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ABSTRACT

Ninety-eight undergraduate education majors received a battery of ability tests, measuring general reasoning, associative memory, and trait anxiety and were randomly assigned to three groups--no feedback, feedback, and learner control--for a computer-assisted instruction course on Xenograde systems (an imaginary science). Four state anxiety measures were taken: prior to the course, following the administration of stress instruction, at the mid-point, and at the end. Learner control subjects decreased more in state anxiety than those in the feedback condition, while no-feedback subjects remained high throughout. High anxiety subjects made more errors under the feedback condition than under no feedback. The feedback condition facilitated performance for high reasoning subjects, but impaired performance for low reasoning subjects. (Author/RH)

THE UNIVERSITY OF TEXAS AT AUSTIN

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AUSTIN

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

TECHNICAL REPORT NO. 16

by

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ABSTRACT

Ninety-eight undergraduate education majors received a battery of ability tests, measuring general reasoning (R), associative memory (Ma), and trait anxiety (A-trait) and were randomly assigned to three groups--no feedback (NF), feedback (FB), and learner control (LC)--for a CAI course on Xenograde systems. Four A-state measures were taken: (a) prior to the course, (b) following the administration of stress instructions, (c) at the mid-point, and (d) at the end.

LC Ss decreased more in A-state than FB. NF remainded high throughout the task. High A-state Ss made more errors under FB than NF. FB facilitated performance for high R Ss but impaired performance for low R Ss.

[1] Doctoral Dissertation, The University of Texas at Austin, May 1972

CHAPTER I

BACKGROUND OF THE PROBLEM

Anxiety: Theory and Research

Anxiety has long been recognized as an important factor in human learning. Until the past two decades, however, the experimental research on anxiety was sparse. Spielberger (1966) has pointed out that the frequency of studies on anxiety increased tenfold from 1930 to 1963. Spielberger credits the publication of four books in 1950 with having stimulated experimental research on anxiety: Rollo May's The Meaning of Anxiety; O. H. Mowrer's Learning Theory and Personality Dynamics; Anxiety, edited by Hoch and Zubin; and Personality and Psychotherapy, by Dollard and Miller. This upsurge in interest may also derive in part from the growing emphasis on individualization of instruction that is now so prevalent in education. This emphasis has led to an increased interest in factors affecting the individual learner such as anxiety and other organismic variables. Some of these variables will be discussed below as specific aptitudes.

Theories of Anxiety

The earliest interest in the motivational value of anxiety was expressed by Freud. He saw anxiety as a "uniquely unpleasant feeling state, accompanied by certain specific efferent phenomena and the perception thereof" (Freud, 1936, p. 70). The prototype for all anxiety was the traumatic experience of birth. Anxiety, in the Freudian conceptualization, has mobilizing effects that serve the organism when confronted with a harmful or dangerous situation. Such anxiety is the response of the Ego to stimulation it is unable to control. Through the process of association, anxiety becomes attached to the expectation of danger. This results in mobilization of ego defenses to protect the individual (ego) from further painful or noxious stimulation.

Freud saw anxiety as being equivalent to fear, the object of which could be either internal or external. Three types of anxiety were delineated by him: real anxiety, neurotic anxiety, and moral anxiety. Real anxiety is a fear of an external object or danger in the real world. "It is a reaction of the organism to the perception of a real danger" (Freud, 1933). Such anxiety serves the function of alerting the organism to allow it to attempt to avoid or reduce the danger.

In neurotic anxiety the threat resides in the instinctual object choice of the id. It occurs as a result of excessive stimulation from the id. Neurotic anxiety has three forms.

The first form of neurotic anxiety identified by Freud is "free floating anxiety." This is a generalized fear response for which no specific causal agent can be found. A second type of neurotic anxiety is "phobic anxiety." This form of anxiety is expressed as an intense irrational fear. It is anxiety that is bound psychically and attached to particular objects or situations (Hall, 1954). The "panic reaction" constitutes the third type of neurotic anxiety. In this form the original cause of the anxiety is lost to view or has been repressed. The behavioral manifestations are spontaneous outbursts, wild or impulsive behavior with "no sign whatever of any danger or of any cause that could be exaggerated into one" (Freud, 1933, p. 40?).

Moral anxiety or guilt arises out of excessive pressure from the superego. The source of threat is the conscience of the superego system. The fear is the fear of punishment internalized by the superego from the societal values and parental influence (Freud, 1933).

The important element common to the three main forms of anxiety is the anticipated real threat from the environment or from some internal source. The major defining characteristic of anxiety in psychoanalytic theory is that of a fear response elicited by a perceived threat to the ego, which gives rise to valuable defense functions.

Taylor (1956) attributes an important role to anxiety in drive theory. According to drive theory, response strength (R) is determined by excitatory potential (E) which is seen to be a multiplicative function of drive level (D) and habit strength (H) such that $R = f(D \times H)$. This formulation predicts that the performance of high drive Ss should be superior to that of low drive Ss in simple non-competitive situations where a single habit tendency is involved. However, in more complex situations where a number of competing habit tendencies are evoked, and only one of them is correct, the relative performance of high and low drive Ss will be determined by the number and comparative strengths of the competing response tendencies. If, initially, the correct response is weaker than a competing response, then the higher drive levels will result in poorer performance during the early stages of the learning task. Habit strength of the correct responses would be expected to increase until they became stronger than the incorrect responses, resulting in superior performance of high drive Ss over low drive Ss during the later stages of learning.

The Manifest Anxiety Scale (Taylor, 1953) was developed as a means of measuring the strength of r_e, a hypothetical emotional response, elicited by aversive stimuli, which contributes to the strength of D. The MAS assumes a relationship between D and r_e such that the degree of anxiety will be reflected in the level of D. While it is frequently misused, the MAS was developed as a selection device for Ss differing in general drive level and not as a clinical tool for the diagnosis of anxiety (Taylor, 1956).

Cattell (1966) offers two basic postulates concerning the relationship of anxiety to motivation. The first of these is that "anxiety arises from threatened deprivation of an anticipated satisfaction when the threat does not carry complete cognitive certainty" (p. 47). In Cattell's formulation, anxiety (A_1) is proportionate to the strength of ergic tension (E) and to the doubt (D) concerning its satisfaction. In equation form $A_1 = f(E,D)$. Doubt can be further differentiated into V_o, the objective uncertainty based on the outcome of past situations, and F, the degree of "...failure of the organism to focus the real sign and narrow the uncertainty" (p. 47). Although, for the realist, V_o is based on the calculated variance of the reward in question in past situations, there might also be inferences from presently available signs which might modify V_o.

The doubt (D) or uncertainty is with respect to satisfaction at some future moment, not now, and a discrepancy could derive from a change in E just as easily as from a change in the external reward situation. The final term for anxiety, A, must contain expressions for both objective variability, V_o, and subjective ergic variability, V_e, which is derived from variance in experience over time. Total uncertainty is thus the sum of the uncertainty of reward in the objective world and the uncertainty of $\underline{S}$'s own impulses. A new formula thus emerges: $A_1 = f(E)(V_e)(V_oF)$. The parentheses in this expression do not imply a product but are used to separate three postulated main sources of anxiety.

Ergic tension, E, can be further differentiated into need strength, drive strength, and level of gratification, such that for a given doubt ratio, D, a stronger need will generate more anxiety than a weaker one.

Cattell's second postulate is that "anxiety is an expression of the erg to escape in response to threatened future ergic deprivation of any kind" (p. 49). Anxiety is a derivative of the fear erg (danger avoidance or security seeking). Cattell assumes that in a highly developed organism fear may arise not only in response to the primary stimulus of danger but also to the concept of deprivation of any ergic satisfaction. In terms of Cattell's dynamic calculus the second postulate is expressed as $A_2 = f(E/R)$, in which E is retained as the ergic tension level and 1/R is the ratio which the anticipated actual level of reward bears to the ergic tension level. Thus A_2 is an inverse function of the anticipated absolute level of gratification, R, whereas A_1 is a function of the anticipated uncertainty of the reward, R.

Activation theory (Malmo, 1957) also relates anxiety to deprivation in a motivational framework. This theory holds that behavioral efficiency is a curvilinear (inverted U) function of arousal. Drive and arousal are on the same dimension and both can be increased through need deprivation. Anxiety is related to drive and arousal by means of its physiological and neurological correlates. It may be inferred from this relationship that a similar curvilinear relationship exists between anxiety and performance.

Such a function predicts that as anxiety or arousal increases, performance efficiency also increases up to some optimal point, after which further increases in arousal result in performance decrements.

Malmo (1966) advocates a multifactor theory of activation in which the physiological changes associated with the deprivation of a need (e.g., water, food, sex, sleep, etc.) are a product of at least two factors: (a) the state of bodily need produced by deprivation, and (b) the relevant environmental stimulating conditions. These two factors interact in such a way that (a) can produce no measurable effect in the absence of (b). Predictions based on the inverted U function have been supported in deprivation studies with rats using a bar pressing task (Belanger and Feldman, 1962), but studies using human Ss have been less conclusive.

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. 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 (1970) as a means of measuring these two types of anxiety separately. This instrument has demonstrated its usefulness in numerous studies conducted at Florida State University, some of which are referred to below.

Summary

It appears that anxiety as a motivational and theoretical construct owes much to the early thoughts of Freud. The perception of threat from an external source enters into the formulations of both Malmo and Cattell, while a reaction to aversive stimuli is the basis of the drive theory concept of anxiety. Freud recognized the importance of the mobilizing effects of anxiety as well as the role of memory and the learning process in relation to anxiety. The later conceptualizations of anxiety as stated above all contain common elements that were first revealed by Freud.

Of the several theories of anxiety discussed above, drive theory has proven most successful in its predictive use with human Ss in learning situations. Recently, however, numerous studies have been directed toward the extension and elaboration of drive theory by means of the State-Trait approach. In the following chapter research into the role of anxiety in learning is reviewed. The studies reviewed are by no means exhaustive of the research in this area, but are selected for their relevance to this study.

CHAPTER II

ANXIETY RESEARCH

Three major focal points for anxiety research are of interest in light of the approach taken in this paper. They are anxiety and intelligence, anxiety and stress, and more recently, anxiety and specific abilities in relationship to learning.

Anxiety and Intelligence

The relationship between anxiety and intelligence has intrigued many investigators, but the results of a plethora of correlational studies have produced conflicting results.

McCandless and Castaneda (1956) found a significant negative correlation between Otis IQ and anxiety as measured by the Children's Manifest Anxiety Scale (CMAS) on a sample of sixth-grade girls, but the correlation for boys, while negative, was not significant. In another study, Castaneda, McCandless, and Palermo (1956) found that sixth-grade girls scored significantly higher than sixth grade boys on the CMAS. Feldhusen and Klausmeier (1962) found a significant negative correlation between IQ, as measured by the Wechsler Intelligence Scale for Children (WISC), and anxiety for both boys and girls. These investigators also found girls to have significantly higher CMAS scores than boys.

Denny (1966) investigated the effects of both anxiety and intelligence on concept learning. Using the MAS, Denny selected the upper and lower quartiles of his sample as high-anxiety (HA) and low-anxiety (LA) groups, respectively. The HA and LA groups were each divided into high intelligence (HI) and low intelligence (LI) by means of a median split using CEEB scores. The concept formation task was preceded by ego-involving instructions for all Ss. Denny's subjects were required to deduce the attributes comprising a conjunctive concept from information given in separate "instances." Each S was presented with thirteen instances, each requiring eight conclusions, one for each potential attribute of the concept. The relevant attributes were contained in positive instances only. Following each instance the S was required to report his conclusions about the concept by recording for each of the eight potential attributes one of the following: (a) the attribute was included in the concept, (b) the attribute was not included in the concept, or (c) he did not know whether it was included or not.

Denny found that HI Ss gave more correct conclusions than LI Ss. HA-LI subjects made more commission errors than LA-LI Ss did. HA-HI Ss made fewer commission errors than LA-HI Ss. Assuming that such a task elicited a large number of competing response tendencies for the LI group and relatively few for the HI group, Denny's results provide support for the drive theory.

Grice (1955) and Kerrick (1955) both reported significant negative correlations between MAS scores and various measures of intelligence for Air Force basic trainees. Grice further revealed that the inferior performance of high anxiety Ss relative to low anxiety Ss could be accounted for just as readily by lower intelligence as it could by higher drive.

Spielberger (1958) failed to find a significant correlation between MAS and ACE scores for 1142 Duke University freshmen. The overall correlation for this sample was -.02, with males producing an $r = -.06$, and females an $r = .01$. Further examination of these results revealed that as mean ACE score increased from 111.4 to 124.6 for male Ss, the size of the negative correlation for males decreased from -.34 to .04. No such trend was found for females. These findings were attributed to selection factors that operated differentially for male and female entering freshmen over the two-year period covered by the study.

In explaining these findings, Spielberger (1966) posits a model which provides an explanation for the lack of consistency in the findings of studies relating MAS scores to intelligence. According to the model, a negative correlation exists between intelligence and anxiety (MAS) when the sample used contains a sizeable portion of Ss of lower intelligence. As the range of intelligence scores is narrowed, such as occurs when high intelligence Ss are selected for admission to college, the correlation is attenuated. The implication of this, according to Spielberger, is that it is important to control for intelligence when selecting Ss on the basis of extreme MAS scores.

Gaudry and Spielberger (1970) utilized a paired-associates list of very low difficulty to investigate the interaction of intelligence and MAS anxiety. The measure of intelligence they used was the combined score on the language and quantitative advanced tests of the Australian Council for Educational Research. A two-by-two factorial design with two levels of anxiety and two levels of intelligence was used. Intelligence and anxiety were counter-balanced by assigning Ss in such a way that the high- and low-anxiety groups possessed highly similar distributions on intelligence and the high- and low-intelligence groups had similar distributions on MAS scores.

The 72 subjects were then given a very easy list of five paired associates. On the first trial the subjects were presented with the stimulus words, one at a time, and were required to guess the correct response. Following each response the correct word was presented for S to study. A total of 15 trials were run, using cumulative response latency on each trial as the dependent measure. A significant ($p < .01$) interaction between anxiety and IQ was obtained over trials one through five, but failed to emerge over trials six through fifteen. Early in learning, high anxiety facilitated the performance of high-IQ subjects and impaired the performance of low-IQ subjects, compared to low-anxiety subjects of corresponding IQ levels. A main effect of anxiety was obtained over all fifteen trials, indicating superior performance for high-anxiety subjects.

These results are consistent with drive theory expectations if it is assumed that the easy task generated fewer competing response tendencies for high-IQ than for low-IQ subjects, and that correct responses became dominant earlier in learning for high-IQ than for low-IQ subjects.

Campeau (1968) used a programmed instruction (PI) task on earth-sun relationships to investigate the effects of both test anxiety and feedback on fifth-grade boys and girls. The TASC was used to obtain upper- and lower-27 percent groupings on anxiety. Gain scores, adjusted by covariance to correct for IQ differences, revealed a significant anxiety-by-feedback interaction for girls but not for boys. No significant effects for boys on either immediate or delayed retention tests were found. For HA girls, performance was better under conditions where feedback was provided following responses than under conditions of no feedback. The results for girls in this study provide support for drive theory but the results for boys do not. The essential difference between Campeau's treatment groups was in the amount of information provided each S following a response. It appears that for young girls, informative feedback serves to facilitate performance when state anxiety is high but not when it is low, while low state anxious girls seem to do better under conditions of no feedback. If informative feedback can be viewed as a means of removing some of the uncertainty about an expected outcome, then Campeau's results become supportive of Cattell also.

Anxiety and Stress

In studying the effects of anxiety in complex learning situations, the independent variables most commonly employed are stress and task difficulty. Stress is usually induced through the use of ego-involving instructions given to the S before or during the experimental task. The procedure typically involves telling the S that he must do well on the task because it is an intelligence test.

It is a fundamental assumption of State-Trait theory that persons who are high on A-Trait are not necessarily going to show high A-State in a learning situation. According to this theory, however, high A-Trait persons are more susceptible to the effects of ego-involving instructions used to induce stress (O'Neil, 1970).

Spence and Spence (1966) have hypothesized that the major effect of ego-involving instructions is to increase D and drive stimulus (S_D). The increase in S_D in a complex task elicits numerous task-irrelevant responses in addition to the task-relevant responses elicited by increased D. Such task-irrelevant responses may interfere with performance. This "response interference hypothesis" is offered by Spence and Spence as an explanation of the frequently-observed performance decrement in studies employing ego-involving instructions. The relationships among the variables involved in such studies, i.e., stress, anxiety, and task-specific variables, are complex and more carefully-planned research is needed to clarify these relationships.

