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9. ABSTRACT

An exploration of some relationships between college students' learning aptitudes, state of anxiety, and learning performance in two types of task sequences: (1) a sequence in which the materials were arranged in easy-to-hard order; and (2) a sequence in which they were arranged in hard-to-easy order. Three hypotheses were investigated, using 81 volunteer Florida State University students from general psychology classes. The first hypothesis was that the anxiety level of a learner while he is engaged in performing learning tasks is a better predictor of his performance than his anxiety level before he begins the tasks. The study findings affirmed that. The second hypothesis was that learners as a group would perform better in easy-to-hard task sequences than in hard-to-easy sequences. The study findings confirmed that. The third hypothesis was that task sequence would affect anxiety levels during performance of the sequence of tasks, and result in a disordinal interaction. This too was confirmed. The results showed very little correlation between pre-task anxiety levels and performance, or between pre-task and within-task anxiety levels. The larger purposes of this research involve developing more effective programmed learning materials for individualized instruction.

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August 1, 1973
Working Paper No. 2

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Multivariate Effect of Aptitude and Anxiety with Performance on Task Sequence in Concept Acquisition

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ABSTRACT

Investigated was the hypothesis that task sequence of easy-to-hard would result in a higher performance on a concept learning task than hard-to-easy. The multivariate data analysis showed that subjects receiving the easy-to-hard sequence had significantly higher scores on both tasks than subjects receiving the reverse sequence ($p < .05$). The within-task measures of state anxiety resulted in a hypothesized dis-ordinal interaction between the two groups ($p < .05$). State anxiety for the 81 college students increased from a pretask measure (taken after an aptitude and trait anxiety test) of 44 (standardized medium of 37) to a posttask mean of 60. The pretask measure of state anxiety correlated negatively with performance on the two tasks and with posttask state anxiety. The results of the study were discussed in terms of decision rules for adaptive instructional models.

Multivariate Effect of Aptitude and Anxiety with Performance on Task Sequence in Concept Acquisition

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Instruction is a process of manipulating the environment to produce change in a learner's behavior. An early attempt in individualizing this process was tracking students by grades or by scores from ability tests. Skinner's (1954) linear programed instruction was incorporated to allow students to progress at their own rates. This procedure emphasized that individuals do function at different learning rates. However, the material was not individualized since all students received the same instructional sequence (Markle, 1969). Technology influenced Crowder's (1959) procedures of intrinsic programing with provisions for branching able students through the same material more rapidly than slower students who received remedial frames whenever a question was missed. This type of programed instruction was not widely used because of the difficult developmental task which required review sections for each alternative answer (M. D. Merrill, 1971).

Cronbach (1967) suggested that if development among individuals is to be facilitated, a wide range of environments suited to the optimal development of each individual must be offered. Instructional units of the same subject matter representing measured learner trait characteristics would be necessary. For example, an interaction of aptitude and

instructional treatment would prescribe one type of sequence and media for a learner of certain characteristics, and another learner of differing trait characteristics would receive a different mode of instruction. Cronbach and Snow (1969) advocated that an extensive research program be conducted to identify the characteristics which interact maximally with instructional treatments.

Research studies (Tallmadge, Schearer, & Greenberg, 1968; Dunham & Bunderson, 1969; P. F. Merrill, 1970; Tennyson & Woolley, 1971) were undertaken to determine the specific environment assignments from pretask measures. The studies indicated that disordinal interactions have an elusive nature. One assumption was that individual difference characteristics may be classified as either trait or state variables. Trait variables are characterized as stable, long-term indices which are descriptive of a learner's expected general behavior. State variables, in contrast, are characterized as dynamic, short-term indices which are descriptive of a learner's behavioral response within a given specific situation. The use of anxiety measures as a variable for adaptive assignment of instructional strategies resulted from the generalization of the Taylor (1956) and Spence (1958) anxiety theory of competing responses. Recent extensions of this relationship between anxiety and instruction (O'Neil, Spielberger, & Hansen, 1969; Leherissey, O'Neil, & Hansen, 1971; Tennyson & Boutwell, 1973a) have shown that trait or state variables measured prior to a learning task were not as effective in predicting student performance as state variables measured while learning the task.

There is considerable research on item difficulty sequencing and individual characteristics in test performance (Berger, et al., 1969; Brenner, 1964; Alpert & Haber, 1960). Given a no-timed testing situation Munz and Smouse (1968) showed that low anxiety subjects had higher correct scores on a hard-to-easy sequence than on an easy-to-hard or random sequence. High anxiety subjects' scores were higher on an easy-to-hard or random sequence than on the hard-to-easy sequences.

