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ABSTRACT

The hypothesis that memory support (MS) reduces state anxiety (A-State) and errors in a computer assisted learning task was investigated. It was predicted that high A-State students given MS would make fewer errors than high A-State students given no memory support (NMS). Low A-State students were expected to perform equally as well with or without MS. Sixty male undergraduates were randomly assigned to MS or NMS conditions. All students received the same learning materials. The MS group was allowed to see their previous incorrect responses to each problem before attempting it again, whereas this information was not available to the NMS group. There were no significant effects of memory support on A-State as measured by the State-Trait Anxiety Inventory. However, the predicted memory support x A-State interaction was found for errors. These findings were compared with the results of previous research on anxiety and memory support. (Author)

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TECH MEMO

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Barbara L. Leherissey, Harold F. O'Neil, Jr., Duncan N. Hansen

Tech Memo No. 20
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The purpose of the present study was to determine the relationship between state anxiety and memory support on a complex computer-assisted learning task for persons differing in trait anxiety. Hypotheses about the relationship between anxiety and performance in a learning task may be derived from the Drive Theory of Spence (1958) and Taylor (1956), which predicts that the effects on performance of individual differences in anxiety (drive) level will depend upon the relative strength of the correct response and competing error tendencies. High drive would be expected to facilitate performance on simple learning tasks where the correct response is dominant, and to produce debilitating effects on difficult tasks where error tendencies are stronger.

In research on Drive Theory, it is generally assumed that scores on the Taylor (1953) Manifest Anxiety Scale (TMAS) reflect individual differences in drive level. Spielberger (1966; Spielberger, Lushene & McAdoo, In Press) has pointed out that the TMAS seems to measure trait anxiety, while the concept of drive is logically more closely associated with state anxiety. State anxiety (A-State) refers to a transitory state or condition that is characterized by feelings of tension and apprehension and heightened autonomic nervous system activity, whereas trait anxiety implies individual differences in anxiety proneness, i.e., the disposition to respond to elevations in A-State under conditions that are characterized by some threat to self-esteem. It would be expected, therefore, that persons who differed in trait anxiety would manifest differences in drive level only under circumstances that caused them to respond with differential elevations in state anxiety.

A general paradigm for studying the effects of anxiety on cognitive activity has been presented by Sieber and Kameya (1967, p.2). This paradigm includes the following features:

> a) assessing initial level of anxiety, b) determining one or more mediating process variables (e.g., discrimination, short term memory, ideational fluency) and an overall performance measure (e.g., learning speed) that are affected by anxiety, and then c) measuring the degree to which anxious and non-anxious persons manifest change in those mediating process and overall performance variables following some experimental treatment.

Sieber has examined the hypothesis that anxiety interferes with memory, but "when memory support is provided, anxious persons appear to take advantage of it and thereby to improve their level of performance" (Sieber, 1969, p. 59). Using the above paradigm, Sieber and Kameya (1967) investigated the relationship between test anxiety, as measured by the Test Anxiety Scale for Children (Sarason, Davidson, Waite, & Ruebush, 1960), and the effects of memory support on the problem solving ability of children. On a Marble Task, high anxious students performed as well as low anxious students when given memory support (MS), but without MS, high anxious students made more errors than low anxious students. Low anxious students performed equally as well with or without MS. Sieber and Kameya (1967) conclude that anxiety interferes with short term memory, but that the performance of high anxious students can be improved when the task is structured to provide external aids so that there is less dependency upon memory.

Paulson (1969) used essentially the same paradigm as Sieber and Kameya, and found no differences in the error rate for high and low anxious students when MS was provided, but that high anxious students did more poorly without MS. Since his concept identification task differed markedly from Sieber and Kameya's Marble Task, Paulson concluded that the facilitating effect of memory support for high anxious students was not limited to a relatively narrow set of experimental tasks.