The following studies are illustrative of the use of stress in anxiety research.

Sarason and Palola (1960) used a digit-symbol substitutions task in which highly-similar symbols were employed. The performance of LA Ss under ego-involving instructions was superior to those receiving neutral instructions, whereas the performance of HA Ss under ego-involving instructions was inferior to HA Ss under neutral instructions. On a more difficult task the performance of HA Ss was inferior to LA Ss, while on the easier task the HA Ss performed superior to the LA Ss.

Nicholson (1958) varied anxiety, stress and task characteristics using a serial learning task. High and low competition lists were used to test assumptions of drive theory. An interaction was obtained between type of list and MAS group under non ego-involving instructions. Under the ego-involving instructions, however, HA Ss did not perform as well as LA Ss on either list.

O'Neil (1970) examined the effects of A-Trait and stress on A-State and performance. Stress was induced by providing negative feedback to half of the Ss following every third problem throughout the task. In the non-stress condition Ss received a brief rest period instead of negative feedback. High and low A-Trait groupings were selected from the upper- and lower-27 percentiles of the STAI scale distribution for all Ss. A-State was measured before, during and after the task. High A-Trait (HA) Ss in the stress condition showed a significantly greater increase in A-State from pre-task levels than did low A-Trait (LA) Ss.

During the learning task, HA Ss showed a marked decrease in A-State under the stress condition, whereas level of A-State remained relatively constant for LA Ss under stress. Under the non-stress condition, the HA and LA groups both showed the same increase in A-State from pre-task levels and approximately parallel changes in level of A-State during the task.

No relationship was found between A-Trait scores and errors on the CAI task. More errors were made by Ss with high A-State levels than low A-State levels throughout the task. No significant differences were found between high and low A-State Ss in their performance on the most difficult part of the three-part task, although their differences were significant on the easier part of the task. This finding is not consistent with the O'Neil, Spielberger, and Hansen (1969) data and does not support drive theory.

An interesting aspect of these findings is that HA Ss in the stress condition continued to decrease in A-State throughout the task, in spite of the negative feedback, while A-State remained high for LA Ss throughout the task. O'Neil suggests that this finding indicates that HA college students have learned to cope with stressful situations better than have LA college students as a result of the HA students' having experienced more stress. If this is so, it may suggest differences in coping ability for different age levels, with younger children showing less ability to cope than older children as a result of the differences in their respective levels of experience.

Specific Abilities and Anxiety in the Individualization of Instruction

In his presidential address before the American Psychological Association, Cronbach (1957) called for a rapprochement between two divergent areas of psychological research, the correlational and the experimental. That presidential address gave impetus to a line of research that has drawn increased interest in recent years, especially from researchers interested in optimizing the relationship between individual abilities and instructional treatments or strategies. Such research is generally characterized as being concerned with the discovery or production of aptitude by treatment interactions (ATI) (Cronbach and Snow, 1969, Bunderson, 1969, Dunham, 1969). The experimental paradigm employed in ATI research involves the measuring of specific cognitive abilities by means of either using available tests such as those found in the Kit of Reference Tests for Cognitive Factors (French, Ekstrom, and Price, 1963), or specific process measures based on the implied information processing requirements of the experimental task to be used. Following the administration of such tests, Ss are presented with a learning task. An attempt is made through the manipulation of task variables to alter the ability requirements of the task. The relationships among various abilities and task variables are thus investigated. Such studies are highly valuable for the data they provide that can be used in developing instructional methods that optimize learning for students with different ability profiles.

Aptitude by Treatment Interaction Research

At the Computer-Assisted Instruction Laboratory at The University of Texas at Austin, a series of ATI studies have been conducted utilizing a CAI program on an imaginary science known as the Science of Xenograde Systems. The Xenograde task consists of ten rules that form a learning hierarchy defining all relationships among the elements of a Xenograde system. The task has undergone several revisions during its life span at the CAI Laboratory. Earlier versions are described by Merrill (1970) and by Olivier (1970). A current version is described in the following chapter under "Procedure."

Three studies reported by Bunderson (1969), using the Xenograde task, focused on the relationship between two different aptitude factors, associative memory (Ma) and general reasoning (R), and two instructional treatments consisting of an expository and a discovery approach. In the first study Ss in the expository condition were presented with an example of a rule displayed on the Cathode Ray Tube (CRT) screen simultaneously with a statement of the rule presented on a 16mm film projector (IBM 1512). In the discovery group the Ss were presented with the same examples as the expository group but they were not given the rules. Following each sample, S was required to answer three short completion-type test questions requiring application of the rule. Two correct answers out of three would result in S being presented with the next rule. Failure to reach the two out of three criterion would result in the presentation of another example of the same rule up to a maximum of five examples for a given rule after which S would automatically be branched to the next rule. In both groups Ss were required to copy each example as it was displayed so that they might refer to it in attempting to answer the questions that followed. The dependent variable was the total number of examples used by each S in learning the task.

A significant disordinal interaction was obtained for the regression of number of examples on Ma factor score. The expository treatment produced a negatively sloped regression line while the discovery treatment produced a positively sloped regression line. The data revealed that many of the rules were too difficult for efficient learning to occur. This led to the revision of the task in which the rules and their corresponding examples were simplified extensively.

The second and third studies were conducted using this revised task. In these two studies, however, Ss were not allowed to copy the examples presented to them. The outcome of these data showed a reversal of the regression slope for the discovery group and a flattening of the regression slope for the expository group, indicating that as displays were simplified and previous example availability was restricted, associative memory ability became facilitative for Ss in the discovery group while not affecting performance for those receiving the expository treatment. Something in the revision of the task had resulted in reversing the relationship between Ma and performance under the discovery treatment. These results were consistent with the results of concept learning studies (Blaine and Dunham, 1969), which have shown the availability of past instances to reduce the memory load in learning tasks.

In the light of the findings of the first three Xenograde studies, a fourth study (Bunderson & Hansen, 1972) was conducted to attempt to replicate the regression slope reversal under controlled conditions. Four treatment groups were devised to investigate the effects of example complexity and previous example availability of performance for Ss possessing varying degrees of associative memory and general reasoning abilities.

A simple example previous example not-available (SNA) group was the same as the discovery group in the first study except that the examples used were the simplified examples that resulted from the task revision. A complex example previous example not-available group (CNA) received examples that contained redundant irrelevant information. A simple example available (SA) group received simplified examples with instructions to copy relevant data from each example onto a special recording form provided for the purpose. A complex example available (CA) group received the complex examples and the recording forms. Preceding the presentation of the learning task all Ss were given a battery of six ability tests, two each for the abilities of general reasoning (R), associative memory (Ma), and inductive reasoning (I). A varimax factor analysis yielded two factors, R and Ma. The results provided a partial replication of studies one and two indicating that the availability of past examples does reduce the memory requirement for Ss who receive simple examples. The data from this study indicated that Ss with high reasoning ability benefit more from complex examples and seem to be able to utilize availability better than Ss of lower reasoning ability. The data also led to the tentative hypothesis that Ss who were high on associative memory did not perform well unless they also possessed high reasoning ability.

While the ATI paradigm provides an effective means of studying the relationships between individual abilities and learning, it may be incomplete inasmuch as its focus has been restricted to cognitive factors, ignoring such non-cognitive factors as anxiety which are known to affect learning. To date very few studies have been reported in which any attempt has been made to bridge the gap between ATI and anxiety research. A few studies, however, have produced results indicating the need for further exploration of the relationships that emerge when anxiety and specific abilities are studied conjointly in a learning situation.

A major experiment, bridging the cognitive and affective domains, was conducted by Meyers (1971) who examined the relationships between stress (high and low involvement), anxiety, ability, and performance on a concept identification task employing an extra dimensional shift, under conditions of both positive and negative transfer. Meyers found a significant anxiety by ability by treatment interaction for low stress under the negative transfer condition, using memory span as the ability. The nature of the interaction was such that memory showed a strong positive relationship to performance for Ss in the low to average anxiety range. High anxious Ss, however, revealed a debilitating relationship between anxiety and performance. Meyers interprets his findings in terms of the relationships between competing responses and task characteristics, concluding that intellectual ability does not contribute directly to the number of competing responses in a learning situation but that ability does have a role in determining the effects of competing responses.

Spielberger[1] has found that mathematical aptitude interacts with anxiety under conditions of stress on a difficult learning task, with high mathematical aptitude subjects performing better and showing less anxiety than low mathematical aptitude subjects.

Katahn (1966) found that anxiety and a measure of mathematical aptitude had an interactive effect on performance on a serial maze task. High and low anxiety subjects performed at about the same level but high anxiety-high aptitude subjects were superior to low anxiety-low aptitude subjects.

A major goal of this study was to further close the gap between ATI and anxiety research by focusing on the relationship between state anxiety and specific abilities in a learning task.

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[1]Personal communication.

CHAPTER III

PROBLEM STATEMENT AND PREDICTED RESULTS

Effects of Stress and Feedback on A-State and Performance in CAI

In a study cited above, employing computer-assisted instruction (CAI), O'Neil (1970) found differential changes to occur in State anxiety (A-State) for high (HA) and low (LA) trait anxious college girls, under conditions of stress-inducing feedback, with HA Ss showing a decrease in A-State and LA Ss showing a continuous low level during the task. As discussed above, O'Neil suggested that HA college girls possess superior coping behaviors for dealing with stress as opposed to LA college girls. This is supposedly a result of HA girls' having had more experience in dealing with stress as a function of their perceiving more situations as being stressful. This explanation, however, is inadequate, because although HA girls did show greater decreases in A-State during the task, they showed greater initial increases in A-State from the pretask period to the beginning of the task period and they remained at a higher level of A-State throughout the task than did the LA Ss.

An alternative explanation for O'Neil's findings could be made in terms of Cattell's (1966) postulates, wherein anxiety is viewed as a function of cognitive uncertainty about the expected outcome of a situation. It is possible that the repeated presentation of negative feedback in O'Neil's stress condition provided HA Ss with enough information about the task and their performance on it to allow them to reduce the uncertainty regarding their performance. This could have happened in either of two ways. Either these Ss detected that the feedback was consistently negative, when they knew they were performing satisfactorily, or in the face of continued failure, they lowered their expectancy level. In either case they would have been utilizing information extant in the feedback to resolve uncertainty about their performance on the task.

Spielberger, O'Neil, and Hansen (1970) report finding a negative relationship between performance and level of A-State on a difficult task involving the solution of complex number problems. High A-State Ss made more errors than low A-State Ss when feedback was informative and non-threatening. High A-State Ss, however, demonstrated a decrement in average number of errors per problem over three sections of a difficult task, while low A-State Ss remained at about the same level of performance across all three sections, a level superior to that of the high A-State Ss. This effect could indicate that high A-State Ss are more susceptible to the effects of informative feedback than are low A-State Ss.

If the speculation made above regarding Cattell's formulation of anxiety being a function of doubt about an expected outcome is correct, then A-State should show a greater decrease during a learning task under conditions of high information feedback than under conditions of reduced or non-existent feedback. The following study represents an attempt to resolve this question and to further clarify the relationships among the variables of A-State, feedback information, specific abilities, and performance on a CAI task under conditions of program control and learner control.

Differential Abilities in CAI Research

The ATI studies cited above (Bunderson, 1969; Dunham, 1969; Blaine and Dunham, 1969) clearly demonstrated that ability requirements in a learning situation can be manipulated by manipulation of task variables.

In view of these general findings it seems reasonable to assume that manipulating feedback information content in a learning task would result in differential demands on the particular abilities required by the task. General reasoning ability (R) has been found to be the factor most strongly related to good performance on the Xenograde task, while associative memory (Ma) has shown a relationship to performance that is highly dependent on the use of certain instructional treatments. The Bunderson and Hansen (1972) study indicated that a discovery treatment where limited feedback was provided led to good performance for Ss of high R ability but not for Ss of high Ma ability. It was inferred from the data that R and Ma may interact in such a way that high memory ability is of little value in the task unless one also possesses sufficiently high reasoning ability to permit the effective use of remembered information in solving problems. One aspect of this study was the further exploration of this idea.

Effects of Learner Control on A-State and Performance

Another goal of the proposed study will be to determine whether allowing the learner to control the flow of informative feedback and the amount of practice he receives will result in either improved performance or reduced A-State. This will be done by allowing Ss to have feedback only upon request and allowing them to terminate instruction on a given rule when they want to. This could affect A-State and learning in either of the two following ways.

(1) Allowing the S some measure of control over the learning situation could reduce at least some of the perceived situational threat. As was pointed out in the beginning of this proposal, Freud viewed anxiety as the response of the ego to stimulation it cannot control (Freud, 1936),

the major defining characteristic of anxiety being that of a fear response elicited by a perceived threat to the ego. In the learner control situation the S has some measure of control over the source of the perceived threat. If he perceives the feedback he is receiving as threatening he can turn it off. If having some control over the presentation of examples and feedback does result in reducing anxiety then the reduced anxiety should lead to fewer competing response tendencies, thereby contributing to improved performance.

(2) On the other hand, if control *per se* lacks anxiety reducing qualities, then one might expect Ss under learner control to request greater amounts of feedback information in an effort to reduce D, the component of doubt (Cattell, 1966), thereby reducing task ambiguity. The reduction in D should then lead to a lowering of A-State. Therefore, regardless of which of these two alternative theoretical approaches one chooses, there is some bias for expecting learner control to result in reduced anxiety and, to the extent that high anxiety states are debilitating in such a task as the one proposed, improved performance.

A-State Hypotheses

The following hypotheses regarding A-State were tested in this study.

(1) A-State will show a significant increase from the period immediately preceding the experimental task to the beginning of the task period, regardless of treatment condition. This is expected on the basis of O'Neil's finding the A-State increased significantly from the pre-task period, regardless of level of A-Trait score in the pre-task period. In the event that this hypothesis is not supported by the data the remainder

of the study will not necessarily be affected, since the primary focus is on changes in A-State after the task begins and does not really depend on the effectiveness of the stress instructions.

(2.a.) If Ss are not presented with feedback they will tend to maintain a constant level of A-State throughout the task period. This will be indicated by a regression line for the regression of A-State measured at the end of the task period on A-State measured at the beginning of the task period immediately following the stress instructions, having a relatively low intercept point and a relatively steep regression slope. The low intercept value will indicate a small overall increase in A-State from the time of the first post-stress measurement to the time of the last, while the steep slope will indicate a high relationship between an individual's A-State score on the first measurement and the same individual's score on the final measurement. This hypothesis is based on the assumption that the absence of feedback will contribute to maintaining a high level of doubt (D) about the expected outcome for a subject. This high level of D is then expected to prevent A-State from declining significantly during the task (Cattell, 1966).

(2.b.) Those Ss who receive feedback after every response will show greater decreases in A-State during the task period than will a group of Ss who receive no feedback.

(2.c.) Subjects who are given control over the amount of feedback and the number of examples they receive will show even greater reductions in A-State from the beginning of the task period to the end than will those who receive feedback after every response. This hypothesis is based on the assumption that, in addition to the anxiety reducing effects of feedback, the measure of control that these Ss have over the CAI medium will serve to reduce some of the situational threat, thereby reducing anxiety further.

These two hypotheses will be evaluated with a three group analysis of covariance conducted by means of linear models. A-State scores taken immediately prior to the task, but following stress instructions, will be used as the covariable, and A-State measures taken immediately following the task will be the dependent variable. The proposed analysis is based on a procedure described by Jennings (1972) and is developed in detail in Appendix C. Briefly, it is based on the argument that if the regression slopes for the regression of post-task A-State on pre-task A-State are homogeneous for the three groups, then the amount of change indicated by the difference between an S's expected posttest score for a given pretest score and his pretest score does not necessarily depend on the value of his pretest score, but does depend on his group membership. If the slopes of the three regression lines can be accepted as being parallel and if their intercepts are not equal, then the amount of change in A-State must be different for each of the three groups.