Hypotheses

The purpose of this study was to investigate the effect of anxiety and aptitude on task difficulty sequencing using a multivariate analysis model that used continuous response variable data. Three aptitude and anxiety variables were selected to measure subject pretask characteristics: a figure classification test (French, Ekstrom, & Heighton, 1963), and trait and state anxiety measures (Spielberger, Gorsuch, & Lushene, 1969). Within-task measures of subject state characteristics were state anxiety measures and performance scores on a hard task and easy task.

Three hypotheses were proposed for investigation. The first was a replication of the Tennyson and Boutwell (1973a) study which showed that within-task measures of state variables are better predictors of learner performance than pretask measures. The extension was the use of a multivariate analysis design using three pretask measures as well as five within-task measures. The sequence effect of easy-hard versus hard-easy was hypothesized to result in a higher performance of the former on the concept acquisition task. And the third hypothesis

was that task sequence would effect within-task anxiety levels, resulting in a disordinal interaction.

Method

Learning Task

The behavioral objective of the learning task required subjects to read a definition of RX_2 crystals that included two prompted examples and two prompted nonexamples. Then the subjects identified examples of RX_2 crystals from a list containing both examples and nonexamples. A prompted instance is when an attribute is individually separated, identified, and defined. The definition of RX_2 crystals focused the subject s attention to the basic, repeating, two-to-one ratio in crystal structure of the RX_2 atoms. Two task sequences each of 10 examples and 10 nonexamples were constructed according to difficulty of instances. Item difficulty was determined by presenting to a sample of subjects, all of the instances, with the definition of RX_2 crystals. They classified the crystals as examples or not examples of RX_2 crystals (see Tennyson & Boutwell, 1973b). The results were ordered in terms of frequency of correct responses along a continuum ranging from 26% to 81%. Crystals within one standard deviation of the mean were not used. The remaining crystal instances higher than one S.D. were classified as easy and all crystals lower than one S.D. were classified as hard.

One task was composed only of easy instances; the second task was composed only of hard instances. The two learning tasks included a standardized definition of RX_2 crystals followed by two labeled examples and two labeled nonexamples. Each page of the task consisted of a

crystal picture taken from Crystal Structure (Wyckoff, 1968). Reproduction of the crystals was made from photoplates which provided shaded pictures so that depth perception would not confuse identification. The subjects could return to the definition at any time during the program. This eliminated short-term memory effect and provided the same conditions as existed when the difficulty levels were determined. Responses were recorded on an IBM answer sheet with no feedback on correctness of answers.

Subjects

The difficulty rating of the crystal instances was conducted with 100 randomly chosen students enrolled in undergraduate educational psychology classes at Florida State University. The program sessions involved 81 volunteer FSU students from general psychology classes. Subjects were selected from the psychology department subject pool and received course credit for volunteering to participate in the study.

Anxiety Measures

The Spielberger, Gorsuch, and Lushene (1969) State-Trait Anxiety Inventory (STAI) was used to measure trait and state anxiety. The A-Trait (Form X-2) Scale asks subjects to indicate how they "generally feel," while the A-State (Form X-1) Scale requires subjects to indicate how they feel "at this moment." Both scales consist of 20 items and were printed on opposite sides of the questionnaire. Within the two tasks a five-question A-State scale was used: I am tense; I feel at ease; I am relaxed; I feel calm; and I am jittery.

Aptitude Measure

A figure classification test (I-3), Part 1, taken from the Kit of Reference Tests for Cognitive Factors (French, et al., 1963) was selected as the pretask aptitude measure. This test requires subjects to identify abstract shapes by discovering the rules; figures range from simple to complex. The test established a range of aptitude scores on this particular task.

Experimental Design

This investigation used a multiple treatment experimental design (Campbell & Stanley, 1963). A counter-balanced design was used; half the subjects received a hard-to-easy task sequence, while the other half received an easy-to-hard sequence. The five dependent variables were hard task and easy task correct scores, the second and third five-item STAI A-State Scale scores (taken within the tasks), and the post-task 20-item STAI A-State Scale score. The pretask measures of aptitude, A-Trait, and A-State Scale scores were used as covariates.

Procedure

Subjects were given a choice of times for participation. A 4' x 4' experimental cubicle, with a desk and chair was available to each subject. An electric fan in the ceiling, an uncovered 100-watt light bulb, and a small clock completed an environment designed to simulate isolation. Individual administration of the task would tend to increase anxiety of subjects more than group administration (cf. Tennyson & Boutwell, 1973a). Subjects were isolated in the cubicle and remained there until finished with the program. The experimenter entered the cubicle only

at the start of the session to read directions. The experimental time per subject averaged 75 minutes.