Several points can be raised regarding the theoretical interpretation and experimental design employed by Sieber and Kameya (1967) and Paulson (1969). First, Sieber (1969) argues that test anxiety is a process variable, and yet the paradigm she has chosen for investigating the effects of anxiety on memory requires only an initial assessment of anxiety level. If anxiety is regarded as a process variable, this would seem to imply a changing state of the organism in which anxiety level varies as a function of the individual's perception of the situation at a given point in time. Consistent with this view, measures of state anxiety should be taken at intervals within the experimental situation.

Sieber also contends that changes in performance rather than changes in level of anxiety are sufficient for investigating the effects of anxiety on intellectual activity. One of her major arguments for measuring performance changes and making only an initial assessment of anxiety level is based on the assumption that anxiety inventories are too insensitive to measure changes in anxiety level (Sieber, 1969). This may be true for anxiety measures such as the TASC, but Spielberger, et al., (In Press) have argued that the A-State scale of the State-Trait Anxiety Inventory (Spielberger, Gorsuch, & Lushene, 1970) has demonstrated both construct and concurrent validity, and state that:

> While measures of A-Trait provide useful information regarding the probability that high levels of A-State will be aroused, the impact of any given situation on the intensity of A-State can only be ascertained by taking actual measurements of A-State in that situation.

The value of measuring State Anxiety in the experimental situation was demonstrated by O'Neil, Spielberger, and Hansen (1969) who investigated the effects of A-State on learning mathematical materials that were presented via computer-assisted instruction (CAI). In this study, the State-Trait Anxiety Inventory (STAI) (Spielberger, Gorsuch & Lushene, 1970) was used to measure A-State during the learning task. High A-State students made more errors on the difficult portion of the learning task than low A-State students, but fewer errors on the easier portion of the task. In a follow-up study, O'Neil, Hansen and Spielberger (1969) found essentially the same anxiety-task difficulty interaction. In neither study was level of A-Trait related to performance. Moreover, in the second study, the mean error rate for the high A-State students on the difficult portion of the task was approximately twice that of the first study.

The major difference between the two studies was that the learning materials were presented on a typewriter terminal (an IBM 1440 system) in the first study and on a cathode ray tube (CRT) (an IBM 1500 system system) in the second. The typewriter terminals provided a printed output of learning materials and the students' responses, and thus, the student could review his previous erroneous responses prior to each trial. In contrast, the learning materials presented on a CRT were programmed to be erased immediately after the subject responded. Thus, there may have been a greater memory load with the CRT and this may have accounted for the higher mean error rates for high A-State students in the second CAI study. Apparently, the typewriter printout associated with the 1440 system provided greater memory support in the first CAI study, which facilitated performance and reduced error rates.

One method for reducing errors on learning materials presented on a CRT would be to provide some type of memory support. In the present study, a major goal was to investigate the effects of providing memory support on performance for persons differing in anxiety when presented complex learning materials on the CRT of an IBM 1500 system. It was expected that the findings of Sieber and Kameya (1967) and Paulson (1969) would be replicated. However, it should be recalled that an A-Trait measure was used in these studies, whereas A-State is logically more closely associated with drive level. Therefore, in the present study, the following hypotheses were formulated: (1) the performance of high A-State students would be inferior to that of low A-State students without MS; and (2) there would be no differences between high and low A-State students with MS.

A second major goal of this study was to examine the effects of memory support on the A-State reactions of students who differed in A-Trait. Assuming that MS reduces the amount of stress inherent in a learning task, it was expected that there would be a less difference in the level of A-State of high and low A-Trait students in the MS conditon than in the NMS condition.

Method

Subjects. The students were 60 male undergraduate student volunteers at Florida State University who were enrolled in the introductory psychology class. The students were run in small groups of 8 to 15 students; a total of five experimental sessions was required to run all groups of students. On the basis of the order of their arrival for each experimental session, the students were randomly assigned to one of two experimental conditions, memory support (MS) or no memory support (NMS). Thus, in each experimental session, approximately half of the students were run in the MS condition and the other half were run in the NMS condition.