(3) Subjects who show high levels of A-State at the beginning of the task, and who are in the no-feedback condition, will tend to show higher levels of A-State throughout the task than Ss who also show high levels of A-State at the beginning of the task but are in the feedback condition. On the other hand, high initial A-State Ss in the feedback condition are expected to show a decrease in A-State over the task period. These two effects when taken in combination will produce a significant interaction. This expectation is based on the assumption that high A-State

Ss will be susceptible to and will therefore respond to the D reducing effects of information feedback. Such a finding would be consistent with and would help to explain the results found by Spielberger, O'Neil, and Hansen (1970) referred to above.

Expected Performance Predictions

The following predictions are offered with respect to performance on the experimental task. These are referred to here as predictions, because in some cases they lack the necessary theoretical base to warrant their being called "hypotheses."

(1) It is anticipated that for Ss who receive no feedback there will be a negative relationship between number of errors made during the task and the posttest score. For the feedback groups there will be no relationship between errors and posttest scores. This will occur because the feedback groups will be better able to learn from their errors than will the no feedback group (Hansen, 1969).

(2) When feedback is presented following each response, Ss in the higher range of the A-State distribution, averaged over the task, will make fewer errors and will obtain higher posttest scores than will Ss from the lower range. This result is expected because it is assumed that feedback will reduce the tendencies of competition among mediating responses by providing Ss with a basis for confirmation or rejection of hypotheses generated in attempting to answer the test items in the task. The reduction of competing response tendencies will result in better performance for this group when compared with the no feedback group.

(3) When no feedback is available following responses, lower A-State Ss will make fewer errors than high A-State Ss and will obtain

higher posttest scores. Confirmation of this prediction and the immediately preceding one will provide support for Campeau's (1968) findings.

(4) In the learner control condition there will be no difference in error rate between Ss whose average A-State score is above the overall mean and those Ss whose average A-State score is below the mean. This will occur because low A-State Ss will show a lower error rate generally, due to less interfering doubt, while the error rate of the higher A-State Ss will be depressed by two factors: the use of feedback information to resolve doubt and the removal of at least some of the situational threat, due to their having a degree of control over the situation.

The ability by treatment interaction predictions that follow are offered as purely exploratory in an effort to examine systematically the interaction of the task variables of feedback and the learner control in CAI with the organismic variables of A-State, reasoning ability, and associative memory ability. To the best of this writer's knowledge these variables have not been investigated in combination in any previous studies. Therefore any findings that derive from this study should provide some empirical basis for further research in this area, research that could well be of major importance to instructional designers and other educational technologists seeking to optimize the relationships between individual learner characteristics and methods of instruction.

ATI - A-State Predictions

(1) It is predicted that under ego involving instruction, Ss who show higher levels of A-State will show a stronger relationship between general reasoning ability (R) and posttest performance than will Ss who exhibit lower levels of A-State. That is, the amount of change in posttest

performance per unit of change in R score will be greater for high A-State than for low A-State Ss. This result is expected because the relationship between A-State and learning is assumed to be such that in this task high A-State will be debilitative, thus requiring greater reasoning ability for good performance.

(2) It is expected that the demand for both reasoning ability and memory ability (Ma) will be greater for Ss in the no feedback condition than for Ss in either of the feedback conditions. That is, the amount of increase in posttest score per unit of increase in each of the ability scores, Ma and R, will be greater for the no feedback group than for either of the other groups. This result is expected because for the no feedback group the task will be more difficult and there will be a greater load on memory since the rule inferred from each example will have to be kept in memory throughout the entire set of problems relating to it.

(3) It is anticipated that Ss who possess both high reasoning and high memory ability will make fewer errors and obtain higher posttest scores than those who are high on either of these two abilities alone.

CHAPTER IV

METHOD

Subjects

The subjects for this study were drawn from the Educational Psychology subject pool at The University of Texas at Austin. A total of 122 Ss participated in the ability testing phase, 24 of which were male. Significant sex differences have been shown to exist in a number of anxiety studies as has been pointed out by O'Neil (1970), with male data showing less stability across studies than female data. Since the sample was comprised of approximately 80 percent females and 20 percent males it was not feasible to use sex as an independent variable; therefore males were excluded from the data analysis, but were not excluded from taking the CAI program.

As each S appeared in the teminal room for his appointment, the proctor on duty randomly assigned that S to one of three treatment groups. Exclusion of the male data resulted in 38 Ss in the no feedback condition, 31 in the feedback condition and 29 in the learner-controlled feedback condition.

Materials and Apparatus

The learning task was a CAI course on an imaginary science, "The Science of Xenograde Systems" (Merrill, 1964). The particular version of the task used was a modification of an earlier version described in detail elsewhere (Merrill, 1970; Bunderson and Hansen, 1972). This version consists of eight rules that form a learning heirarchy based on an information processing task analysis (Merrill, 1970). The rules specify a set of relationships between a nucleus and a satellite in a closed oscillating system. The nucleus and satellite are composed of tiny particles called "alphons". The satellite moves back and forth between its original orbit and the nucleus. When it reaches the nucleus a collision may occur and an exchange of alphons may take place between the satellite and the nucleus. The rules specify when and under what conditions such exchanges will take place, what the alphon count of the satellite and the nucleus will be and what the distance of the satellite will be from the nucleus at any given moment of time. By using the rules an S should be able to make predictions regarding the location of a satellite, its alphon count, and when the next collision will occur.

The task was presented by means of the IBM 1500 computer system in the CAI Laboratory at the University of Texas. The system has eight terminals of the cathode ray tube (CRT) type (IBM 1512) for the computer controlled presentation of 16 mm transparencies. The terminals are housed in individual carrels constructed to provide isolation and work space for each student and are located in a special room of the CAI Laboratory.

Experimental Design

A three group design with three repeated measures on A-State was employed. The dependent variables of interest were A-State, percent errors on the CAI task and posttest. This design is shown in Table 1. Two ability covariables, general reasoning (R) and associative memory (Ma), were also used in the investigation of ability by treatment interactions.

Procedure

In a separate session prior to the administration of the learning task, each S was given a battery of five tests. These tests were administered in small groups and were scheduled at the convenience of the Ss. The

TABLE 1

Three Group Repeated Measures Design

	Group									
	No Feedback (NF)			Feedback (FB)			Learner Control (LC)			
A-State Measures	A1	A2	A3	A1	A2	A3	A1	A2	A3	
	N = 38			N = 31			N = 29			N = 98

test battery included the following tests: The Trait scale of the State-Trait Anxiety Inventory (Spielberger, Gorsuch, & Lushene, 1970); The Ship Destination Test; Object Number Test; First and Last Names Test (French, Ekstrom, & Price, 1963); and the Bi-Column Number Series Test (Merrill, 1970). The Trait scale of the STAI consists of twenty items designed to test individual anxiety proneness or susceptibility to stress. This scale has a reported KR-20 reliability of .89. The use of the A-Trait scale in this study was exploratory, with no specific hypotheses being based on it. It was hoped, however, that it would provide correlational data that would be of interest in examining the relationship between A-Trait and A-State. The Ship Destination Test is a measure of general reasoning ability (R). This test has been shown to be the best predictor of performance on the Xenograde task in four previous studies (Bunderson, 1969; Merrill, 1970; Bunderson & Hansen, 1972). The Object-Number Test and the First and Last Names Test are both measures of associative memory (Ma), which is defined as the ability to remember bits of unrelated material (French, et al., 1963). The Bi-Column Number Series Test was developed specifically for use with the Xenograde task as a task relevant process measure. This test has been found to load highly on the R factor also.

Following the administration of the test battery each S was required to call the proctor on duty in the terminal room of the CAI Laboratory to make an appointment to take the Xenograde course. Upon arriving at the terminal room at the scheduled time, each S was assigned randomly to one of the three experimental conditions, no feedback (NF), feedback (FB), or learner control (LC). After being seated at a terminal, S was given a paper and pencil version of the twenty-item STAI A-State scale

(Spielberger, Gorsuch, & Lushene, 1970) and was instructed to complete the form. Following completion of the A-State scale each S was given an instruction booklet appropriate to that S's treatment condition. Each booklet contained a brief description of Xenograde systems, including a fictitious account of their discovery. The booklets also contained specific instructions for each of the three conditions. An example of an instruction booklet for each group can be found in Appendix A. After reading the instruction booklet each S was signed on the terminal by the proctor, and then received a short sequence of instruction via the CRT terminal on the use of that terminal. Following this sequence of instruction the stress instructions stated below were presented on the CRT screen for each S.

Stress Instructions

> The course you are about to take is designed to test your ability to infer and apply logical rules from complex data displays. Performance on this task has been shown to be highly correlated with intelligence. A record of your performance will be maintained by the computer as you proceed through the program so that you can be compared with other college students who have taken this course. It is important that you do your best in order for valid comparisons to be made, so work carefully and try hard.

Task Presentation

Immediately following the stress instructions each S was presented with the first of a series of displays on the CRT screen of tables of values each of which illustrates a Xenograde system at a particular increment in time. Each such display is an exemplar of one of eight conjunctive rules which together constitute the rules of the system. All Ss were instructed to study each example carefully and to try to discover in it a rule which would explain the relationships illustrated by it. When an S was satisfied that she had discovered the rule she typed the letter "c" which caused the computer to present three questions, one at a time, requiring application of the rule. The questions were of the completion type and required the S to type in a numerical value for a distance, a time or an alphon count. All responses were entered through the typewriter keyboard and were automatically evaluated by the computer program. Three examplars, each with its corresponding three test items, were presented for each of the eight rules for Ss in the NF and FB conditions. In the LC condition Ss were allowed to control the number of examples received. The rules were presented in the same order for all Ss, an order that has been determined to be optimal based on an information processing task analysis (Merrill, 1971).

State Anxiety

The A-State scale of the STAI was administered to each S in a paper and pencil form immediately before the presentation of the task. Three short five-item versions of the A-State scale were presented on-line. The first of these followed the ego-involving instructions but immediately preceded the first example display on the CRT. The second short A-State scale was presented immediately following the last test item for the fourth rule. The third of these measures was given immediately following the last test item for the eighth rule. In this manner a record of the changes in A-State over the task period was obtained for each S.

Feedback Conditions

In the NF condition each S was presented with the next question following each response. No information was provided to Ss in this group regarding their performance or the accuracy of their hypotheses about what the rules were. In the FB condition Ss were presented with the words "right" or "wrong" following each response. In addition to this these Ss were presented with a printed statement of the appropriate rule on the image projector following their responses to the ninth test item for each rule. The right-wrong feedback presumably enabled the Ss to adjust their hypotheses. Presentation of the rule allowed Ss final confirmation of their hypotheses prior to moving to the next rule. The two conditions, feedback and no-feedback, then, represented high and low points on an information gradient. The NF condition provided very little information whereas the FB condition provided a much greater amount of information.

Learner Control

In this condition Ss were allowed control over the number of examples they received and over the presentation of feedback following each test item response. Presentation of the task was similar to that in the FB condition with the following exceptions: (1) following each test item S was required to type the letter "y" to receive right-wrong feedback or "n" to receive no feedback; (2) following the third test item for each example the S was, in addition, allowed to request the rule. The question "do you want to see the rule, Y or N?" appeared on the CRT screen. Typing "y" caused the rule to be presented on the image projector simultaneously with the words "Look at filmstrip" on the CRT. If the S elected to see the rule the presentation of examples for that rule was terminated and the next display was an example of the next rule in the sequence. If the S typed "n" the next example of the same rule was presented followed by its corresponding test items, until all three examples and their test items had been presented. If the S failed to request the rule following the third test item for the third example she was presented with the first example of the next rule without being shown the rule.

Immediately following the responses to the third test item of the third example for any rule, all Ss, regardless of treatment condition, were shown the statement "This was the last example for this rule." This message was intended to aid each S in recognizing that the next example would pertain to a new rule. In the learner control group it also served as a signal that it was the last chance to request a statement of the rule before moving to the next rule in the hierarchy.

Immediately following the CAI task a 64-item paper and pencil posttest was administered to each S while she was still seated at the terminal. The items in the posttest were comprised of partial Xenograde tables. The S's task was that of completing each table correctly by making inferences from the information already provided in the partially complete table. Sample posttest items can be found in Appendix B.

CHAPTER V

RESULTS

Descriptive Statistics

Figures 1.a. - 1.d. show the distributions of each of the four ability tests for all Ss, excluding males. Obvious ceiling effects occurred on the two memory tests, as can be seen from the histogram data. Figure 1.e. is a histogram of the posttest scores for the 98 female Ss who completed the experiment.

A varimax rotation factor analysis of scores on the four ability tests was conducted by using the computer program "Factor" (Veldman, 1970). This analysis yielded the two factors, R and Ma. The factor matrix for this analysis can be found in Table 2. Factor scores expressed in score equivalents were used in all analyses involving the two abilities. A comprehensive correlation matrix of all variables on which measures were taken can be found in Table 3.

Hypotheses

The first A-State hypothesis predicted a significant increase in A-State scores from the pre-task period to the beginning of the task period, following the administration of the stress instructions, regardless of treatment condition. The mean A-State score for the pre-stress period was 9.91, whole post-stress mean A-State was measured at 11.20. A trials-by-subjects analysis of variance with two trials (pre- and post-stress) revealed a significant increase in A-State scores; $F(1/97) = 27.99$, $p < .01$, indicating that the stress instructions were probably effective in increasing anxiety for these female Ss.

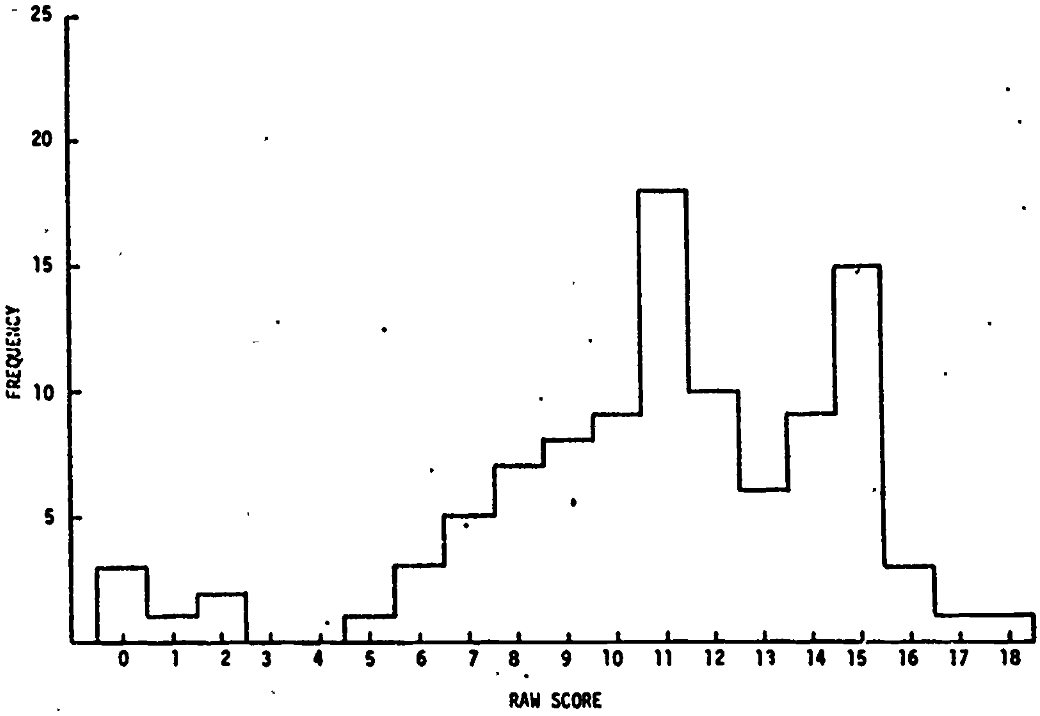

Figure 1a.--Bi-Column Number Series Test (R).

