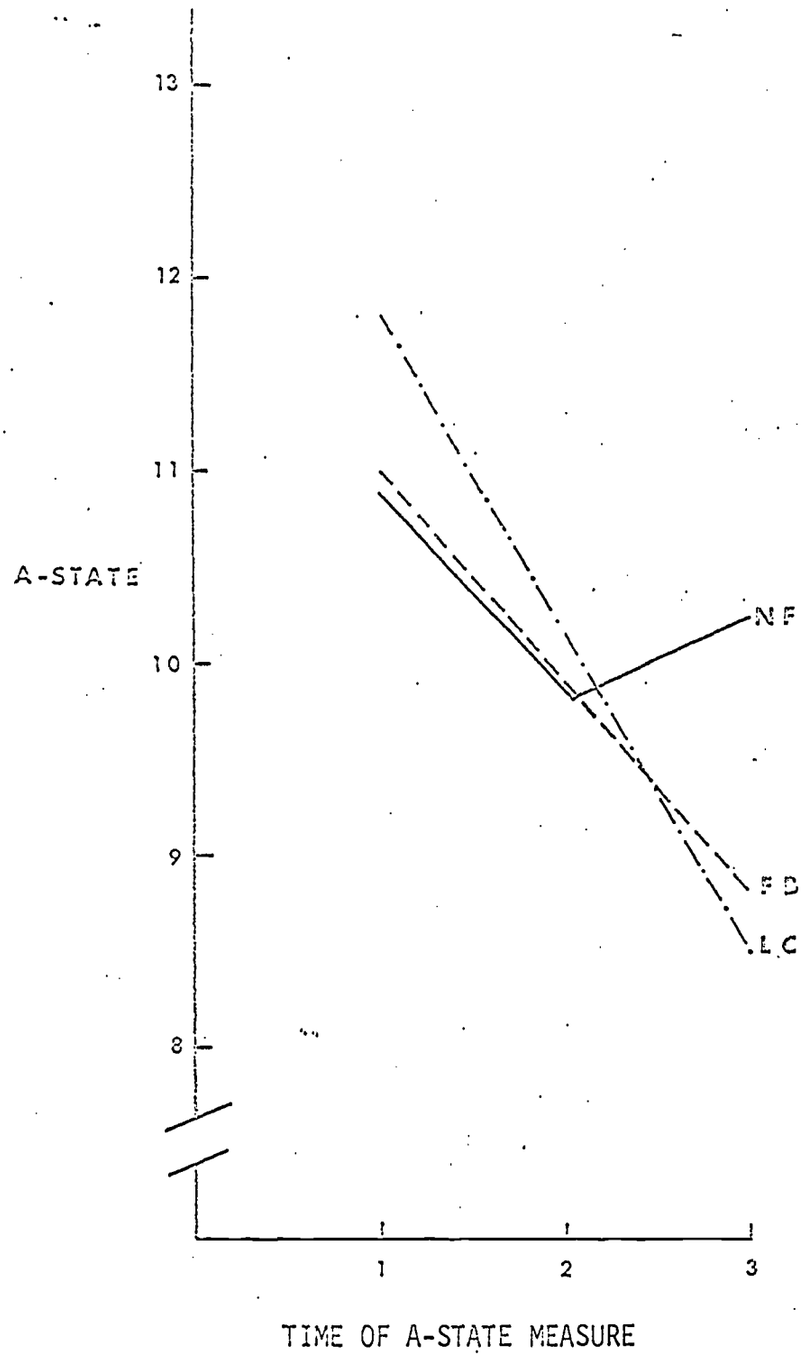

Figure 1.--Mean A-State Scores by Group.

