DOCUMENT RESUME

ED 034 704 24 SP 003 372

AUTHOR	Sieber, Joan E.; And Others
TITLE	The Effect of Memory Support on the Problem-Solving Ability of Test-Anxious Children. Research and Development Memorandum No. 53.
INSTITUTION	Stanford Univ., Calif. Stanford Center for Research and Development in Teaching.
SPONS AGENCY	Office of Education (DHEW), Washington, D.C. Bureau of Research.
BUREAU NO	BR-5-0252
PUB DATE	Sep 69
CONTRACT	OEC-6-10-078
NOTE	21p.
EDRS PRICE	EDRS Price MF-$0.25 HC-$1.15
DESCRIPTORS	*Anxiety, Elementary School Students, *Memory, *Problem Solving, *Testing

ABSTRACT

A study investigated the effects of test anxiety, as measured by the Test Anxiety Scale for Children (TASC), on memory processes in problem solving and the extent to which memory support reduced this effect. Two experiments were performed on 40 and 96 subjects respectively, from grades 5 and 6. Each experiment utilized a factoral design involving two levels of test anxiety (Ss having upper- or lower-quartile TASC scores) and two memory conditions (supported and not supported). Experiment 1 subjects, selected from 170 who had completed the TASC, were paired: high-anxious (upper quartile) subjects with low-anxious (lower quartile) subjects by matching with respect to sex and IQ before assignment to the two memory-support conditions. Experiment 2 subjects, selected on the same basis from a similar group of 379, were divided by sex and assigned at random (with some restrictions) to the two conditions. Experiment 1 involved a puzzle; dependent measures were errors committed and recognition of potential errors. Experiment 2 involved concept formation; dependent measures were trials to criterion, and positive- and negative-exemplar memory errors. Analyses of variance and chi square analyses were performed. Significant main and interaction effects indicated that test anxiety interfered with short-term memory, and memory support reduced differences between performance of high- and low-anxious subjects. (Author/JS)

STANFORD CENTER
FOR RESEARCH AND DEVELOPMENT
IN TEACHING

Research and Development Memorandum No. 53

THE EFFECT OF MEMORY SUPPORT ON THE PROBLEM-SOLVING ABILITY OF TEST-ANXIOUS CHILDREN

Joan E. Sieber, Lawrence I. Kameya,
F. Leon Paulson

School of Education
Stanford University
Stanford, California

September 1969

Published by the Stanford Center for Research and Development in Teaching, supported in part as a research and development center by funds from the United States Office of Education, Department of Health, Education, and Welfare. The opinions expressed in this publication do not necessarily reflect the position, policy, or endorsement of the Office of Education. (Contract No. OE-6-10-078, Project No. 5-0252-0504.)

Abstract

The effect of test anxiety on performance of two nonverbal tasks as a function of memory-support conditions was reported earlier in Research Memorandum No. 11. Subsequently, additional research has been performed using tasks in which verbal responses were required. In addition, the investigators have developed new theoretical conceptions of possible processes by which test anxiety may affect memory processes and have resolved certain problems of design and analysis which hindered prior investigations. The present memorandum describes one of the previously reported experiments which has been reanalyzed and reports a new experiment involving primarily verbal behavior.

These two experiments were performed on 40 and 96 subjects respectively, from grades five and six. The effect of test anxiety and memory support on short-term memory processes in problem solving was examined. Each experiment utilized a factorial design involving two levels of test anxiety (Ss having upper- or lower-quartile TASC scores) and two memory conditions (supported and not supported). Experiment I involved a puzzle; dependent measures were errors committed and recognition of potential errors. Experiment II involved concept formation; dependent measures were trials to criterion, and positive- and negative-exemplar memory errors.

Significant main and interaction effects indicated that (a) test anxiety interfered with short-term memory, and (b) memory support reduced differences between performance of high- and low-anxious Ss.