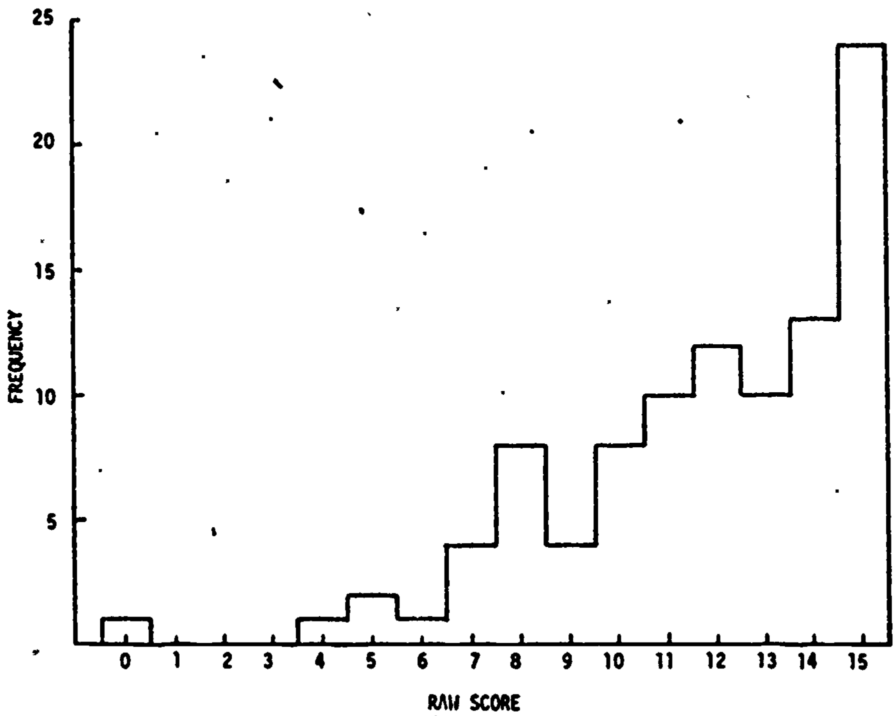

Figure 1b.--First and Last Names Test (Ma).

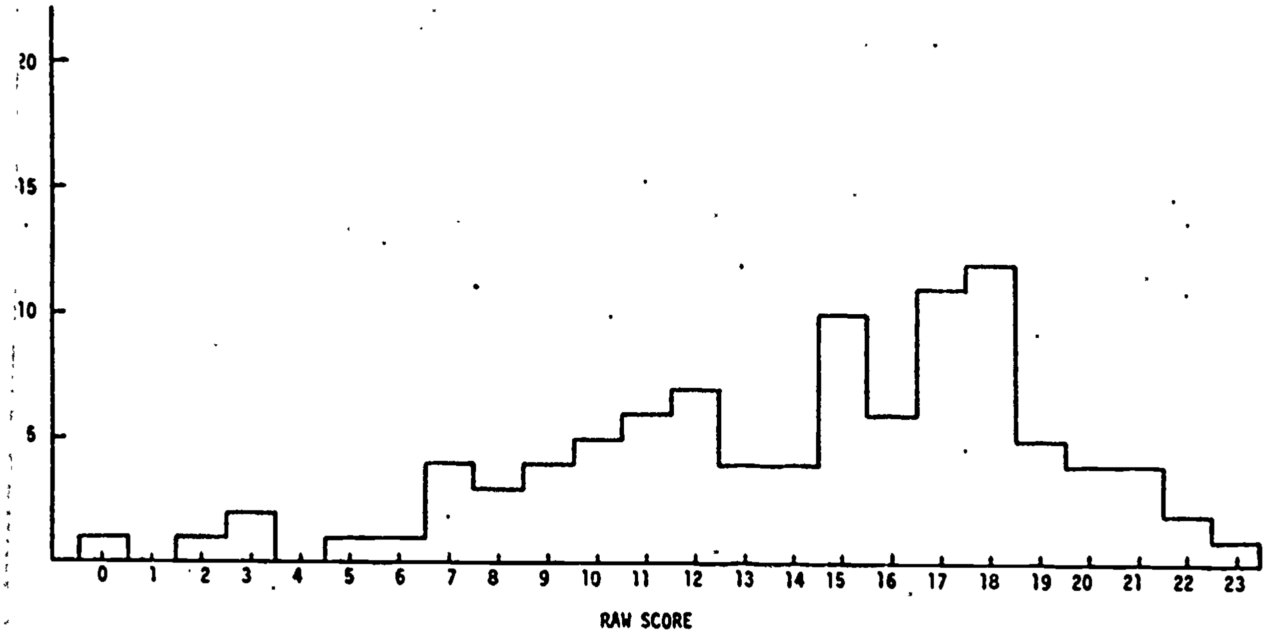

Figure 1c.--Ship Destinations Test (R).

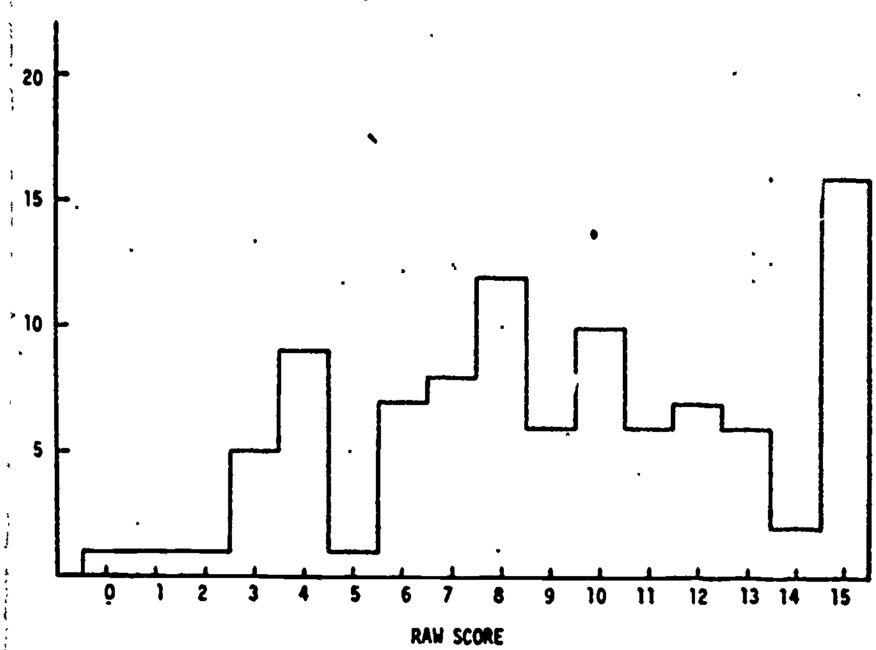

Figure 1d.--Object-Number Test (Ma).

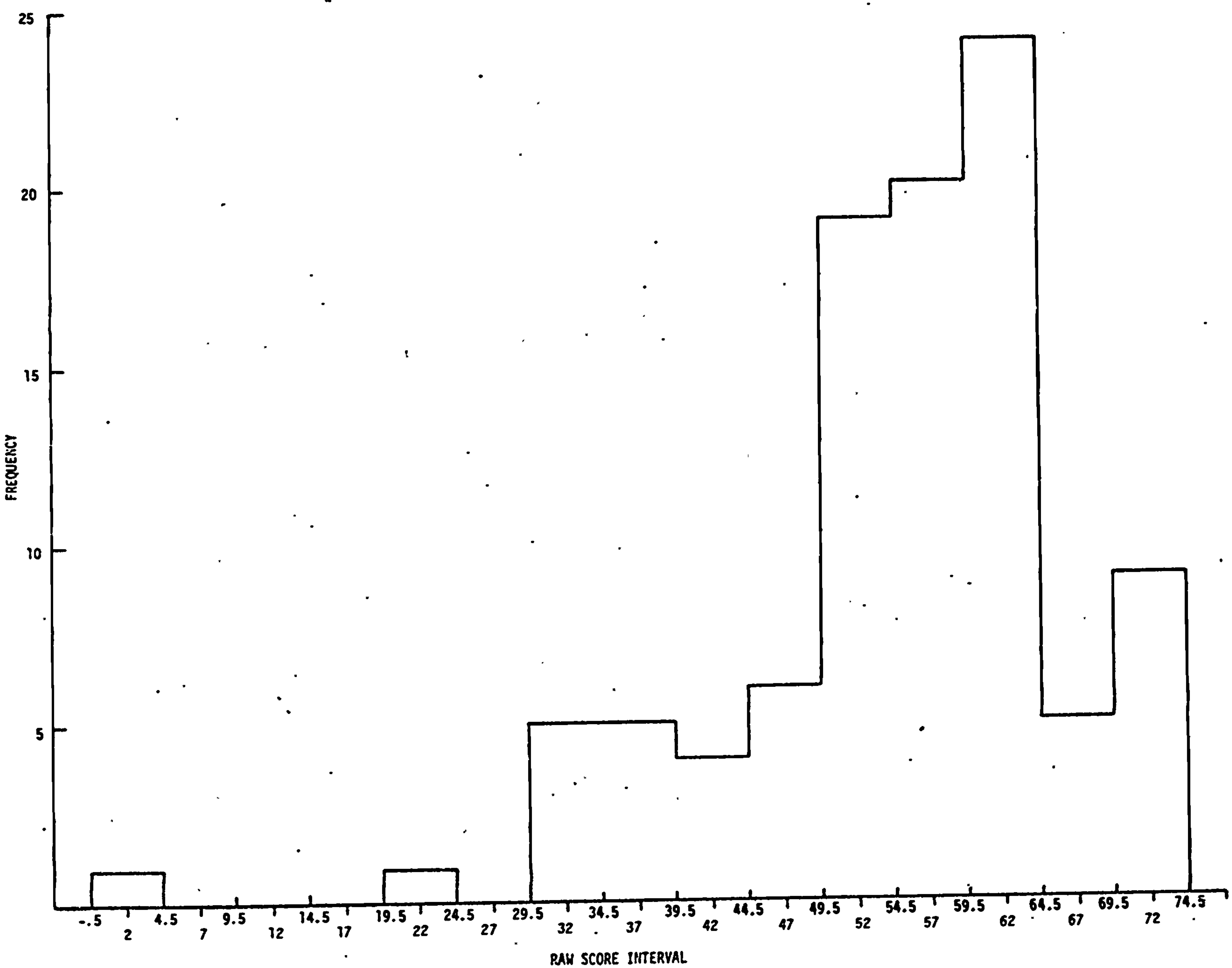

Figure 1e.--Posttest.

TABLE 2

Varimax Factor Loadings of Ability Test Scores

Test	Factor Loading	
	R	Ma
Bi-Column No. Series	.8525	.0901
First and Last Names	-.0089	.8428
Ship Destinations	.8659	.0107
Object-Number	.1076	.8222

TABLE 3

Intercorrelation Matrix of all Variables Measured, n = 98

Variable Name	1	2	3	4	5	6	7	8	9	10	11
1. Bi-Column No. Series	1.000	.190	.526	.175	.333	.165	-.070	-.067	-.201	-.207	-.372
2. First and Last Names		1.000	-.127	.441	.208	.052	-.085	-.089	-.077	.058	.011
3. Ship Destination			1.000	.169	.405	.166	.014	-.080	-.190	-.298	-.351
4. Object Number				1.000	.138	-.099	-.071	-.087	-.177	-.086	-.039
5. Posttest					1.000	.292	-.021	-.059	-.221	-.252	-.452
6. Trait Anxiety						1.000	.197	.175	.184	.141	-.019
7. State Anxiety 1							1.000	.533	.443	.274	-.038
8. State Anxiety 2								1.000	.548	.368	.051
9. State Anxiety 3									1.000	.707	.305
10. State Anxiety 4										1.000	.400
11. Mean % Errors											1.000

A-State hypothesis 2.a. predicted that there would be little, if any, change in A-State over the task period for Ss in the no-feedback condition. To test this hypothesis a linear model was constructed in which A-State scores taken immediately following the task were used as the dependent variable (A3) and a vector containing A-State scores taken immediately following the stress instructions but preceding any example displays from the task was used as a predictor (A1). This model served as a "full" or starting model, whose error sum of squares could be used as a basis for making comparisons against error sums of squares of various restricted models. Appendix C contains examples of linear models of each type used in this study.

A restricted model was then constructed in which the slope of the regression line for the regression of A1 on A2 was zero, indicating no relationship between the A1 and A3 measures for any S. The resulting test statistic indicated that the two A-State measures were somewhat related; $F(1/36) = 3.09$, $p < .09$.

This F value was not sufficiently high to provide conclusive evidence for the hypothesis, but did seem to indicate a tendency in the predicted direction, therefore further analyses were conducted to explore this tendency. A second restricted model was constructed in which the slope of the regression line was set at unity and the y axis intercept was allowed to vary. When the error sum of squares for this model was compared against the error sum of squares for the original model the results were significant; $F(1/36) = 4.46$, $p < .05$. These data are still inconclusive, indicating that although the relationship between the posttest and pretask anxiety scores is less than unity it cannot be said definitively that there is no relationship between these measures. However, inspection of the graph produced by plotting the predicted values of the full model reveals that some relationship does exist between the two measures, with a slope coefficient of .45, indicating that persons who differ by 1 unit on the first measure differ by less than 1/2 unit on the final measure. This graph can be seen in Figure 2.a.

Hypothesis 2.b. predicted that feedback would result in greater decreases in A-State than would no feedback. Hypothesis 2.c. further predicted that Ss in the LC group would show even greater reductions in A-State than either of the other two groups. These two hypotheses were evaluated concurrently by means of an analysis of covariance using linear models. The specific models and procedure are explained in Appendix C.

An F test for homogeneity of the three regression slopes for the regression of final A-State scores on pre-task A-State scores for the three groups failed to attain significance. A subsequent F test using the equal slopes model as a full model against which to test the restriction that the intercepts of the three regression lines were equal produced a significant F value, $F(2/94) = 3.73$, $p < .05$. The regression lines for these data are shown in Figure 2.b.

On the basis of this analysis it was concluded that FB and LC resulted in greater A-State reductions than did NF.

In an effort to investigate these findings more thoroughly, the group means and standard deviations for each of the three A-State measures were computed and F tests for simple effects were conducted. These data are shown in Tables 4.a. and 4.b. The group means are plotted in Figure 3.

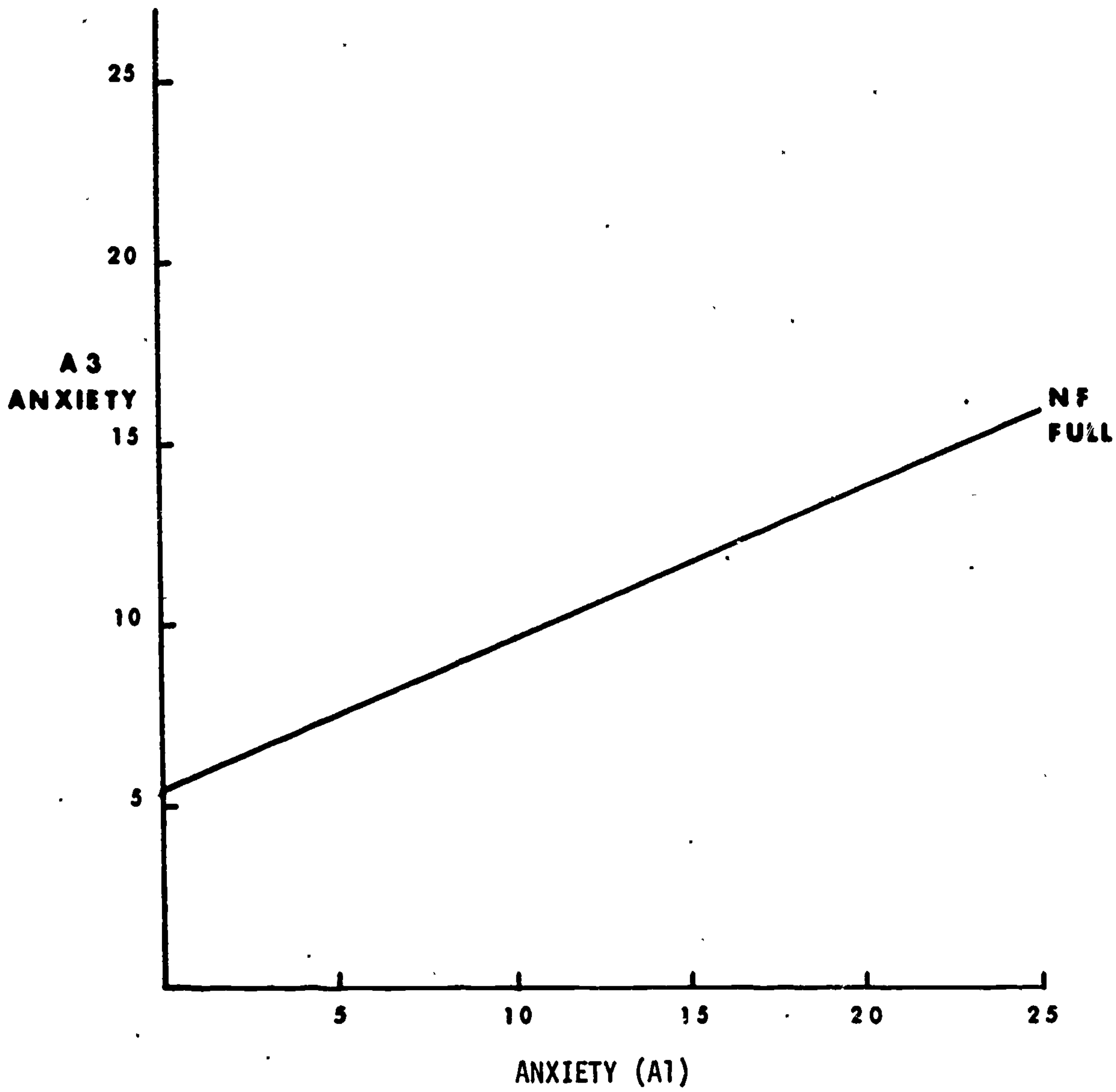

Figure 2.a.--Regression of Time 3 A-State Scores on Time 1 A-State Scores for No Feedback Condition.