Apparatus. An IBM 1500 CAI system (IBM, 1967) was used to present the learning materials. The terminals for the system, which consist of a cathode ray tube (CRT), a light pen, and a typewriter keyboard, were located in a sound-deadened, air-conditioned room. The

CAI system also presented the STAI A-State scales while students worked through the learning materials and recorded students' responses.

Learning Materials and Program Description. The learning materials consisted of a mathematics program on the field properties of complex numbers which is reported in detail by O'Neil (1969). This program is divided into three sections (Parts A, B, and C) with five problems each, for a total of fifteen problems. Each problem consists of a mathematics statement for which the student is required to select the most appropriate validating proof from a list of alternatives. The learning materials were programmed such that students were required to successfully solve each problem before being allowed to progress to the next problem.

Anxiety Measures. The A-State and A-Trait scales of the State-Trait Anxiety Inventory (STAI) (Spielberger, Gorsuch & Lushene, 1970) were used to measure anxiety. A total of five A-State measures were obtained during the experimental session: (1) The 20-item STAI A-State scale was administered on the CRT prior to presenting the CAI mathematics learning materials, and after program completion (2) Three 5-item short form A-State scales were inserted after each of the three sections of the learning materials. The short form A-State scales consisted of the five items having the highest item-remainder correlations for the normative sample of the STAI A-State scale (Spielberger, et al., 1970). Following the experimental session, the 20-item A-Trait scale was administered via paper and pencil.

The 20-item A-State scales were given with standard instructions, i.e., students were asked to indicate how they felt right now, at this moment. The three short form A-State scales were given with instructions which asked the students to indicate how they felt while they were working on the previous section of the mathematics learning task. The three short form A-State scales were programmed to provide random presentation of the five items during each of the three administrations of these scales.

Procedure. The experimental session consisted of the following three stages: (1) the Pre-Task stage, during which students received instructions on the operation of the CAI terminals and took the first 20-item A-State scale on the CAI system; (2) the Performance stage, in which the students learned the mathematics materials and responded to the short form A-State measures after each part of the task was completed; (3) the Post-Task stage, during which students took the second 20-item A-State scale on the CAI system, and were then given the A-Trait scale via paper and pencil, and finally interviewed and debriefed. Each of these stages is further described below:

1. Pre-Task Stage Students were randomly assigned to MS and NMS conditions according to order of arrival at the CAI Center. They were then assigned to CAI terminals and asked to read instructions on the operation of CAI features such as the light pen and typewriter keyboard. The students then took the 20-item A-State scale on the CAI system.

2. Performance Stage. All students worked through the same learning materials at their own rate. During this stage, the students received either MS or NMS based on their assignment to memory condition. Students in the MS condition were provided the following special instructions and procedures by the CAI system:

> As you work through the math problems, the answers you type in will be stored. If you make an error, you will be permitted to see your previous wrong responses so that you can avoid entering the same wrong response more than once. In the case of wrong responses, a statement will appear at the bottom of the screen which states, "Your previous answers were." Your previous incorrect responses will then appear and remain on the screen until you make a correct response.

In the NMS condition, the CRT was blank for 20 seconds, which was comparable to the time required for students in the MS condition to read the above instructions. In the learning task, the students in the MS group were shown all their previous incorrect responses to each problem before attempting the problem again. The students in the NMS condition were also required to attempt each problem again; however, their previous incorrect responses were not available. These students in the NMS condition received a pause in the learning material presentation comparable to the length of time required by MS students to review their previous incorrect responses. Following completion of each section of the learning materials, the students were asked to respond to the short A-State scale.

3. Post-Task Stage. Upon completion of the third short A-State scale, students were asked to respond to the second 20-item STAI A-State scale on the CAI system. The 20-item A-Trait STAI measure was then administered by paper and pencil, and this was followed by a

three-minute structured interview on the nature of the experimental task. In addition, students were asked not to discuss the experiment with any of their classmates.