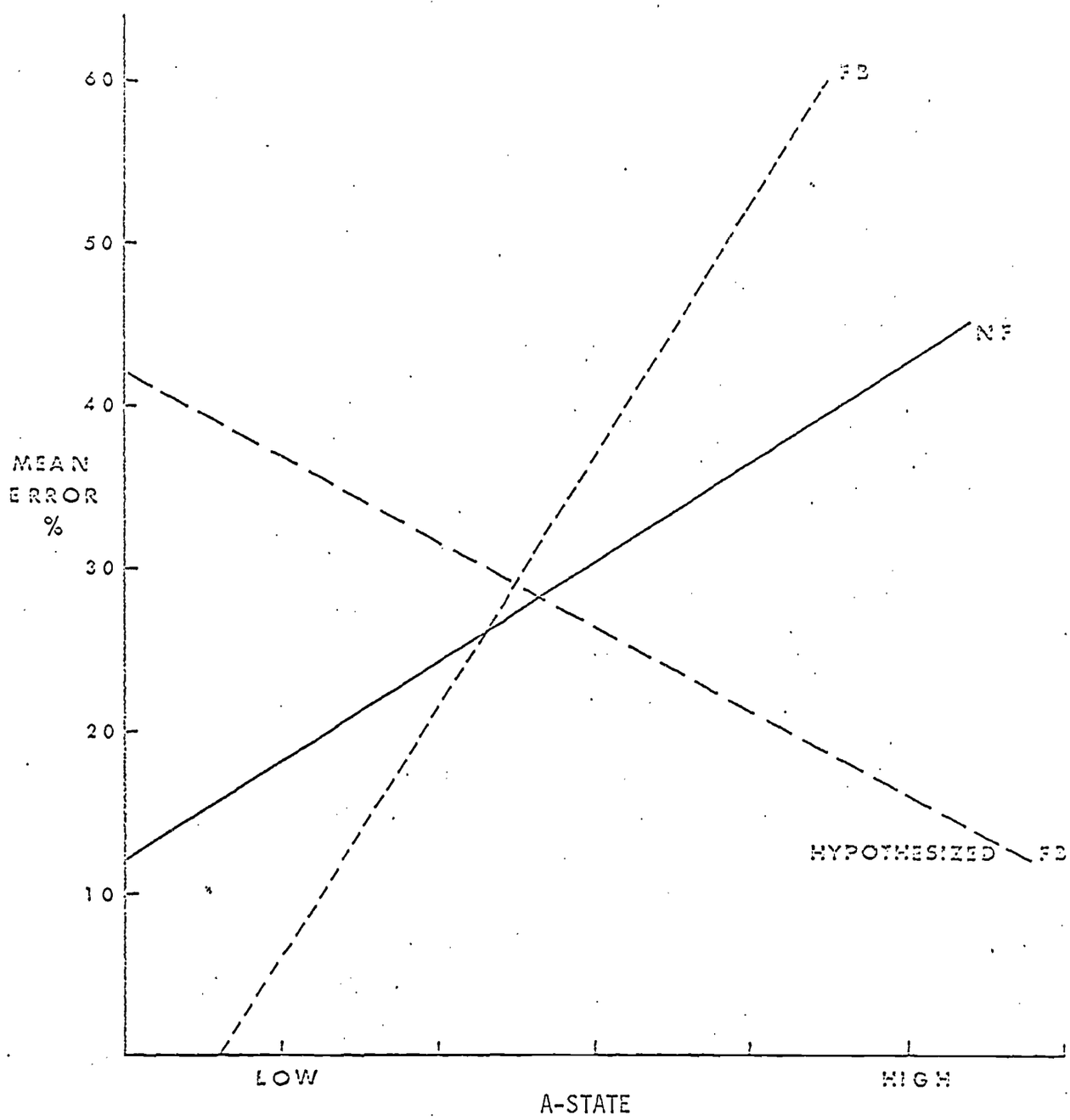

Figure 2--Regression of Error Rate on Mean A-State for NF and FB Groups.