THE EFFECT OF MEMORY SUPPORT ON THE PROBLEM-SOLVING ABILITY OF TEST-ANXIOUS CHILDREN[1]

Joan E. Sieber, Lawrence I. Kameya,[2] and F. Leon Paulson[3]
Stanford University

It is well documented that test anxiety may interfere with cognitive processes. For example, test anxiety has been found to have a cumulative adverse effect on IQ measures and school performance over the elementary-school years (Sarason, Davidson, Lighthall, Waite, & Ruebush, 1960; Hill & Sarason, 1966), and to be associated with academic failure in college students (Spielberger, 1962). However, no concerted research program has been undertaken to discover and develop new learning environments which minimize the adverse effects of anxiety or extinguish its characteristic interfering ramifications. This lack of applied research is probably due to two kinds of conceptual and methodological problems:

First, existing means of reducing anxiety, such as behavior therapy, removal of threatening cues, and pharmacological treatments are inappropriate for improving school performance. The first two of these approaches, for example, involve reduction of motivation and of the salience of task-relevant cues, both of which are required for effective problem solving. The effects of drugs are insufficiently understood to warrant their use for this purpose.

---

[1]The authors wish to thank the Los Altos School District, the Conrad Noll School in Fremont, and the Lincoln School in Redwood City for their cooperation in supplying subjects and facilities for this research. Appreciation is also expressed to Patricia Engle and Susan Crockenberg for their assistance with the experiments; to Dr. Janet D. Elashoff for her advice in the design and analysis of the experiments, and to Dr. Lee J. Cronbach, Dr. Mara Southern, and Dr. Gavriel Salomon for their criticisms of an earlier draft of this manuscript.

[2]Now at the University of Michigan.

[3]Now at Teaching Research, A Division of the Oregon State System of Higher Education, Monmouth, Oregon.

Second, there are unresolved problems of defining and measuring test anxiety: (a) Measures of test anxiety are too imprecise for assessing the effectiveness of procedures which purport to reduce anxiety; (b) the nature of test anxiety, its causes, and its manifestations are not clearly defined; and (c) it is not clear what intervention would be appropriate. Can anxiety, _per se_, be eliminated in evaluative situations? What comprises the anxiety that should be eliminated: consciously perceived feelings of apprehension or certain overt behaviors? Since anxiety facilitates cognitive processes under certain conditions (Waite, 1959; Spielberger, 1966), perhaps it should not be eliminated at all.

In the present study, however, these problems were avoided, since anxiety, _per se_, was not studied. Rather, the experimenters investigated (a) the effects of test anxiety, as measured by the Test Anxiety Scale for Children (TASC), on memory processes in problem solving and (b) the extent to which memory support reduced this effect. A paradigm was used which required neither a comprehensive definition of test anxiety nor a means of reducing it. (The details of such a general paradigm are described in Sieber, 1969). Memory errors and performance errors were studied as a function of level of test anxiety and memory support. Memory support was provided in one condition of each task. In the memory-support conditions, Ss worked problems with the aid of a record of the results of prior trials, thereby reducing the need to recall details of prior trials.

The short-term memory variable examined in these experiments was ability to remember and select correctly select from among various related sets of information in problem solving. Related sets of information might consist of facts about the problem (e.g., beliefs about the nature of the stimulus, factual observations, etc.), or conceptual links by which facts may be integrated to provide a solution (e.g., procedures, principles, etc.). When confronted with a difficult problem, one typically generates facts and conceptual links which seem relevant to finding a solution. Then, unless some form of memory support is available (e.g., a diagram or notational system), these sets of information must be held in short-term memory while the individual determines how any of them could be used to solve the problem. One example of a task requiring this process is a mathematical problem in which the student must discover what algorithm to use. Another example is the task of reading a complex novel, and outlining its plot or describing its significance. A counterexample, a task which provides memory support and thereby places little demand on short-term memory, is the Porteus Maze Test (Porteus, 1950). Here, all relevant information is displayed before the subject, enabling him simultaneously to see and compare all choice alternatives and their respective outcomes.

The effect of anxiety on this memory function has not been studied previously. However, by comparing studies of problem solving (as a function of anxiety) which differ as to whether memory support was provided, differences in the behavior of anxious persons may be observed. For example, Waite (1959) found that high-anxious persons made fewer errors than low-anxious persons in the Porteus Maze Test when under little pressure to respond. He attributed this to anxious persons' tendency to be cautious and hence to acquire and consider more information before acting. We note, however, that high-anxious persons are neither cautious nor accurate problem solvers when the necessary information is not available and organized for them in some external form. Evidence indicates that in such situations, anxious persons seek <u>less</u> information before making decisions, and reach decisions more rapidly (Lanzetta, 1963). Their word-association performances are more often characterized by errors of commission consisting of emitting first-available, incorrect responses (Castaneda, Palermo, & McCandless, 1956; Stevenson & Odom, 1965).