Results

Effect of Experimental Conditions and Trait Anxiety on Errors

In order to determine the effects of memory conditions and trait anxiety on performance, a three-factor analysis of variance with repeated measures on the last factor was calculated. Independent variables were levels of A-Trait, high (HA), medium (MA), and low (LA), Memory Conditions (MS, NMS) and Periods (A, B, C). Mean errors per correct response was the dependent variable in this analysis. The cut-off scores for the high A-Trait (HA) and low A-Trait (LA) groups corresponded to the upper and lower quartiles of the published A-Trait norms for college undergraduate males (Spielberger, et al., 1970). Medium A-Trait (MA) students were those students whose scores were in the middle portion of the normative A-Trait distribution. The number of students within A-Trait level and memory condition was unequal but proportional for each group. The mean A-Trait scores for the students in the MS condition were 36.0; mean A-Trait scores for the NMS group were 35.2 ($t = .412$, $df = 58$, N.S.). Thus, the MS and NMS groups were well matched for A-Trait.

Results of the ANOVA on mean errors made by HA, MA, and LA students in the MS and NMS conditions in periods A, B, and C of the learning task revealed a significant main effect of Periods ($F = 11.91$, $df = 1/108$, p .001). Examination of the mean errors across the three periods indicated that all groups made more errors on Period A ($\bar{X} = 4.57$)

than on either Period B ($\bar{X}$ = 2.49) on Period C ($\bar{X}$ = 2.79). No evidence was found that errors in the three periods of the learning task were influenced by level of A-Trait or experimental conditions.

The failure to find any relationship between A-Trait and errors in the present study was consistent with the results of O'Neil, Spielberger, and Hansen (1969), O'Neil, Hansen, and Spielberger (1969), and O'Neil (1969) in which A-Trait and errors were also unrelated. However, in the three previous studies, there was a significant relationship between A-State and errors; consequently, in the present study, the relationship between A-State and errors was evaluated for the three sections of the difficult task.

Effect of Experimental Conditions and State Anxiety on Errors

A similar three-factor ANOVA was calculated to determine the effects of in-task state anxiety and memory conditions on errors. The independent variables in this analysis were levels of A-State (high, medium, low), memory conditions (MS, NMS) and periods (A, B, C). The students were divided into high, medium, and low A-State groups based on their summed A-State scores across periods A, B, and C. This distribution of in-task A-State scores was ranked and divided into thirds (n=20 for each group). The MS and NMS students were then separated out of this distribution yielding an unequal but proportional N in each group. The range of high A-State was 36-60; medium A-State scores ranged from 27-36; the range of low A-State was 15-27. Mean errors per correct response was again the dependent variable in this analysis.

The means and standard deviations for errors made by high, medium, and low A-State students in the MS and NMS conditions on periods A, B, and C are shown in Table 1.

Table 1

Mean Errors per correct response for high, medium, and low A-State students in MS and NMS Conditions on Periods A, B, and C

	Groups	Period A	Period B	Period C
	All Groups (N = 60)			
	Mean	4.57	2.49	2.79
	SD	3.49	2.94	4.17
	High			
	Mean	4.26	3.67	4.24
	SD	2.85	3.98	5.56
	Medium			
MS	Mean	3.30	1.92	1.52
	SD	2.58	2.33	2.07
	Low			
	Mean	3.90	1.87	1.43
	SD	2.47	1.81	1.34
	High			
	Mean	9.63	4.23	8.13
	SD	4.72	2.50	6.62
	Medium			
NMS	Mean	4.14	2.10	2.24
	SD	2.51	3.20	2.64
	Low			
	Mean	4.21	1.51	.91
	SD	3.70	2.09	1.10

The most important finding in the ANOVA on these data was a significant interaction between A-State and Memory Conditions ($F = 3.51$, $df = 2/54$, $p < .05$). A plot of this interaction is shown in Figure 1,