A session included seven parts, each requiring separate directions. The first part consisted of the subject taking the figure classification test; he answered directly on the test sheet. This was approximately a 20-minute test in which the subject was told to work as rapidly as possible. The remainder of the task was contained in a self-instructional booklet with a separate IBM answer sheet. Directions explaining how to mark on the IBM answer sheet were contained in the booklet. The subject was directed to continue with the program until completed. The second part of the pretask was administration of the STAI A-Trait Scale followed by the STAI A-State Scale.

Following the pretask measures the subjects were introduced to the crysta tasks (Part four). After reading the definition and studying the examples and nonexamples, the subjects proceeded to the learning task. Subjects were told they could return to the definition during the task. The introduction to the easy task was written to decrease stress in taking the test, "You are now about to take a very easy test on crystal identification. You will be given a definition of the concept, and two examples and two nonexamples illustrating the concept." The hard task was designed to produce a condition of mild stress, "Now you will be tested on crystal identification again, but this time the items are very difficult. This part of the program was taken from a test designed for doctoral students in biochemical physics. You will have the same number of items but should have more trouble identifying examples." Within each task, after completing 15 identifications, the subjects took the five

question STAI A-State Scale. The original A-State directions were changed emphasizing, "...how you feel right now, that is, while you are taking this test on crystal identification." The seventh part of the session, the STAI A-State Scale, was administered after a three-minute wait following the completion of the second task. The rest period was included because previous investigations (O'Neil, et al., 1969; Tennyson & Woolley, 1971) had shown that subjects tended to relax at this point; reporting STAI A-State on a level similar to the pretask state measure. Subjects were directed to return all materials to the experimenter when finished. The experimenter then checked the figure classification test and the IBM answer sheets for errors.

Results and Discussion

Dependent variables. Five dependent variables were analyzed using a multivariate statistical design. These were the correct total scores on the easy and hard tasks, the two five-item STAI A-State Scale scores taken within the tasks, and the 20-item STAI A-State Scale score taken at the conclusion of the session. The three pretask measures, figure classification aptitude score, STAI A-Trait and A-State Scale scores, were used in the data analysis as covariates. The multivariate analysis was selected because of the interdependence of the various measures. The two STAI A-State Scales within the two tasks can only have meaningful interpretation by the assumption that the task affected anxiety level, and that anxiety affected task performance. The two tasks are dependent because they were composed of similar instances, varying only in difficulty.

TABLE 2

Within-Task Variable Means and Standard Deviations

Groups	Measures				
	Easy Task	A-State(1)	Hard Task	A-State (2)	A-State (3)
I. Easy-Hard					
M	13.7	15.4*	8.2	14.4*	60.1*
SD	3.6	.8	1.8	2.1	3.9
II. Hard-Easy					
M	9.3	13.9	6.4	15.4	60.1
SD	1.8	1.2	1.8	1.1	3.1

Note.--Group I received an easy to hard task sequence, while Group II received a hard-to-easy task sequence.

*A-State scores number (1) and (2) are based on five items, A-State (3) is based on 20 items.

42.7) were compared with other premeasured A-State means obtained in the CAI Center at Florida State University in the past several years and were found to be from one to four points higher. In the STAI manual the average A-State score is 37 (Spielberger, et al., 1969). This increase shows that even as a premeasure, sequence of measuring instruments has an effect on state variables. Similarly, the anxiety levels of the two within-task five-point A-State scores were three to seven points higher than on data collected on other studies using A-State on within-task conditions. The final 20-item A-State score showed an extremely high mean of 60 for both treatment groups. Such an increase of A-State was not anticipated. From previous research it was felt the hard task would cause an increase in reported A-State and a decrease in the easy task to a more normal level. A sequence interactive effect was hypothesized (to be reported below), but not the overall high scores. The isolating environment in the experimental cubicle produced a frustrating and/or stress condition that interacted with the demands of the task resulting in the unusually high A-State means.

Interactions. Of primary concern for this research was the interactive effect of task sequence on reported A-State. The five-point A-State Scales, taken within the tasks, can only be interpreted in terms of dependence on the task, not on sequence of occurrence. This assumption makes it possible to analysis interactive effects of A-State and task difficulty. Using a multivariate interaction of A-State (1) with A-State (2), the hypothesis test was significant ($U = .85$, $df = 2/1/78$, $p < .05$) (Table 2). To test for the disordinal interaction a univariate test on each A-State task was used. On the first univariate