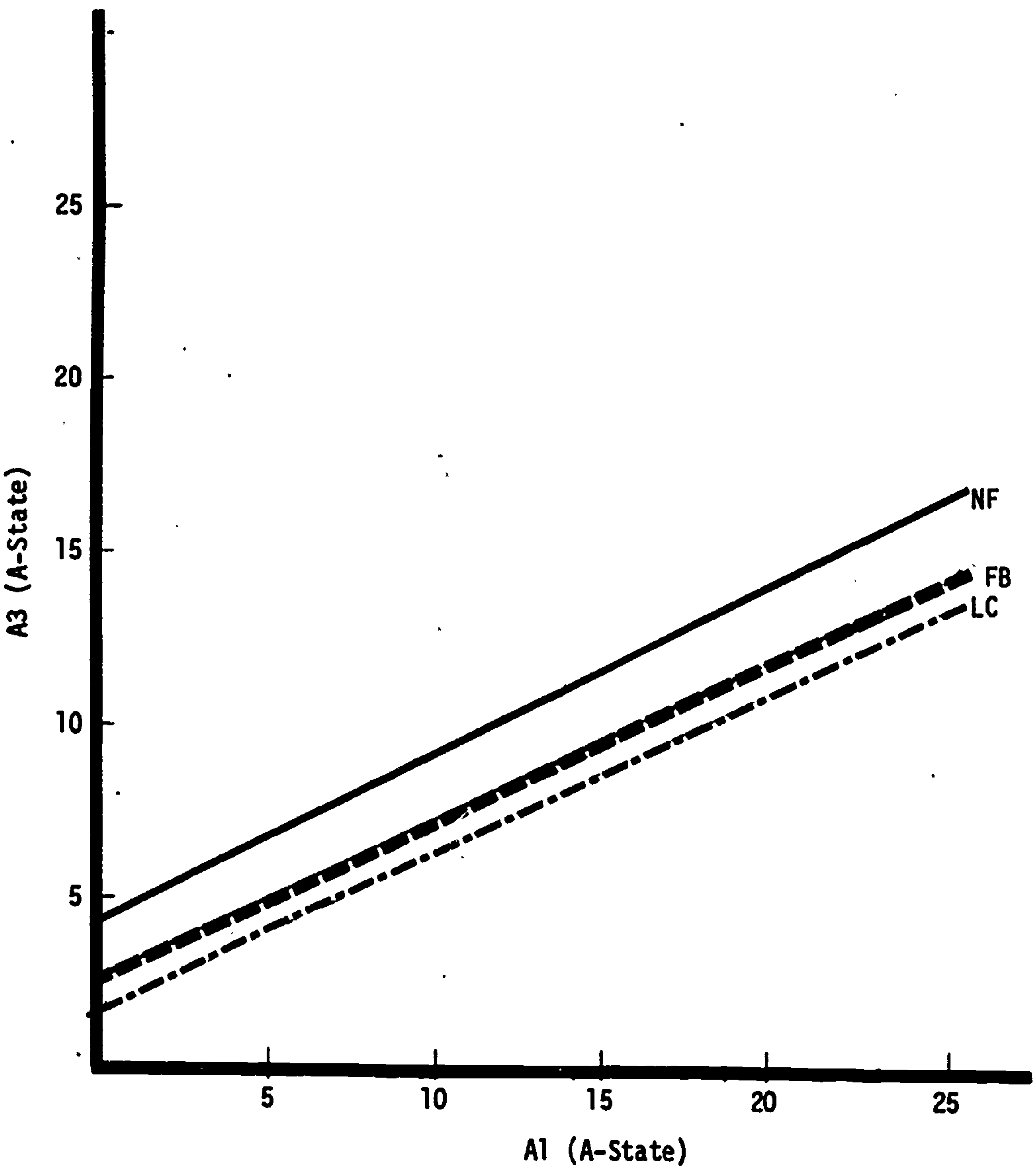

Figure 2.b. Regression of final A-State on pre-task A-State for NF, FB and LC groups.

TABLE 4.a.

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 4.b.

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

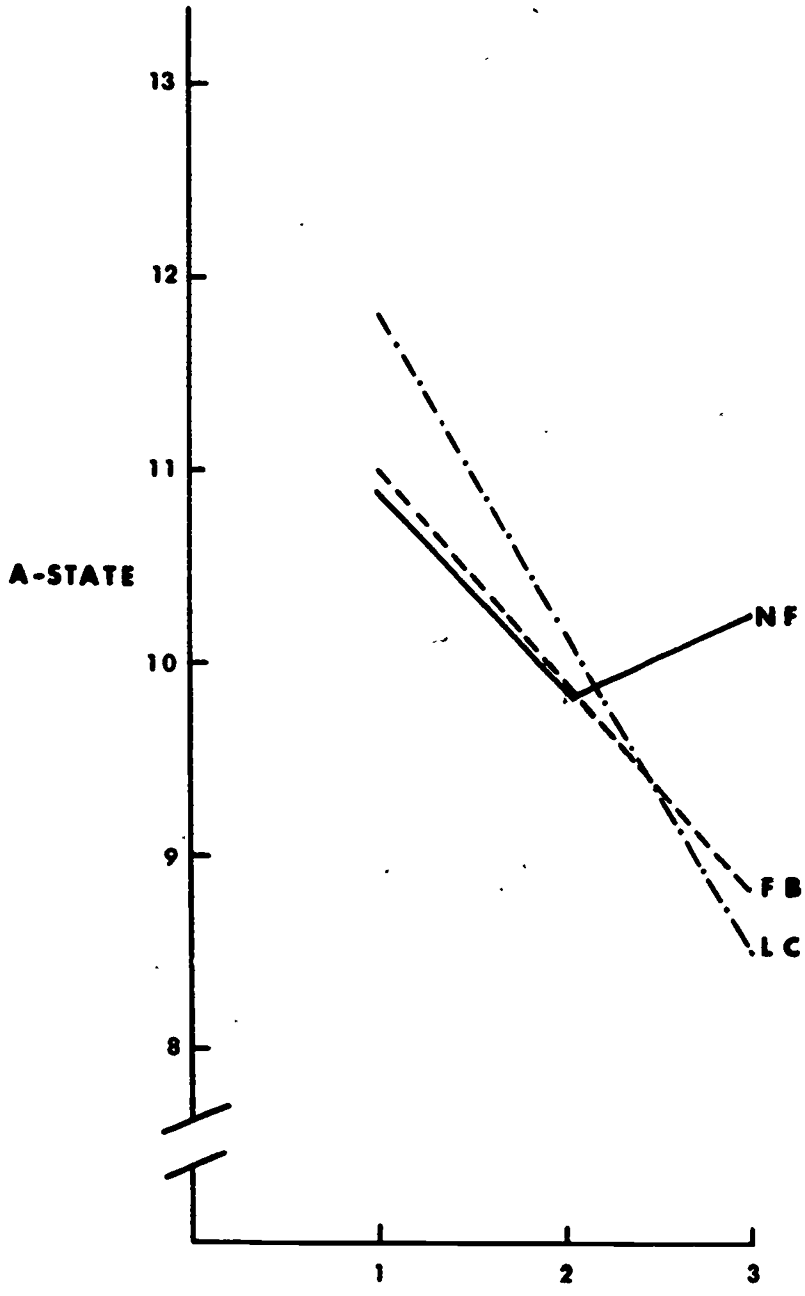

Figure 3.--Mean A-State Scores by Group.

As can be observed from Table 4.b., significant reductions in A-State occurred under both the FB and LC conditions, but not under the NF condition, as was predicted by hypotheses 2.a., 2.b., and 2.c.

Hypothesis 3 predicted that for Ss who revealed high initial A-States (following stress), those in the NF condition would tend to remain high throughout the task, whereas those in the FB condition would tend to show a decrease in A-State, thereby demonstrating the doubt (D) reducing effects of information feedback. In order to evaluate this hypothesis, a median split was performed on the two groups, using A-State scores immediately following the stress instructions. A groups-by-trials analysis of variance, using only Ss whose scores were above the median, was then conducted on the two groups over three trials. Table 5 reveals the groups-by-trials (GxT), two-group, three-trial design employed in this analysis, with mean A-State scores and n shown for each group.

This analysis produced the predicted interactions; $F(2/64) = 4.01$, $p < .05$, indicating that information feedback does reduce state anxiety for high A-State Ss.

Performance Predictions

It was anticipated in performance prediction 1 that the condition NF would produce a significantly stronger negative relationship between posttest and mean number of errors per problem than would the FB condition. This was expected because Hansen (1969) had found that information feedback reduced the negative relationship between errors on a CAI task and gain scores. As can be observed from Figure 4, the linear regression analysis produced results opposite to the expected findings. The correlation between posttest and mean percent errors for the NF group was $r = -.445$, $p < .01$, while the correlation between these variables for the FB group was $r = -.744$, $p < .01$. The regression slope coefficients were $b_1 = -.62$, and $b_2 = -1.1$, respectively. An F test for parallel slopes approached significance; $F(1/65) = 3.01$, $p < .09$, but did not reveal a significant interaction effect.

Performance prediction 2 predicted that higher A-State Ss, under the FB condition, would perform better, i.e., produce lower error rates and higher posttest scores than lower A-State Ss. For Ss in the NF condition opposite results were predicted as stated in performance prediction 3. For purposes of analysis these two statements were combined and two analyses of covariance were computed using linear models. In the first covariance

TABLE 5

A-State Means for

NF and FB High A-State Ss Only

	A-State (Trials)		
	A1 Post Stress	A2 Mid Point	A3 Post Task
No Feedback	$\overline{X} = 9.00$ n = 19	$\overline{X} = 8.32$ n = 19	$\overline{X} = 9.58$ n = 19
Feedback	$\overline{X} = 8.80$ n = 15	$\overline{X} = 8.20$ n = 15	$\overline{X} = 6.73$ n = 15

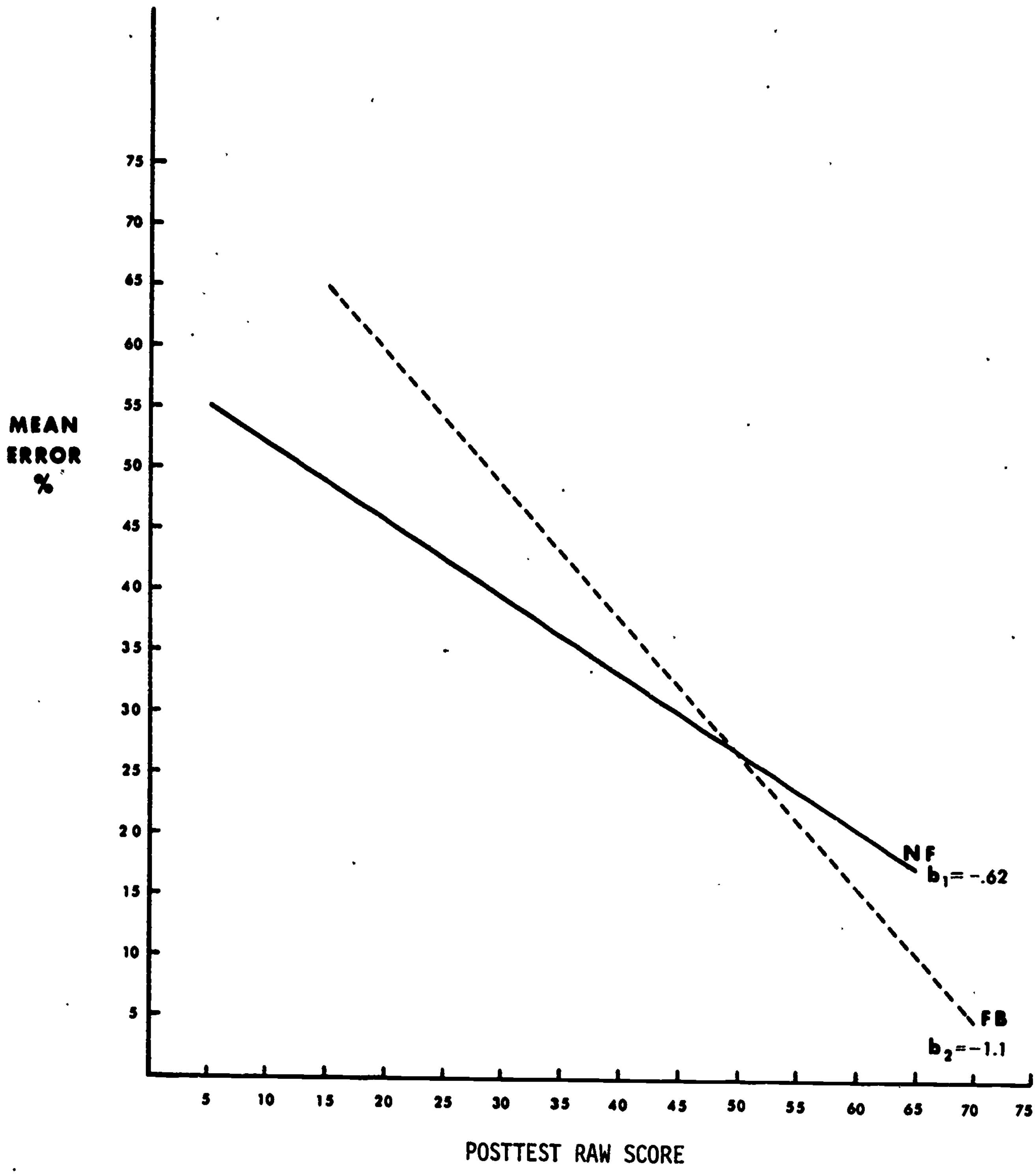

Figure 4.--Regression of Mean Percent Error on Posttest Score for No Feedback and Feedback Groups.

NF $r = -.445$, $p. < .005$
FB $r = -.744$, $p. < .0001$

analysis, the dependent variable was mean percent errors while in the second, posttest score was the dependent variable. Both analyses employed mean A-State scores on A2, A3, and A4 combined as the covariable. Although no significant results were obtained in either of these analyses the first analysis produced an anxiety-by-treatment interaction that approached significance and was of sufficient psychological interest to warrant being reported.

Figure 5 shows the results of this analysis. Table 6 reveals the F-values and significance levels obtained in the analysis. F_1 was the test to determine whether the regression slopes of the NF and FB groups were parallel. F_2 was the test for equal intercepts. F_3 imposed both of the previous restrictions simultaneously in a test for collinearity.

Inspection of Figure 5 reveals that the regression slope for the NF group conformed very well to the predicted outcome, but that the obtained regression line for the FB group was in the opposite direction to that which was predicted. That is, the prediction called for a negatively sloped regression line, indicating an inverse relationship between A-State level and error percentage as shown by the broken line in Figure 5; whereas the obtained regression line had a highly positive slope, indicating a positive relationship.