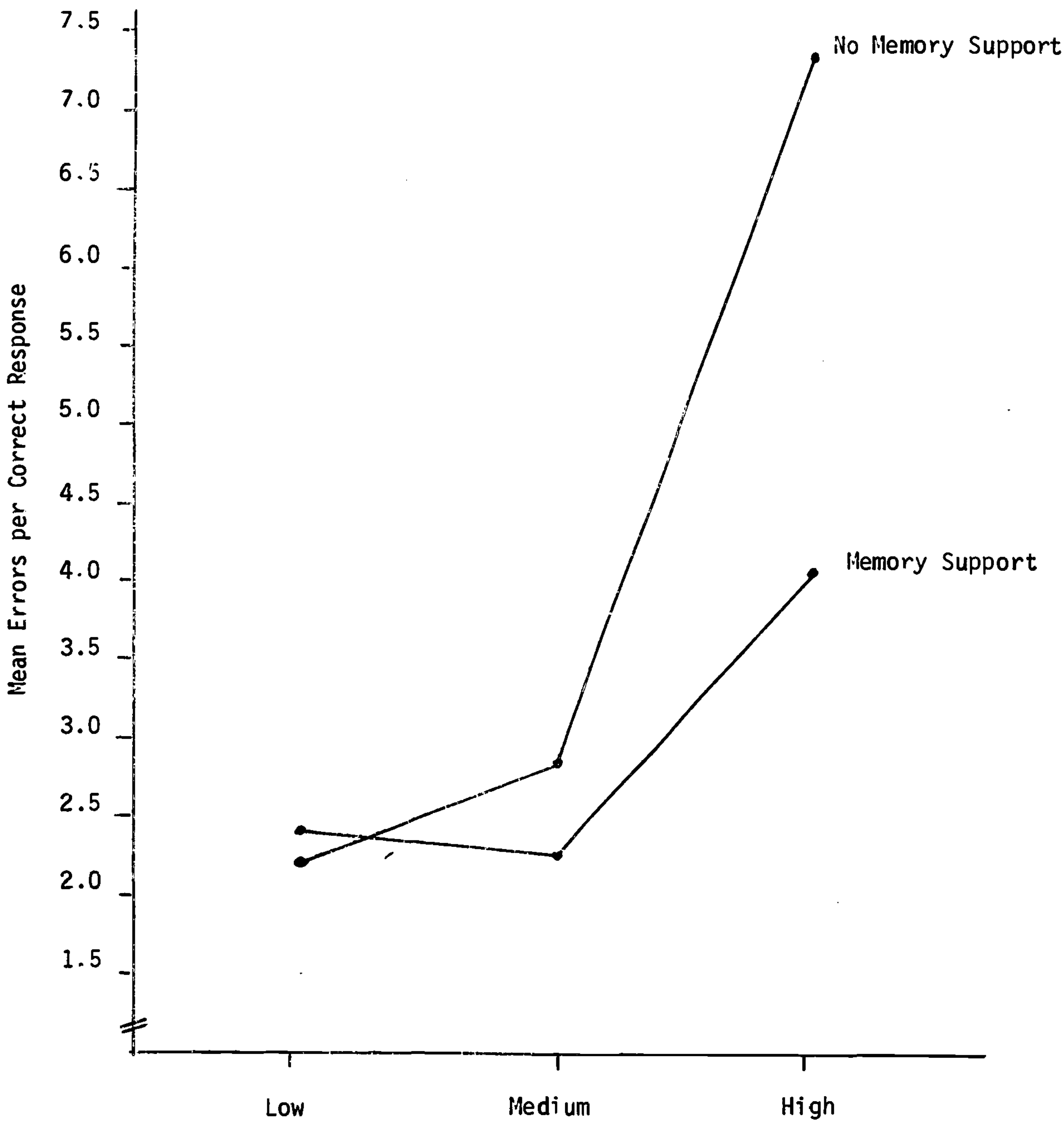

Fig. 1.--Mean Errors per Correct Response for Low, Medium, and High A-State Ss in the Memory Support and No Memory Support Conditions

which indicates that high, medium and low A-State students were differentially influenced by memory conditions. High A-State students in the NMS condition made approximately 1.75 times as many mean errors per correct response as high A-State students in the MS condition and a t test indicated that these differences were significant ($t = 2.38$, $df = 58$, $p < .025$). In addition, high A-State students in the MS condition made significantly more errors than low A-State students in the MS condition ($t = 2.03$, $df = 58$, $p < .025$). Medium and low A-State students were found to perform approximately as well with or without memory support.