The present experiments were performed to compare, in a more controlled way, the effect of anxiety on memory processes under conditions of memory support versus no memory support. The following predictions were made: (a) When information must be remembered before a correct strategy can be formulated, high-anxious persons make more wrong choices, commit more memory errors, and less frequently "catch potential errors" before they are are fully committed than low-anxious persons; (b) provision of memory support reduces the difference between high- and low-anxious persons in these respects.

Method

Experiment I

<u>Subjects and design</u>. The subjects were 20 boys and 20 girls chosen from

six fifth- and sixth-grade classes provided by a middle-class elementary school not far from Stanford. Their mean IQ, as measured by the California Test of Mental Maturity (CTMM), was 114.0, and the standard deviation was 11.8.

The subjects were selected from among 170 children who had completed a modified version of the TASC a few weeks earlier. This version of the TASC and the administrative procedure are described by Wallach and Kogan (1965). From this initial pool of students, subjects whose TASC scores fell into the upper or lower quartile were selected. High-anxious (upper quartile) Ss were then paired with low-anxious (lower quartile) Ss, by matching with respect to sex and IQ, until ten matched pairs of boys and ten matched pairs of girls were obtained. For five of the pairs of boys, the low-anxious Ss were assigned to the memory-support condition and the high-anxious Ss were assigned to the no-memory-support condition. Of the other five pairs of boys, the high-anxious Ss were assigned to the memory-support condition and the low-anxious Ss were assigned to the no-memory-support condition. Girls were assigned in the same way.

For each dependent measure, an analysis of variance was performed on pairs by memory-support condition, yielding main effects and interactions for anxiety, sex, and memory-support conditions.

Problem materials. The marble puzzle to be solved in this experiment consisted of the following: A board containing a row of nine small, evenly spaced holes was placed before the subject. Four black marbles were placed over the holes at one end of the board and four white marbles over the holes at the other end, leaving the middle hole uncovered. The puzzle was solved when the marbles of the two respective colors were moved to the end of the board opposite their starting position. Only two types of moves were permitted: (a) forward (i.e., toward the opposite end of the board) to an adjacent empty hole, and (b) forward by jumping over one adjacent marble of the opposite color to an empty hole. Only one sequence of 24 moves resulted in the solution. Any other sequence led to an impasse. An aspect of this task which made it quite difficult was that a wrong move did not result in an impasse until two moves later. Hence, the task was primarily one of remembering what configuration of marbles, at each juncture, would lead to an impasse two moves later.

In one version of the marble puzzle, no memory support was provided. Thus, the ability to avoid repeating errors depended on remembering the characteristics of wrong moves. In the second (memory-support) version, three marble boards were provided. If an error was made, the subject tried again on the second board, keeping the first board intact before him for reference to avoid similar errors. He continued to rotate and reset the three boards until the correct solution was found.

Procedure. Subjects were called individually from their classrooms by a messenger who led them to a trailer in which the experiment was conducted. At this time, the messenger said to each S: "You are going to participate in a Stanford University research project. We are going to give you some problems to solve. It is very important that you do well on these tasks."

Inside the trailer, S was greeted by the experimenter, introduced to the task, and given practice trials as follows: "I have a test here that is designed to examine your problem-solving ability. Your task is to move the four white marbles to the right and the four black marbles to the left. We have a few rules you are to follow: You can move a marble only one hole at a time or over only one marble at a time. You cannot move a marble backwards nor can you jump a marble over another of the same color. Once you remove your hand from a marble, you cannot move the marble back. Do you understand what you are to do? What is your task? What are the rules for moving the marbles? If at any time you find that you cannot move, please try again from the beginning. You may start now."

The subject was then allowed to work until he had completed one successful trial on the marble puzzle without memory support. This practice was given to control for individual differences in prior experience with such tasks, and to reduce the influence of variables other than short-term memory functioning. Half of the subjects were then told to continue to work on the marble puzzle until they attained a second correct solution. The other half of the subjects were given two additional boards of marbles and told: "Try to solve the puzzle again. If you make a mistake on one board and have to start over, put that board up here in front of you where you can see it. Then take another board and try again."

All Ss were able to reach a correct solution within 20 minutes.