test the two groups on the easy task had significantly different STAI A-State Scale scores ($\underline{U}$ = .94, $\underline{df}$ = 1/1/79, $\underline{p}$ < .05), with Group I (M = 15.4) having approximately a two-point higher score than Group II (M = 13.9). This condition was reversed on the hard task, with Group II (M = 15.4) having a significantly higher STAI A-State Scale score than Group I (M = 15.4) ($\underline{U}$ = .91, $\underline{df}$ = 1/1/79, $\underline{p}$ < .05). Because these A-States were dependent on the specific task and the sequence, the interpretation of the disordinal interaction is that an initial easy task, although eliciting a high state anxiety, does not interfere with performance, but allows for covert positive reinforcement. With a hard task following, A-State does not significantly decrease, as in the hard-to-easy sequence, but performance on the hard task is facilitated. The Group II sequence does effect a decrease in A-State, but the performance level on the easy task is only slightly improved (three points) over the hard task. The covert positive reinforcement occurring in Group I is not evident in Group II; the biased sequence forces the subject into a pattern of response boredom caused by excessive difficulty (Tobias, 1972).

Covariates. Three pretask measures were included for study as variables for possible use in adaptive individualized instruction. Presented in Table 3 are the regression coefficients for the three covariates; figure classification test, STAI A-Trait, and A-State Scales. The first set of data shows the effect of all three covariates on the multiple dependent variables. The easy task is not nearly as affected by the covariates as the hard task. The adjustments of the negative figure classification test on the hard task data results in an upward trend

TABLE 3

Covariate Regression Coefficients

	Dependent Variable Measures				
Covariates	Easy Task	A-State (1)	Hard Task	A-State (2)	A-State (3)
Figure Classification	-.0091	-.0046	-.0346	.0039	-.0385
A-Trait	.0492	-.0281	.0263	.0302	-.0473
A-State	-.0210	.0234	-.0210	-.0293	-.0995
Figure Classification	-.0088	-.0072	-.0323	.0076	-.0135
A-Trait	.0354	-.0087	.0194	.0064	-.1141
A-State	.0074	.0114	.0073	-.0160	-.1060

for the means. The two within task A-State dependent measures are not significantly affected by the three covariates. The interesting data analysis is the negative slopes of the final A-State measure, i.e., the higher the figure classification test, A-Trait, and A-State pre-task measures, the lower the final A-State score. The lower the state anxiety, the higher the performance score; but the reversal of the A-State scores from pre- to posttask is not readily interpretable.

The single covariate regression coefficients are in the same direction as the multiple coefficients. Although the slope is minimal, the negative coefficients of the figure classification test on the two tasks on both the multiple covariates and single figure classification test covariate would indicate a nonsignificant relationship between the pretask measure and within-task performance. The negative slope of the A-State (3) continues on the three separate covariates.

Correlations. When analyzing with multivariate data it is appropriate to cross-check the results with correlation data. Within correlations of Groups I and II are reported here. The pretask measures of A-Trait and A-State had a .63 (Group I) and a .61 (Group II) correlation. These correlations are similar to earlier data and with Spielberger, et al. (1969). There was no significant correlation of the figure classification test with the two anxiety measures; subjects did equally well on the classification test regardless of anxiety. Likewise, the correlation of the figure classification test and the two tasks was minimal (Group I r = -.12 and -.31; Group II r = .06 and -.22). As a pretask measuring instrument the figure classification test has the criticism that Bunderson (1968) states concerning the inadequacy of generalized aptitude tests for use

in selecting individualized instructional treatments. Even though this particular instrument was chosen because of its similarity to the task, we recommend that pretask aptitude measures should be of the same subject matter and behavior as the learning task. The correlations of the pretask STAI A-State measure and the two within-task A-State measures were zero. This corresponds with previous research (Tennyson & Boutwell, 1973a) which showed that within-task measures are better predictors of learner performance than pretask measures. In the individualized environment/treatment used here the elusive nature of an aptitude treatment interaction is, indeed, significant (cf. Bunderson & Dunham, 1970). The correlation of .14 (Group I) and .10 (Group II) of within A-State measures shows that specific tasks elicit different subject reactions, and that the pay-off for adaptive instruction is more appropriate by measures within the given task, and that additive effects, at least with these instruments would have minimal effect. The within A-State correlations for each group is approximately .18. The posttask STAI A-State Scale score correlation with the pretask was -.27 (Group I) and -.33 (Group II). Subjects reporting high anxiety prior to the task reported anxiety lower after the task than subjects reporting low on the pretask measure.

The data analysis of this investigation showed that task sequencing by difficulty did effect subject performance both on the individual task scores and on the overall score. When interacted with the state characteristic of anxiety it can be shown that subjects' respond differently to specific tasks and that within task aptitude treatment interactions would be more appropriate to designing adaptive instructional models than selective pretask decision variables.

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