Performance prediction 4 predicted that the error rate for high average A-State Ss in the LC condition would not differ from the error rate for low average A-State Ss in the same group. A one way, two group analysis of variance was conducted to compare the mean error percentages of the high and low A-State groups under the LC condition. The results were of such magnitude as to provide rather convincing support for the

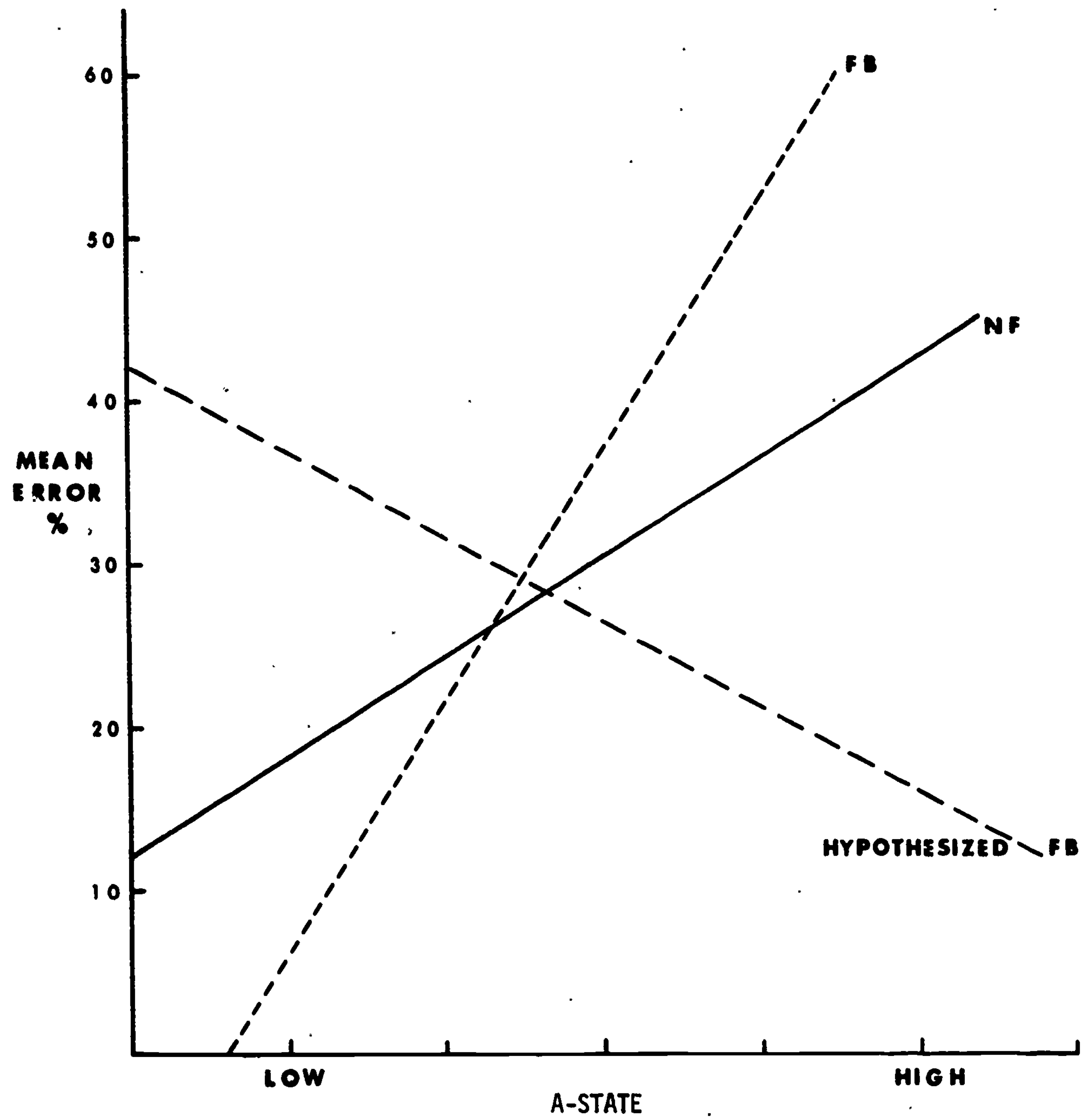

Figure 5.--Regression of Error Rate on Mean A-State for NF and FB Groups.

TABLE 6

F Values for Regression of Error Rate

on Mean A-State - FB vs. NF

Analysis Results			Restriction
$F_1 = 2.72$	$p = .10$	d.f. = 1/65	Parallel Slopes
$F_2 = 3.48$	$p = .07$	d.f. = 1/65	Equal Intercepts
$F_3 = 1.89$	$p = .16$	d.f. = 2/65	Collinearity

no-difference prediction; $F(1/27) = .005$, $p = .94$. The mean error percentages were .276 for high A-State and .279 for low A-State. It would be very difficult to attribute a difference of less than .003 to anything but chance variation, given the sample size.

Ability-Treatment Interactions

Figure 6 shows the regression of posttest scores on reasoning for high and low mean A-State groups. The prediction stated that the relationship between general reasoning (R) and posttest scores as indicated by the slope of the regression line for the regression of posttest on R would be greater, i.e., produce a steeper slope, for the high A-State Ss than for the low A-State Ss. Although the observed differences were in the predicted direction, these differences also failed to attain a satisfactory level of statistical significance; $F(1/94) = 2.02$, $p = .16$.

In order to test the prediction that for each unit of change in each of the ability scores the amount of change in posttest scores would be greater for the NF condition than for either of the other conditions as stated in ATI prediction 2, a two covariable analysis of covariance was conducted using program COVAR 2.[1] In this analysis, the two ability scores were covaried simultaneously, while posttest served as the dependent variable. This analysis began with a full model in which: (1) the slopes and intercepts of the regression line for each of the groups were allowed to vary on each covariable; (2) a covariable by covariable interaction term was included for each group; and (3) a term was included for the square of each covariable over all groups to allow for non-linearity.

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

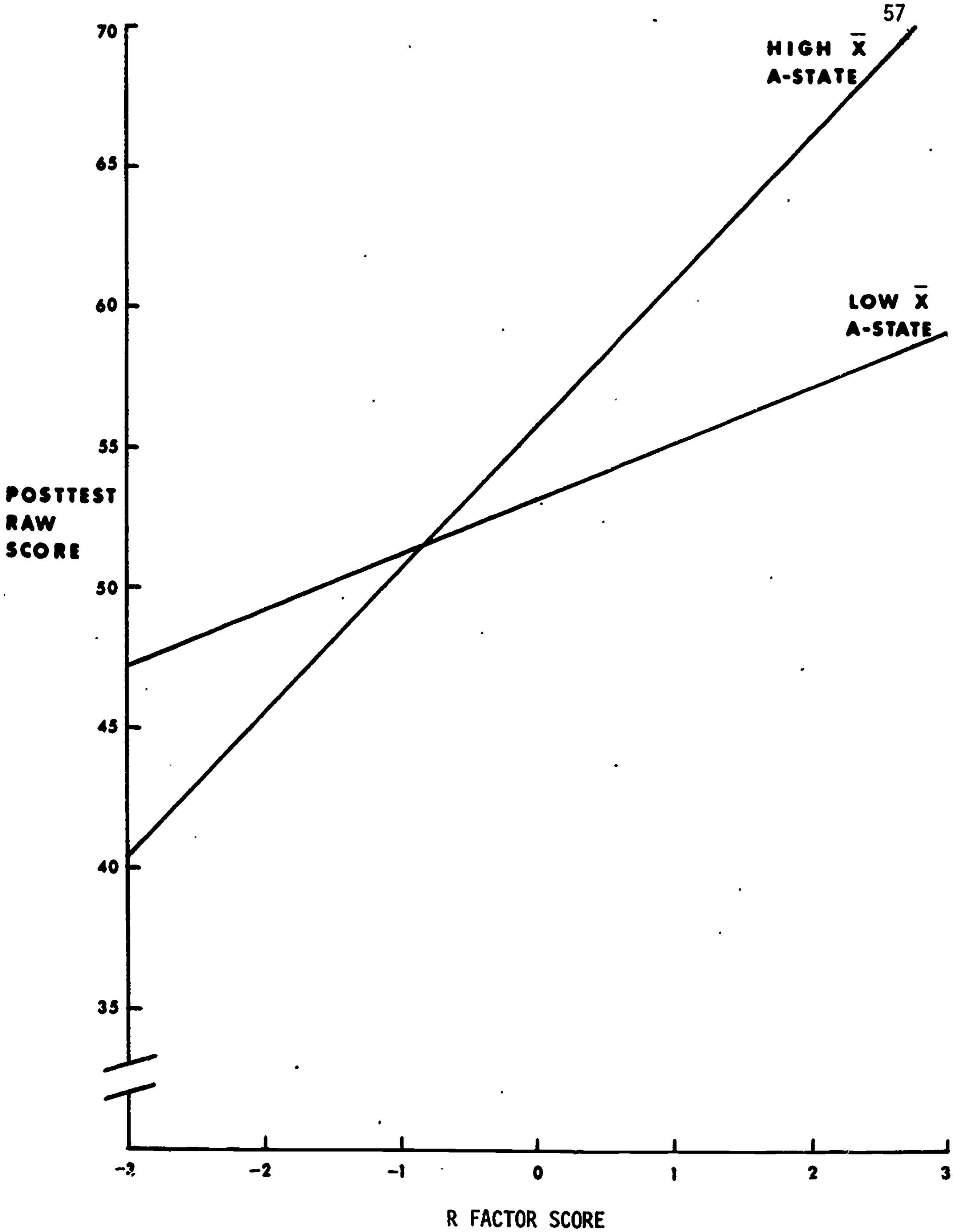

Figure 6.--Regression of Posttest Scores on R Factor Scores for High and Low Mean A-State Groups.

The result for a three group analysis was a starting model containing fourteen parameters.

This model was then used as a full model against which the first restricted model (R_1) was tested. Model R_1 contained all of the same parameters as the full model except that it assumed linearity. If the F ratio resulting from the comparison of the error sum of squares of R_1 against the starting model were not statistically significant then R_1 would have become the full model for testing the subsequent restriction that there was no interaction between covariables. This process could be repeated with subsequent restrictions until a significant F ratio was produced or until seven restricted models had been tried.

The analysis revealed no interaction between covariables. It also failed to produce the predicted interaction between the treatments and the two covariables combined. A significant interaction was obtained, however, between the treatment conditions and R factor scores. This interaction; $F(2/91) = 3.15$, $p < .05$, is illustrated in Figure 7. Although statistically significant results were obtained, the regression slopes were virtually opposite to the direction predicted. It was predicted that the amount of increase in posttest score per unit of increase on each of the ability factors would be greater for the NF than for the FB or LC group, thus producing stronger positive regression slopes for NF than for either of the other two groups. The slope of the lines for the NF condition, however, are nearly horizontal while the FB condition produced strong positive slopes, with LC slopes falling in between.

Although the double covariance analysis failed to produce the predicted results, it did reveal an interesting ATI. It was therefore

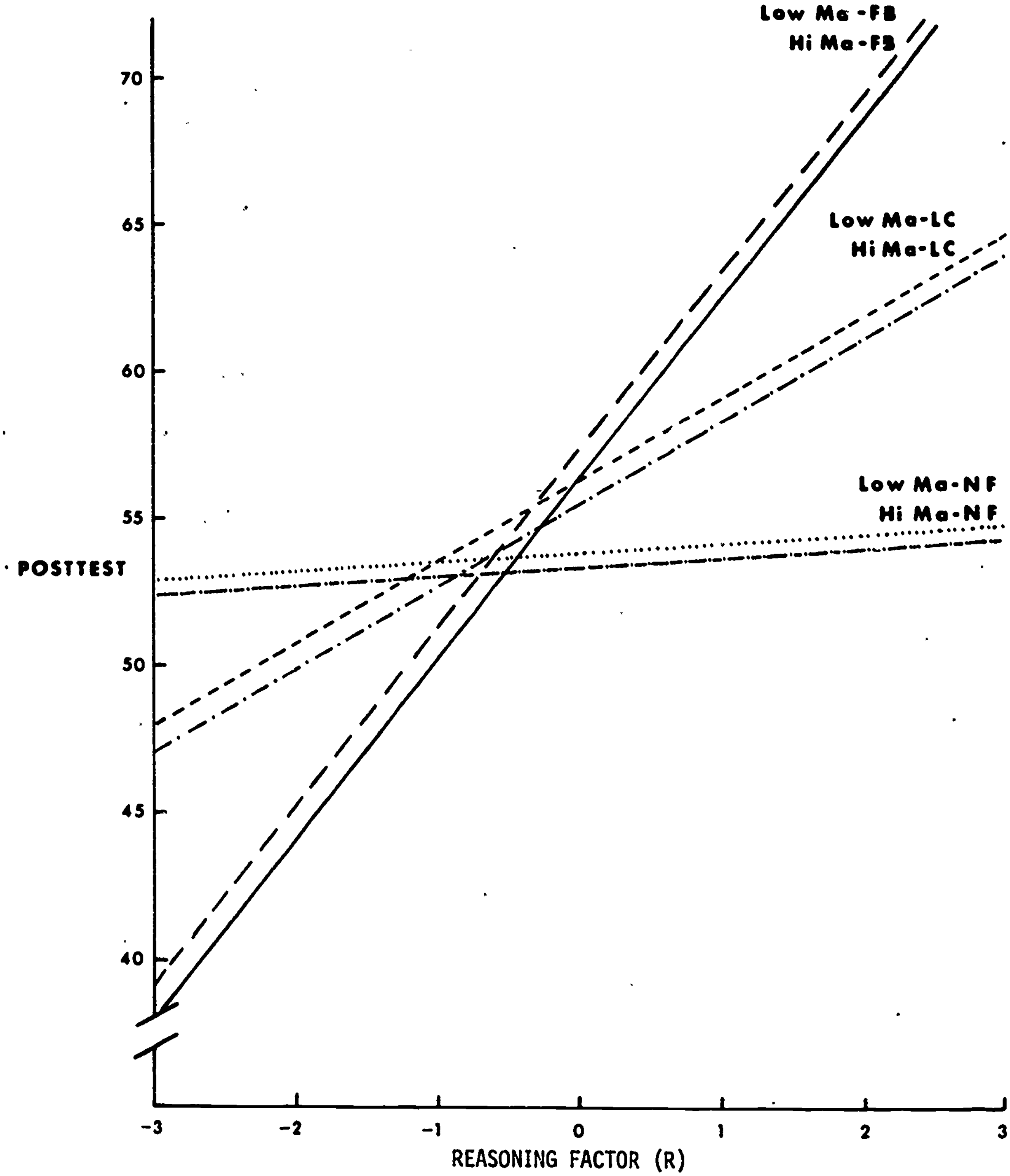

Figure 7.--Double Covariance Analysis with Posttest as Dependent Measure and Memory (Ma) and Reasoning (R) Factor Scores as Covariables.

decided to conduct further analyses on these data. Linear models were constructed to test the interaction of reasoning with the treatment conditions, using posttest score as the dependent variable. This is essentially the same analysis as described above with the exception that only one covariable, reasoning (R), was used here. This analysis yielded a significant disordinal ATI; $F(2/92) = 3.15$, $p < .05$, as would be expected on the basis of the two covariable analysis results. Since percent errors were known to be negatively correlated with posttest performance, a similar analysis was conducted using mean percent errors as the dependent variable. This analysis also revealed a significant disordinal ATI; $F(2/92) = 7.27$, $p < .01$. The results of these two analyses are shown in Figures 8 and 9, respectively. As can be observed from these figures, the FB condition produced the strongest relationship between reasoning ability and performance with NF and LC showing weaker relationships. Figure 8, as would be expected, is essentially the same as Figure 7, except for the omission of the memory covariable. One interesting aspect of these data is that the LC condition more closely approximates the NF than the FB when errors are the dependent measure as shown in Figure 9. Reasoning ability seems to be of greater benefit to Ss under the FB condition than for either of the other conditions.