E sat across the table from S and recorded data on a rating form. Data were recorded on trials to criterion, and recognition of potential errors. "Potential errors recognized" was defined as any incorrect move of a marble that was retracted before the hand was removed from the marble. (Recall that in the instructions, S was told that removing his hand completed the move).

The experimenter was not aware of the subjects' TASC nor IQ scores. He did not give any form of reinforcement to Ss during the administration of the tasks. In spite of the game-like nature of the two tasks, it was not difficult to maintain a test-like atmosphere.

Experiment II

Subjects and design. The subjects were 48 boys and 48 girls chosen from nine fifth- and sixth-grade classes provided by two middle-class elementary schools not far from Stanford. Their mean IQ, as measured by the CTMM, was 109.3, and the standard deviation was 15.4.

These subjects were selected from among 379 children who had completed the modified version of the TASC (as in Experiment I) a few weeks earlier.

A 2 x 2 factorial design was employed with two levels of anxiety (high and low) and two levels of memory (supported and not supported). There were 24 subjects, divided equally by sex, in each cell. Ss whose TASC scores fell into the upper or lower quartile of scores in each class and for each sex formed the subject population. Ss were assigned at random to the memory-support and no-memory-support conditions with two restrictions: (a) a second S from the same sex, classroom, and anxiety classification was assigned to the alternate condition, and (b) a second pair of Ss of the same sex and classroom but of the other anxiety group was assigned to the two remaining cells.

Problem materials. Practice materials consisted of sets of figural material, each having one, two, or three binary dimensions relevant to solution, mounted on 2" x 3" cards. The dimensions were size (large, small), shape (square, triangle), color (brown, black) number (one, two), and color of card border (red, black). The cards were mounted in groups of four or eight per page in a loose-leaf binder. Each page contained sufficient information to describe a concept.

Materials used in the experiment consisted of a deck of 4" x 6" cards containing all possible combinations of three binary dimensions. The dimensions were size (large, small), shape (triangle, arrow), and color (red, black).

Procedure. Each S was taken individually to a room provided by the school. It was explained that he had been chosen to participate in a Stanford University experiment in which he would be given some problems to solve, and that it was important for him to do very well.

Inside the room, E greeted S and said, "Before we begin, we will do some practice problems so that you will understand what we want on the main problems. I will not keep score on the practice problems."

The first page of the practice book was exposed. S was told: "On this page there are some cards. No two of these cards are alike, but there are ways in which they are similar. For instance, these two (A & B) are similar because they both have brown on them. How are these two (C & D) similar?"

The appropriate response was one that named the correct value of the relevant dimension. In this case "color" was the relevant dimension and "black" the correct value. Therefore, the appropriate response was "black," or a suitable substitute like "dark." E then responded by saying: "Yes, that is correct; they both have black on them." If S did not respond, E prompted by noting that A and B both had brown on them. The question of how C and D were similar was then repeated. Additional prompting was given if necessary.

When the subject had succeeded in classifying cards C and D, E selected a new stimulus dimension. The experimenter pointed to cards B and D and asked "How are these similar?" The appropriate response was "triangle." The response "three corners" was acceptable, with S being told, "That is correct. You can call them triangles. They all have triangles on them."

If S did not respond, or made an irrelevant response, E prompted by saying: "Do you see some (other) way in which they go together?" If S still did not respond: "Is there something about the shape of these (B & D) that is different from these (A & C)?"

New stimuli were successively introduced until S became proficient at stating similarities. E then taught S how to state rules instead of similarities by responding to S's correctly stated simularity as follows: "I can say this another way. I can say that certain cards go together because they follow a certain rule. If I think of a rule that 'all browns go together,' then these two cards (indicating A & B) fit the rule. As a matter of fact, any card that had brown on it would also fit the rule. Now, what rule would I be using if I said that these two (C & D) went together?"

The appropriate response was "black" or "all blacks go together." If S failed to answer, or answered inappropriately, he was prompted as follows: "How did you say that they were similar?" S usually answered, "Black," to which E replied, "Yes, they are similar because they have black on them. Because they are similar in having black on them, you can say that they follow the rule: 'All blacks go together.'"

Pairs of cards that the subject classified correctly were then reviewed. Each pair of cards was pointed out, and the experimenter asked: "Can you think of a rule that makes these (indicating cards) go together?" If S answered correctly, E replied, "Yes, that is correct." Erroneous responses were extremely rare in this stage of practice.