The ANOVA on mean errors made by high, medium and low A-State students in MS and NMS conditions across Periods A, B, and C also indicated that high A-State students made more errors ($\bar{X} = 5.04$) than either medium A-State students ($\bar{X} = 2.54$) or low A-State students ($\bar{X} = 2.27$). This main effect of A-State was significant at the $p < .01$ level ($F = 7.22$, $df = 2/54$). In addition, the main effect of Periods was significant at the $p < .001$ level ($F = 11.86$, $df = 2/108$).

Effects of Experimental Conditions on A-State for HA, MA, and LA Students

To investigate the relationships between levels of A-Trait and experimental conditions on A-State scores across the five periods, a three-factor analysis of variance with repeated measures on the last factor was calculated. Independent variables in this analysis were levels of A-Trait (HA, MA, LA), Memory Conditions (MS, NMS), and Periods (Pre, A, B, C, Post). The dependent measure was mean A-State scores in each of the five periods. The statistical analysis of the A-State data was based on the short form of the STAI A-State scale. The same five items in the short form were extracted from the total A-State scale given before and after the experimental task. The alpha reliabilities for the five A-State scales were, respectively, .87, .83, .87, .86, and .93.

The means and standard deviations of A-State scores for HA, MA, and LA, students in the MS and NMS conditions for the five periods are reported in Table 2.

Results of the ANOVA on these data indicated that HA students had higher A-State scores ($\bar{X}$ = 12.27) than either MA ($\bar{X}$ = 9.75) or LA ($\bar{X}$ = 8.50) students. This main effect of A-Trait was significant at the p .001 level (F = 10.52, df = 2/54). Students were also found to differ in mean A-State scores across the five periods (F = 21.23, df = 4/216, p .001). The mean A-State scores for the MS condition ($\bar{X}$ = 10 39) were higher than the NMS condition ($\bar{X}$ = 9.33); however, this difference was not significant at the $p < .05$ level (F = 2.90, df = 1/54, p .10). No other effects were observed.

Discussion

The Sieber & Kameya (1967) and Paulson (1969) finding that high A-Trait students in the MS condition made fewer errors than high A-Trait students in the NMS condition was not supported in the present study. In this study, high, medium, and low A-Trait students were not found to differ significantly in mean errors for either MS or NMS conditions. The A-Trait results were consistent with the two previous CAI studies reported (O'Neil, Hansen, & Spielberger, 1969; O'Neil, Spielberger, & Hansen, 1969).

Table 2

Mean A-State Scores for HA, MA, and LA Students in MS and NMS Conditions on Periods Pre, A, B, C, and Post

Groups			Pre	Period A	Period B	Period C	Post
	All groups (N = 60)						
		Mean	8.25	11.65	10.22	10.05	9.13
		SD	2.57	3.62	3.52	3.80	3.25
	HA						
		Mean	10.75	14.25	13.25	13.25	11.87
		SD	1.83	3.69	3.01	2.82	4.22
	MA						
MS		Mean	8.27	12.36	11.55	10.73	10.55
		SD	1.90	2.73	1.57	3.00	2.66
	LA						
		Mean	6.91	10.36	9.36	8.91	6.64
		SD	1.97	4.08	4.32	4.48	2.38
	HA						
		Mean	10.50	13.50	11.50	12.17	11.00
		SD	3.15	3.51	2.26	3.43	2.53
	MA						
NMS		Mean	8.17	10.67	8.83	8.58	8.17
		SD	2.52	2.64	2.55	3.09	2.92
	LA						
		Mean	6.75	10.50	8.50	8.75	8.33
		SD	2.01	3.94	4.17	3.91	2.23

The predicted relationship was found, however, between A-State, Memory Conditions, and errors. Memory support was found to reduce the errors made by high A-State students, i.e., high A-State students in the MS condition made approximately 1.75 fewer errors than high A-State students in the NMS condition, whereas medium low A-State students performed equally as well with or without memory support. This significant interaction between levels of A-State and memory conditions may be interpreted as an indication that the performance of high state anxious students can be facilitated by the provision of some type of memory support. This interpretation is consistent with that of previous memory support studies (Sieber & Kameya, 1967; Paulson, 1969) which point out the need for considering the differential effects of memory support for high anxious vs. low anxious persons.