The results obtained from the LC group provided still another unanticipated but perhaps important finding. In both the NF and FB conditions the number of examples presented per rule was fixed at three, resulting in a total number of examples of 24 for Ss in each of these two groups. In the LC condition, however, Ss were afforded some measure of control over the number of examples they received. This was done by means of the "rule" option. If an S responded in the affirmative to the question

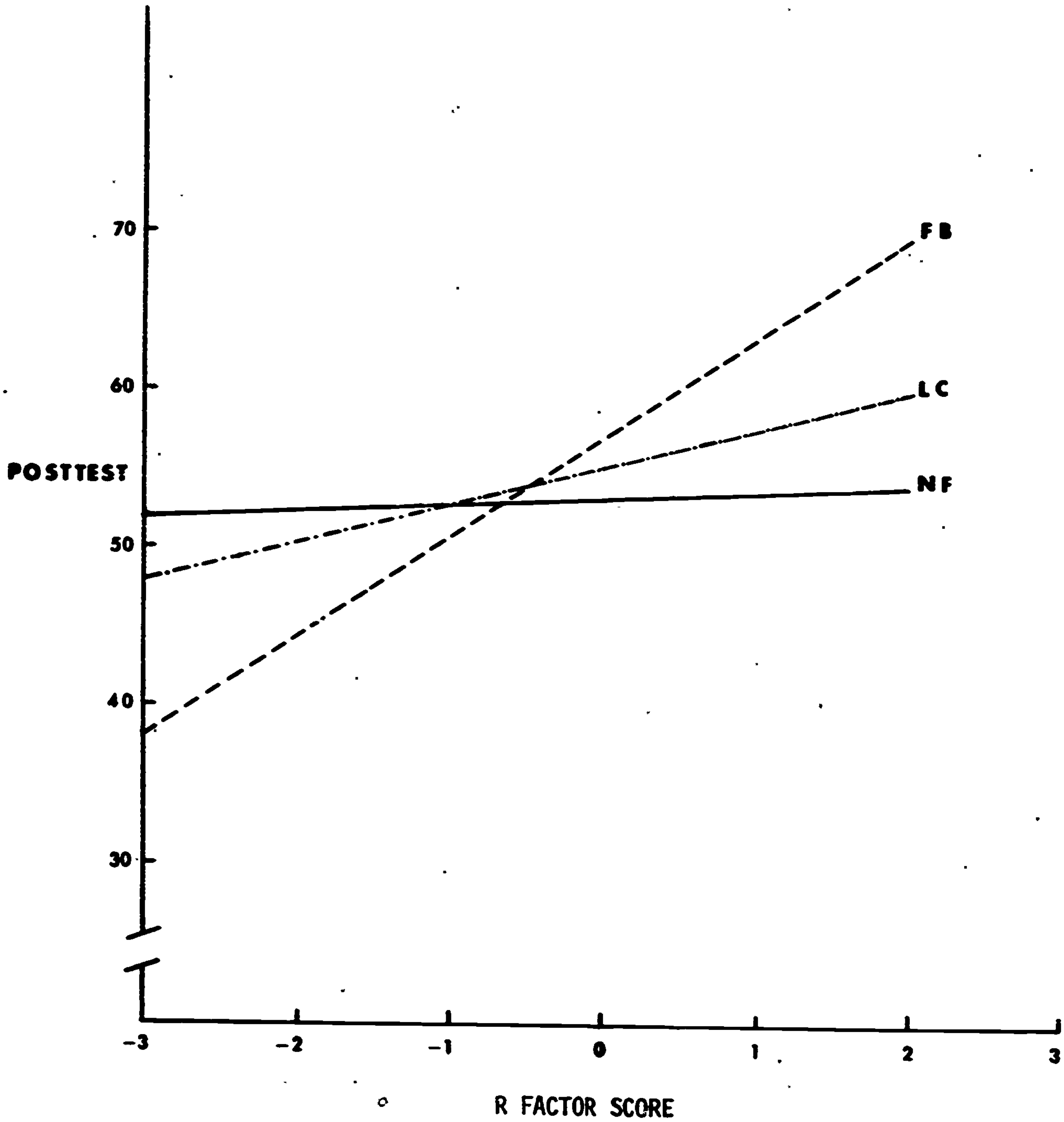

Figure 8.--Regression of Posttest on R Factor Scores by Group.

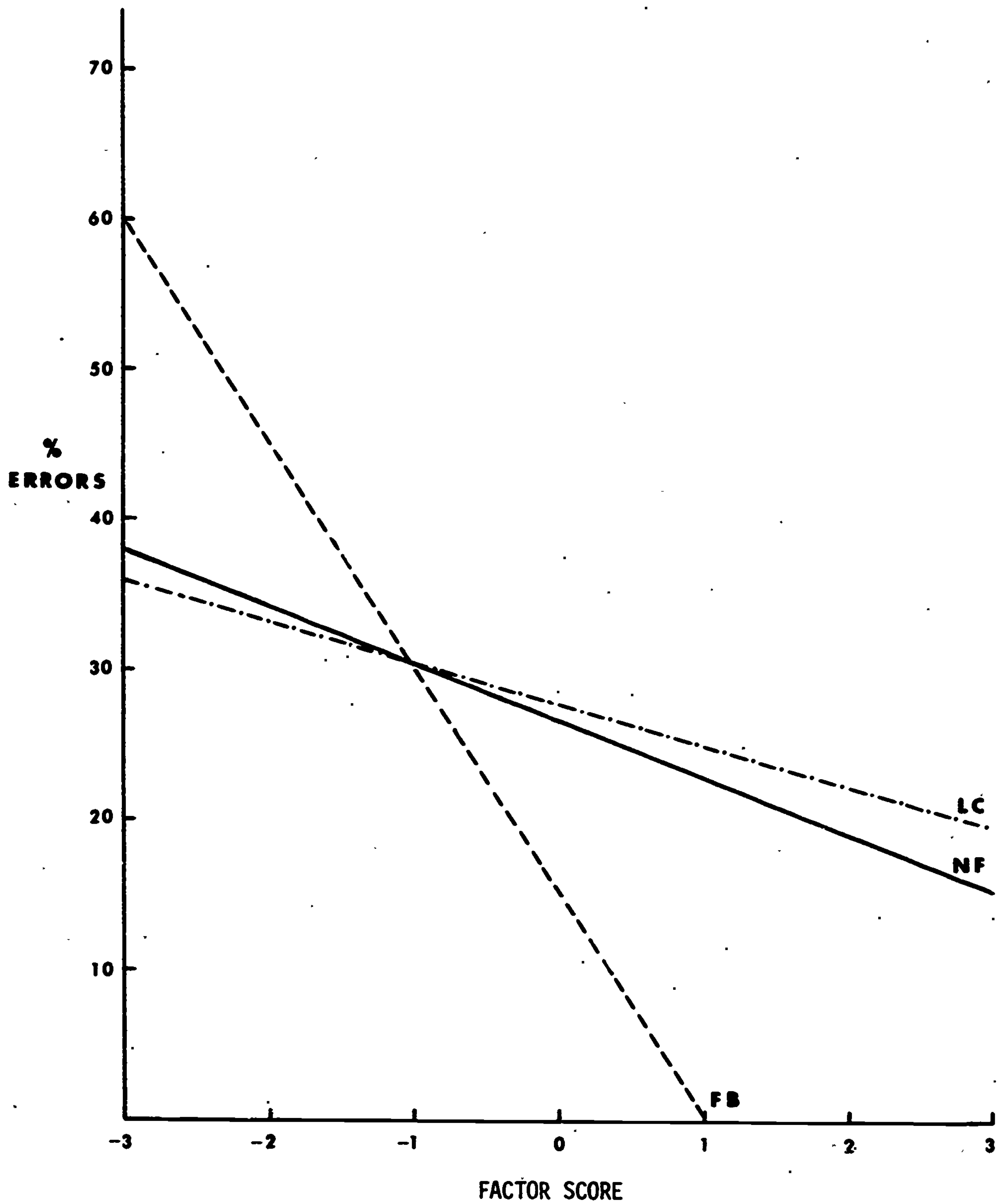

Figure 9.--Regression of Error Rate on R Factor by Group.

"Do you want to see a statement of the rule?", the S was shown the rule and branched to the first example of the subsequent rule without being presented any further examples on the same rule. This meant that Ss could shorten the number of examples received and hence the length of time spent on the CAI task by taking the rule option sooner than following the third example. The mean number of examples for the LC group was 10.6, whereas the means for the FB and NF group were both 24.

Three one way analyses of variance were conducted to determine whether there were any significant differences between groups on each of the two dependent variables of task performance, mean error rate and posttest score. No significant differences were obtained between groups, indicating that a single superior treatment was not established on the basis of these two variables. However, when it is noted that Ss in the LC group completed the task in fewer examples, with no appreciable loss of performance, the LC group seems to emerge as the best single treatment if individual abilities are not taken into account.

CHAPTER VI

DISCUSSION

Hypotheses

Hypotheses 2.a., 2.b., and 2.c. taken together represent an attempt to answer two basic questions: Can feedback information be used to reduce anxiety states in learning tasks? and Does the amount of control a learner has over feedback and subsequent example presentation effect a further reduction in A-State? The results seem to indicate that the answer to each question is at least a qualified yes. Some of the anxiety reduction probably occurred as a result of adaptation to the CAI medium and the task. That is, as Ss became more familiar with the CAI medium and with the nature of the task, anxiety that may have resulted from their apprehension concerning a novel situation abated somewhat. However, the crossing of the FB and LC groups over the NF group, as seen in Figure 3, suggests that the treatments probably did have some effect. In any event, the ordinal relationships among the groups conformed to predictions at the end of the task.

An obvious question arises as to whether allowing the student to control the feedback situation contributes to anxiety reduction more than does providing feedback. This question can be illuminated somewhat by noting the fact that 14 of the 29 Ss in the LC group completed the course with the minimum number of examples possible (8). For the remaining 15 Ss there were a total of only 45 instances where an S took more than the minimum of one example on a single rule, the maximum number of examples possible, being 3 x 8 or 24, for each of the 15 Ss. It should be noted that the feedback and learner control variables are somewhat confounded in the LC treatment. The results of lower A-State levels for both FB and LC would seem to be more parsimoniously explained by the effect of feedback than control. On the other hand, the effect of learner control as a means of controlling aversive stimuli affords an alternative but not competitive rationale. Perhaps allowing high A-State students some degree of control over the presentation of material that could be perceived as aversive or anxiety inducing can have a beneficial effect in terms of reduced anxiety. Further research is obviously necessary in order to clarify the questions raised here.

Some support for Cattell's (1966) hypothesis concerning the reduction of doubt can be seen in the results of the analysis for A-State hypothesis 3, as shown in Table 5. High A-State Ss showed significant reductions in A-State under FB but not under NF. As discussed in Chapter III, O'Neil (1970) found high A-Trait college girls to decrease in A-State under conditions of receiving negative feedback statements during a CAI task, while low A-Trait college girls showed no significant decrease in A-State. O'Neil attributed this difference to superior coping behaviors acquired by the high A-Trait girls due to their having faced more situations that were anxiety inducing (for them) than the low A-Trait girls had. However, it was suggested by this author that the reduction in A-State for the HA girls was due to the information load carried by the negative feedback having a greater doubt reducing effect on the HA than on the LA girls.

The effect of feedback in reducing anxiety seems to be demonstrated by the data shown in Figure 3. It was shown by the results of the analysis for A-State hypothesis 3 as illustrated in Table 5 that High A-State

Ss are susceptible to the anxiety reducing effects of information feedback. These results provide support for the contention that informative feedback reduces anxiety for high A-State Ss. It may therefore be more plausible to attribute O'Neil's (1970) findings to the effects of information that his Ss could have inferred from the negative feedback, than to differences in coping behaviors.

Performance Predictions

The data analysis on performance prediction 1 failed to provide support for Hansen's (1969) finding that information feedback reduced the relationship between errors and gain scores. It was found instead that information feedback did not reduce the magnitude of the negative relationship between committed errors and posttest performance, but on the contrary, seemed to increase that relationship when Ss' A-State level was not considered. This failure may be due to the use of posttest scores as the criterion measure rather than gain scores. The posttest distribution as shown in Figure 1.e. shows a rather strong negative skewness ($S = -2.80$, $p = .005$), indicating some ceiling effect. This points to a recurring problem in CAI-based research. The problem, briefly stated, is that if CAI is effective as an instructional method, such ceiling effects must be expected to occur, thereby creating difficulties in selecting meaningful dependent variables that will permit discrimination among treatment groups based on performance.

It had been predicted that under the FB condition, higher A-State would result in better performance than lower A-State; whereas, under NF, the opposite would occur. It may be recalled by the reader that 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 the high A-State group showed a decrease in average number of errors per problem over three parts of the CAI course. These findings were supported by the present study. As can be observed in Figure 5, high A-State was more debilitating under the FB than under the NF condition.

These results also 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 interference hypothesis" of the Drive Theory. Spence and Spence (1966), as discussed in Chapter II, 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 further that increased information 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.

Sieber and Kameya (1967) have suggested a general paradigm for the study of the effects of anxiety on cognitive processes. In this paradigm, one or more mediating process variables and performance measures that are affected by anxiety are determined. An initial anxiety level is ascertained and then, following the administration of an experimental treatment, measures are obtained of the degree of change in mediating processes and performance level, by high and low anxious subjects. Such a paradigm offers a means of empirically investigating the speculation offered above regarding the interference of anxiety with the hypothesis formation-evaluation cycle under differential information loadings. It is clear that further research is needed in this area to define more specifically the relationships between affective states and information processing variables.

ATI - A-State

A significant interaction was predicted between R ability and A-State level with posttest as the dependent variable, but such an ATI failed to obtain. This failure may be, in part, attributable to the lack of sensitivity in the posttest score as a dependent measure.

A general positive relationship was observed between R ability and performance in the LC and FB groups. This relationship, however, was stronger for Ss in the FB condition than for the LC condition. On the other hand, Ma ability seemed to have very little effect on learning in this task. It would appear that the interaction illustrated in Figure 8 could be attributed primarily to the absolute amount of information feedback received by Ss in each group. In terms of total amount of feedback information, the LC group received less than the FB group. The steepness of the regression slopes for each group corresponds approximately to the amount of information received in feedback. These results are consistent with the findings of Bunderson and Hansen (1972), who found that an increased information load in the form of past example availability enhanced performance for high R Ss and impaired performance for low R Ss on the Xenograde task.

It seems likely on the basis of these two studies that a minimal level of R ability is necessary in order for Ss to benefit from the increased information available to them, whether presented as feedback or memory support. This suggests a positive relationship between information processing capacity and R ability. Since R ability is known to be a good predictor of performance on this task, and the task itself has been characterized as an hypothesis formation-evaluation task, a fruitful area for further research might be an investigation of the interaction of hypothesis generation-evaluation with feedback information load.

A question can be raised regarding the choice of instructional paradigms employed in this study as illustrated by the treatment conditions. In each of the three conditions the paradigm was essentially a discovery approach. That is, the S was required to infer the rule from the available data. Merrill (1970) has shown that for the Xenograde task, an instructional paradigm utilizing both rules and objectives is superior to a paradigm utilizing either of these aids and that a pure discovery approach is inferior to the use of rules, objectives, or both. What then, one might ask, is there to be derived from a study such as this in terms of implications for instructional design? The questions this study sought to answer had little to do with discovering which of the three treatments could be considered "best," but were instead concerned with the effects of the specific variables upon one another. It should be noted that even though a discovery condition may not be the most efficacious method of learning, there are many real life learning situations in which discovery learning is the only available approach. Therefore, it seems a worthwhile endeavor to examine learning performance and the effects of anxiety and abilities under such conditions in order to acquire insight into the way things are, rath than the way they ought to be.

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 (I) 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.

Summary

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 dealt 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.

The major objectives of this study were: To determine whether information feedback provided during a difficult task would reduce state anxiety (A-State) and lead to a corresponding performance increment; and to determine whether learner control would lead to further reductions in A-State and an additional performance increment. Another objective was to attempt to bridge cognitive and affective domains by examining the relationships obtained between the task variables of feedback and learner control, anxiety, and cognitive abilities.

The Ss were 98 undergraduate female education majors at The University of Texas at Austin who were randomly assigned to three groups: no feedback (NF), n = 38; feedback (FB), n = 31; and learner control (LC), n = 29. All Ss were given a CAI course on the Science of Xenograde Systems. The course, a modification of earlier versions, 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 NF group, Ss received no feedback following their test item responses. In the 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 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. All Ss were required to take the State Anxiety Inventory (SAI) first, after which they received appropriate instructions on terminal operations, followed by ego-involving stress instructions. Then a five-item version of the SAI was presented on-line, followed immediately by the first example test item sequence. This same five-item scale was repeated mid-point and at the end of the task. Thus, each S's anxiety level was tracked throughout the task. Prior to the CAI task, all Ss had received a battery of four cognitive ability tests and the Trait

Anxiety Inventory (TAI). The ability tests included one marker each on general reasoning (R) and induction (I) and two associative memory (Ma) tests. A Varimax factor analysis reduced these data to two factors, R and Ma.