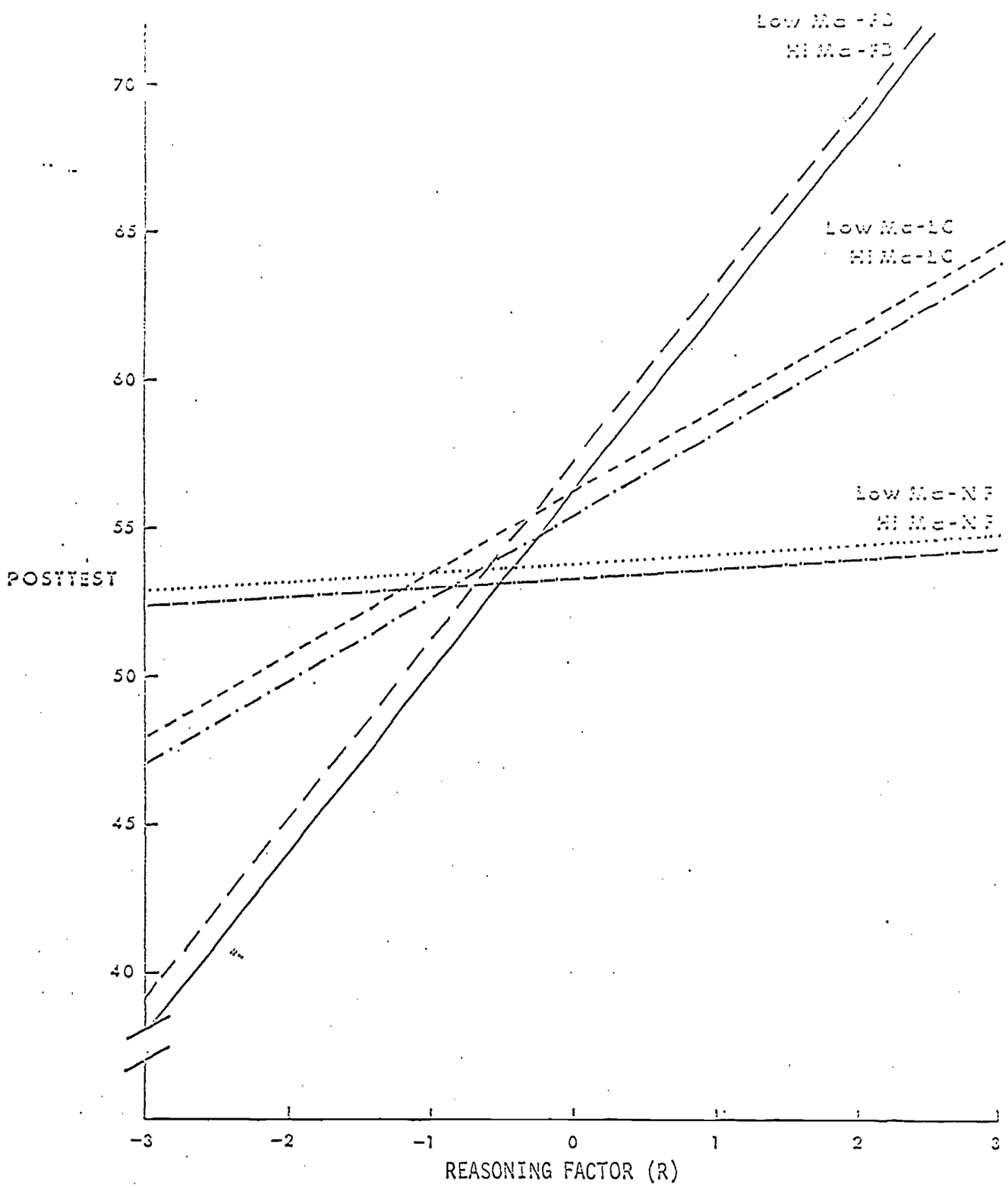

Figure 3.--Double Covariance Analysis with Posttest as Dependent Measure and Memory (Ma) and Reasoning (R) Factor Scores as Covariables.