One interpretation for the superior performance of high A-State students in the MS vs. the NMS condition may be derived from Drive Theory. Drive Theory (Spence & Spence, 1966) predicts that the effects of drive (state anxiety) on learning depend on the relative strength of correct and competing error tendencies. If, as Sieber & Kameya (1967) and Paulson (1969) claim, memory support reduces the disruptive effects of anxiety on memory, memory support may be seen as reducing the competing response tendencies, i.e., task-irrelevant responses, for high A-State students which would reduce their errors. Thus superior performance of high A-State students in the MS as compared with the NMS condition would be expected.

The fact that Sieber & Kameya (1967) and Paulson (1969) used a trait rather than a state measure of anxiety and found a relationship with memory conditions and errors may have been due to the use of the TASC scale This scale may be tapping anxiety which is more closely related to the situation than the STAI A-Trait scale used in the present study. As Spielberger et al. (In Press) have stressed, inventories which measure anxiety aroused in a specific situation are more likely to be related to the behavior of students in that situation.

An interesting finding in the present study is the mean differences in A-State scores in the MS and NMS conditions. A-State scores were found to be higher for students in the MS group. Although this difference only approached significance ($p < .10$), it may be possible to infer that the MS condition was operating as a stress condition, in that providing these students with their previous incorrect responses was also providing them with a constant reminder of their past failures.

Also of interest in the present study was whether the provision of memory support would reduce errors of high A-State students on the 1500 system to the level of errors made by high A-State students on the 1440 system. On the 1440 system (O'Neil, Spielberger, & Hansen, 1969), the mean error rate of high A-State students on Period A was 3.8; in the followup study on the 1500 system (O'Neil, Hansen, & Spielberger, 1969), high A-State students had a mean error rate on Period A of 6.6. The present study found that the mean error rate of high A-State students in the MS condition on Period A was 4.3. It would appear on the basis of these three studies that memory support was successful in reducing male students' errors on the CAI 1500 system to a rate comparable with that of high A-State students on the CAI 1440 system.

Conclusions and Implications

The findings of the present study seem to indicate that the provision of memory support can improve the performance of male college students with high levels of state anxiety. This finding and those of previous memory support studies (Sieber & Kameya, 1969; Paulson, 1969; Sieber, Kameya, & Paulson, 1970) also indicate that memory support may be helpful for high anxious students on a variety of conceptual tasks involving memory processes (i.e., problem-solving, concept-formation). The results of this study, however, suggest that it may not be memory support per se that reduces the undesirable effects of anxiety on performance. A question of primary importance seems to be centered on the type of memory aid which is provided. The data reported seems to indicate that whereas providing high A-State students with their previous incorrect response does facilitate performance, it also leads to an increase in levels of state anxiety for students in the MS condition. As has been suggested, threat of failure may be the undesirable side effect of memory support of this nature. A fruitful research effort would seem to be one which examines those memory aids which not only improve performance, but which reduce anxiety experienced in the learning situation.

Memory aids which may prove beneficial in a variety of learning tasks for students high in state anxiety might include: (1) provision of cues for coding information, e.g., category systems, stories; (2) provision of cues for retrieving information, e.g., search for specific organizers. In addition, it has been pointed out (Sieber, 1969; Sieber, Kameya, & Paulson, 1970) that (1) external aids, e.g., diagrams, outlining systems, mnemonic devices, could be provided; or (2) information-coding strategies could be learned to enable efficient information processing without the use of external memory aids.

The investigation of memory aids, such as those suggested above, in a research design which measures both changes in performance and changes in state anxiety is thus seen as the best procedure for determining optimal instructional treatment for students differing in level of state anxiety.

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