A groups-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 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. For the learner control group, there was no difference between high and low A-State Ss on percent of errors.

The regression of error rate on mean A-State scores produced an interaction between FB and NF that approached significance, suggesting that feedback may have been more beneficial to high A-State than low A-State Ss. Significant ATI's were obtained for the regression of error rate on R, and for the regression of posttest scores on R. The regression slopes for the FB group were much steeper than for either of the other groups, indicating facilitating effects of feedback for high R ability, with NF or LC being preferred for low R ability. The general findings indicate that high R Ss are better able to utilize FB than low R Ss. Furthermore, High A-State seems to interfere with utilization of FB. Since feedback provides the S with more data to process and R ability is an indicator of information-processing skill, anxiety may be thought to interfere with information processing. Contrary to popular belief, FB may not be beneficial to all learners, but its value seems to depend on the amount of anxiety induced by the learning situation and on the ability of the learner. Learner control was found to be equally effective to FB in reducing anxiety while providing the added advantage of allowing Ss to take a shorter route to task completion, without deleteriously affecting performance.

Finally, suggestions were made for further research, employing an "Approach Model" (Dunham, 1969; Costello & Dunham, 1971), which breaks ability factors and task variables down into common process factors.

APPENDIX A

INSTRUCTIONS FOR TAKING C.A.I. COURSE ON XENOGRADE SCIENCE

The instructional program concerns an imaginary science called The Science of Xenograde Systems. A Xenograde System consists of a nucleus with an orbiting satellite. The satellite is composed of small particles called alphons which may also reside in the nucleus. Under certain conditions a satellite may collide with the nucleus. When such a collision occurs, a "blip" is said to have occurred, and the satellite may exchange alphons with the nucleus. The science deals with the laws by which the activity of satellites and alphons may be predicted.

The following diagram is one way of conceptualizing a Xenograde System.

Instructions for Reading the Displays

In taking this course, you will need to be able to read a tabular display on the CRT which records the activity of the particles making up a Xenograde System.

Figure 2 is a sample display.

FF = 2

Time	ACN	Blip Time	Satellite Distance	ACS
0	2		24	3
1	2		18	3
2	2		12	3
3	2		6	3
4	1	4	0	4
5	1		8	4
6	1		16	4

FIGURE 2. Sample display of a Xenograde table.

The symbols stand for the following.

F.F.--Force field--Physically this can be thought of as an area in space, which if entered by an Xenograde System, will exert certain predictable affects on the system. The strength of the force field can be measured and given numerical values. The effect of the force field on the Xenograde System is based on the strength of tl. ·rce field.

TIME--This column serves as a clock which provides a basis for presenting the state of the system at small sequential intervals of time. It is increased by a value of 1 (one) with each reading. Notice that time always starts at time 0 (zero).

ACN--Alphon Count of the Nucleus--As the name suggests, the numerical values in the column under ACN refer to the number of alphons that are located in the nucleus at any given time. For example, in the figure the number of alphons on the nucleus at time 2 is 2 while the number of alphons on the nucleus at time 6 is 1.

Blip Time--In the column under this heading are recorded the value of the time clock when a blip occurs, that is when a satellite collides with the nucleus. In Figure 2 you will notice that such a collision occurred at time 4.

Satellite Distance--The values recorded in the column under this heading refer to the number of units of distance between the satellite and the nuclues. From Figure 2 you will notice that the satellite is 24 units from the nucleus at time 0 while it is only 6 units from the nucleus at time 3.

ACS--Alphon Count of the Satellite--The values recorded in the column under this heading refer to the number of alphons which make up the satellite at any given time. For example, in the figure, the number of alphons in the satellite at time 2 is 3 while there are 4 alphons in the satellite at time 5.

⋮--A series of three dots in any column refer to a series of values that have been skipped. For example, if the time column starts with three dots followed by the number 24, then all the values from time 0 to time 24 have been skipped.

Justifications

Your participation in the study of Xenograde Systems will enable the research staff of this laboratory to study how people learn a science and how they form and test hypotheses.

The interaction with the materials in this study will give you some idea of the potential of computer-assisted instruction in simulation of a science and testing. Later you may want to sample some demonstration programs showing other uses of computer-assisted instruction.

Instructions for Group 1 (No Feedback)

Follow these instructions in taking the course.

1. After the proctor signs you on the terminal you will be instructed in how to use the terminal and given time to practice typing in numbers and correcting errors.

2. When you begin the course an example of a Xenograde table will appear on the Cathode Ray Tube (CRT). Your task will be to study each example as it is presented and try to discover a rule which determines how the values in the tables change.

3. After you have studied the example, type the letter "C" to continue.

4. You will then be given a series of 3 test items one at a time. These items will consist of partial tables with missing values represented by a shaded box. You will be asked to predict the missing by using the rule which you think was illustrated in the example. After typing in your answer and performing the ENTER function, you will automatically be given the next item. After taking the 3 test items, you will be presented with another example followed by 3 more test items. This sequence will be repeated 3 times for each of the 8 rules of the science.

5. Following your initial instructions on how to use the terminal you will be presented with a short 5-item questionnaire with items similar to the questionnaire you just filled out. The questionnaire will require that you type in a number

from 1 to 4, indicating how you feel at that moment. Please respond to every item on the questionnaire. The same questionnaire will be presented twice more during the program, once following the test items for the fourth rule and once following the test items for the eighth rule.

6. After learning all the rules of the science, you will take a posttest. The posttest will assess your ability to predict entries in a table of Xenograde readings line by line given the initial condition. It is important that you refrain from discussing the details of the science and posttest with fellow classmates who have not yet taken the course. Prior knowledge of the details of the course may confound the results causing your time to have been spent in vain.

Please make no notes of any of the instructional material. Paper and pencil are not allowed to be used during any of the instruction at the computer terminal. One goal of this research is to investigate your ability to remember without using notes or any reference materials.

Please Note: If you run into difficulty, it may be helpful for you to refer back to this booklet. Try to relate the numbers in the examples to the diagram and the explanation found on the first page of this booklet.

Instructions for Group 2 (Feedback)

Follow these instructions in taking the course.

1. After the proctor signs you on the terminal you will be instructed in how to use the terminal and given time to practice typing in numbers and correcting errors.

2. When you begin the course an example of a Xenograde table will appear on the Cathode Ray Tube (CRT). Your task will be to study each example as it is presented and try to discover a rule which determines how the values in the tables change.

3. After you have studied the example, type the letter "C" to continue.

4. You will then be given a series of 3 test items one at a time. These test items will consist of partial tables with missing values represented by a shaded box. You will be asked to predict the missing values by using the rule which you think was illustrated in the example. After typing in your answer and performing the ENTER function, you will automatically be told whether your answer was right or wrong.

5. For each rule you will be shown 3 examples, each followed by 3 test items with feedback. After you have answered the third test item of the third example for a rule, you will be presented with a statement of the rule on the image projector to the left of the CRT terminal. You are to look at the rule to see if it is the same rule that you had guessed it to be. Following the presentation of the rule you will be presented with

the first example for the next rule. This sequence will be repeated for each of the 8 rules of the science.

6. Following your initial instructions on how to use the terminal you will be presented with a short 5-item questionnaire with items similar to the questionnaire you just filled out. The questionnaire will require that you type in a number from 1 to 4, indicating how you feel <u>at that moment</u>. Please respond to every item on the questionnaire. The same questionnaire will be presented twice more during the program, once following the test items for the fourth rule and once following the test items for the eighth rule.

7. After learning all the rules of the science, you will take a posttest. The posttest will assess your ability to predict entries in a table of Xenograde readings line by line given the initial conditions. It is important that you refrain from discussing the details of the science and posttest with fellow classmates who have not yet taken the course. Prior knowledge of the details of the course may confound the results causing your time to have been spent in vain.

Please make no notes of any of the instructional material. Paper and pencil are not allowed to be used during any of the instruction at the computer terminal. One goal of this research is to investigate your ability to remember without using notes or reference materials.

<u>Please Note</u>: If you run into difficulty, it may be helpful for you to refer back to this booklet. Try to relate

the numbers in the examples to the diagram and the explanation found on the first page of this booklet.

Instructions for Group 3 (Learner Control)

Follow these instructions in taking the course.

1. After the proctor signs you on the terminal you will be instructed in how to use the terminal and given time to practice typing in numbers and correcting errors.

2. When you begin the course, an example of a Xenograde table will appear on the Cathode Ray Tube (CRT). Your task will be to study each example as it is presented and try to discover a rule which determines how the values in the tables change.

3. After you have studied the example, type the letter "C" to continue.

4. You will then be given a series of 3 test items, one at a time. These test items will consist of partial tables with missing values represented by a shaded box. You will be asked to predict the missing values by using the rule which you think was illustrated in the example. After typing in your answer and performing the ENTER function, you will be automatically presented with the statement "Type y to see if your answer was correct, otherwise n." If you type "y" the computer will tell you whether your answer was right or wrong. If you type "n" you will be given the next test item without being told right or wrong.

5. After the third test item has been answered and you have typed "y" or "n" you will be presented with the following question, "Would you like to see the rule, y or n?" If you

type "y" you will be shown a statement of the rule on the image projector to the left of the CRT terminal. Once you have been shown the rule, you will receive no further examples or questions concerning that rule, but will be presented with the first example of the next rule. If you type "n" you will be presented with another example of the same rule. There are a maximum of three examples, each with three test items for each rule. If you do not ask to see the rule following the test items for the third example, you will automatically be presented with the first example of the next rule. This sequence will be repeated for each of the 8 rules of the science.

6. Following the initial instructions on how to use the terminal you will be presented with a short 5-item questionnaire with items similar to the questionnaire you just filled out. The questionnaire will require that you type in a number from 1 to 4, indicating how you feel <u>at that moment</u>. Please respond to every item on the questionnaire. The same questionnaire will be presented twice more during the program, once following the test items for the fourth rule and once following the test items for the eighth rule.

7. After learning all the rules of the science, you will take a posttest. The posttest will assess your ability to predict entries in a table of Xenograde readings line by line given the initial conditions. It is important that you refrain from discussing the details of the science and posttest with fellow classmates who have not yet taken the course.

Prior knowledge of the details of the course may confound the results, causing your time to have been spent in vain.

Please make no notes of any of the instructional material. Paper and pencil are not allowed to be used during any of the instruction at the computer terminal. One goal of this research is to investigate your ability to remember without using notes or any reference materials.

Please Note: If you run into difficulty, it may be helpful for you to refer back to this booklet. Try to relate the numbers in the examples to the diagram and the explanation found on the first page of this booklet.

APPENDIX B

XENOGRADE POSTTEST SAMPLE ITEMS

Name: ______________________ (first) (last) Student No. ____________

Jenog Posttest Instructions

The purpose of this test is to determine how well you have learned the rules for predicting entries in Xenograde tables.

Each table in this test contains four blank spaces in the last line of the table. Thus, you are to make four predictions for each table. Write each prediction in the blank space in the appropriate column.

Note that in some tables it may be that you should not make an entry in a column. When such a case occurs, leave the appropriate space blank.

Jenog Posttest

****

Table 1. F.F. = 2

System Time	ACN	Blip Time	Satellite Distance	ACS
0	3		40	2
1	(____)	(____)	(____)	(____)

****

Table 2. F.F. = 1

System Time	ACN	Blip Time	Satellite Distance	ACS
0	.		28	.
1	4		25	3
2	(____)	(____)	(____)	(____)

****

Table 3. F.F.= 3

System Time	ACN	Blip Time	Satellite Distance	ACS
.	.		.	.
.	.		.	.
.	.		.	.
14	0		18	3
15	0		9	3
16	(____)	(____)	(____)	(____)

****

APPENDIX C

EXAMPLES OF LINEAR MODELS USED IN DATA ANALYSIS

Hypotheses 2.b. and 2.c.

Assume that the expression:

$\mathcal{E}(j,q)$ represents the expected post-task A-State score for a person in group j with a pre-task A-State score of q.

Given the above, it is argued that $\varepsilon(j,q) - q$ can be used to represent the change in A-State from pre-task to post-task, for a person in group j with a pre-task score of q.

To test the null hypothesis that the amount of change for one group is the same as the amount of change for the other:

$$[\mathcal{E}(1,q) - q] - [\mathcal{E}(2,q) - q] = 0$$

$$[\mathcal{E}(2,q) - q] - [\mathcal{E}(3,q) - q] = 0$$

$\mathcal{E}(1,q)$ is estimated by $a_1 + b_1q$
$\mathcal{E}(2,q)$ is estimated by $a_2 + b_2q$
$\mathcal{E}(3,q)$ is estimated by $a_3 + b_3q$

Thus: $(a_1 + b_1q-q) - (a_2 + b_2q - q) = 0$
and: $(a_2 + b_2q-q) - (a_3 + b_3q - q) = 0$

The expected value $[\varepsilon(j,q)]$ depends on both group membership and the initial A-State score. If we assume that $b_1 = b_2 = b_3$ then substituting b_1 for b_2 and b_3 results in $(a_1 + b_1q - q) = (a_2 + b_1a - q) = (a_3 + b_1q - q)$ for the null hypothesis, which reduces to $a_1 = a_2 = a_3$.

Model 1 - Full Model

$$Y = a_1A^{(1)} + a_2A^{(2)} + a_3A^{(3)} + b_1X^{(1)} + b_2X^{(2)} + b_3X^{(3)} + E^{(1)}$$

Y = criterion vector or scores on the dependent variable.

a_1, a_2 and a_3 are the least squares regression weights for vectors $A^{(1)}$, $A^{(2)}$, and $A^{(3)}$, respectively.

$A^{(1)}$, $A^{(2)}$, and $A^{(3)}$ are the group membership vectors for groups NF, FB, and LC, respectively. $A^{(1)}$ contains a "1" if the score on Y is for a member of the NF group and a "0" otherwise. $A^{(2)}$ contains a "1" if the Y score is for a member of the FB group and a "0" otherwise. $A^{(3)}$ contains a "1" if the score on Y is for a member of the LC group and a "0" otherwise.

b_1, b_2, and b_3 are the least squares regression weights for vectors $X^{(1)}$, $X^{(2)}$, and $X^{(3)}$, respectively.

$X^{(1)}$, $X^{(2)}$, and $X^{(3)}$ contain as elements the A-State scores at the beginning of the task period, used as predictors, that correspond to the elements in the membership vectors $A^{(1)}$, $A^{(2)}$, and $A^{(3)}$.

Model 2 - First Restricted Model (test for equal regression slopes)

$$Y = a_1A^{(1)} + a_2A^{(2)} + a_3A^{(3)} + b_1 [X^{(1)} + X^{(2)} + X^{(3)}] + E^{(2)}$$

All vectors are defined in the same manner as in the full model. This time, however, the single regression weight b_1 is substituted for b_2 and b_3 to allow testing of the hypothesis that the slopes for the separate regression lines for the NF, FB, and LC groups are equal ($b_1 = b_2 = b_3$).

The error sum of squares obtainedfrom model 2 is tested against the error sum of squares for the full model in the following manner.

$$F_1 = \frac{(ESS_1 - ESS_2)/(6 - 4)}{ESS_1/(N-6)}$$

If a significant F value is obtained then the regression slopes for each of the two groups are assumed to be different ($b_1 \neq b_2 \neq b_3$), and it must be concluded that the amount of change in A-State for an individual depends on <u>both</u> his group membership, and his pre-task score.

If, on the other hand, the F value thus obtained is non-significant, then the null hypothesis that $b_1 = b_2 = b_3$ is accepted and model 2 is used as a model against which model 3 can be tested.

Model 3 - Second Restricted Model (the three regression lines have the same intercept)

$$Y = a_1 [A^{(1)} + A^{(2)} + A^{(3)}] + b_1 [X^{(1)} + X^{(2)} + X^{(3)}] + E^{(3)}$$

All vectors are defined in the same manner as in model 2. This time, however, a_1 is substituted for a_2 and a_3 to allow testing of the hypothesis that the regression lines have the same intercept value ($a_1 = a_2 = a_3$).

$$F_2 = \frac{(ESS_3 - ESS_2)/4 - 2)}{ESS_2/(N-4)}$$

If a significant F value is obtained in this analysis then one can conclude that $b_1 = b_2 = b_3$ but $a_1 \neq a_2 \neq a_3$, therefore the amount of change for two individuals from different groups with equal pre-task scores is not the same.

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