If S verbalized the dimension (e.g., 'size') rather than the appropriate attribute (e.g., 'large'), E corrected him as illustrated in the following example: "Yes, they are different in size, but the size itself is important because later on when we start the main part of the test, the only answers I can score are those that actually say the correct words 'These are the same size, and that size is large.'"

The concept-learning experiment immediately followed the practice problems. Two forms of presentation were used: cumulative presentation, in which exemplars remained exposed after presentation (the memory-support condition), and successive presentation in which each exemplar was removed before the next was presented (the no-memory-support condition).

The experimental task was introduced with the following instructions: "Now we are going to do the main part of the testing. From now on I will keep score. I am going to show you cards just like we did on the practice problems. The only difference is that I will show them to you one at a time.

I will ask you to guess the rule I am using to group the cards together. This is the same thing that we did in the practice book. The only difference is that you will see them one at a time."

Subjects in the cumulative (memory-support) presentation condition were told: "I will leave some of the cards out so that you will not have to remember so much. You can check back to remind yourself of what the earlier cards had on them."

Subjects in the successive (no memory-support) presentation condition were told: "After I have shown you each card, I will take it away. You will have to remember what was on the earlier cards. I will show you the cards one at a time, and I will tell you which cards fit and which do not fit the rule. Before we begin, let me show you some of the cards so that you will know the parts of the cards that count."

Several cards from the problem deck were then shown to the child, and E asked S to verbalize all of the values of the dimensions represented on those cards. This procedure followed that of the closed system employed by Hovland (1952), Hovland and Weiss (1953), and Cahill and Hovland (1960), in that the universe of attributes and values was known to S at the beginning. The exposed cards were then gathered up, and the following instructions were then given: "I will now show you the cards one at a time. I will tell you which cards fit the rule and which do not fit the rule. After you see each card with the rule, I want you to guess the rule. I will not tell you when you are correct. You will have to figure that out for yourself. Do you know how to tell when you are correct? (Here E paused to allow S to consider the problem. Generally, S did not offer a solution). "The way you will know that you have guessed the correct rule is that you never have to change any part of the rule. You will be able to keep guessing the same rule over and over, and it will always fit. If you have to change any part of the rule, then you do not have the correct rule. Go ahead and start--you will catch on after you have done a few cards."

The cards were exposed to the child one at a time. Exposure times of 10 to 20 seconds were used (exact time was difficult to control). The series began with a positive exemplar, and positive and negative exemplars were presented alternately. With each positive card, S was told: "This card fits the rule. What do you think the rule is?" With each negative exemplar, S was told: "This card does not fit the rule." E recorded the hypothesis stated by S after each positive exemplar. S was not encouraged to state hypotheses after negative exemplars, and any hypotheses that were not stated were not recorded.

If S stated more than the requisite number of parts of the rule, he was told: "Remember, the rule has only one part."

Children sometimes perserverated on an incorrect response. E.g., if size was irrelevant, one may have guessed 'large' and 'small' alternately. After ten such trials, he was told: "Remember, the same rule must fit all cards. You keep changing the rule by saying 'large' then 'small.' You must find a rule that you never have to change. What part of the rule do you keep changing?"

(Pause, then hint).

A criterion of four successive correct responses was used, at which point testing was terminated.

The experimenter recorded (a) number of trials to criterion, (b) number of positive-exemplar memory errors, i.e., hypotheses involving stimulus dimensions that had been present in the immediately preceding negative exemplar. E was not aware of S's anxiety classification.

Results

Experiment I

The means and standard deviations of errors committed and potential errors recognized appear in Table 1.

An analysis of variance of number of errors committed indicated that anxiety interacted with memory support as predicted ($F = 5.23$, $df = 1,16$, $p < .05$). Main effects were observed in which fewer errors were committed by low-anxious Ss ($F = 5.70$, $df = 1,16$, $p < .05$) and Ss with memory support ($F = 6.35$, $df = 1,16$, $p < .05$; see Figure 1a).

The analysis of number of potential errors recognized indicated that low-anxious Ss recognized more potential errors than high-anxious Ss. ($F = 22.00$, $df = 1,16$, $p < .01$). No other effects were observed.

FIGURE 1

a. Mean Number of Errors Committed in Experiment I
b. Mean Number of Positive-Exemplar Memory Errors Committed in Experiment II
c. Mean Number of Negative-Exemplar Memory Errors Committed in Experiment II

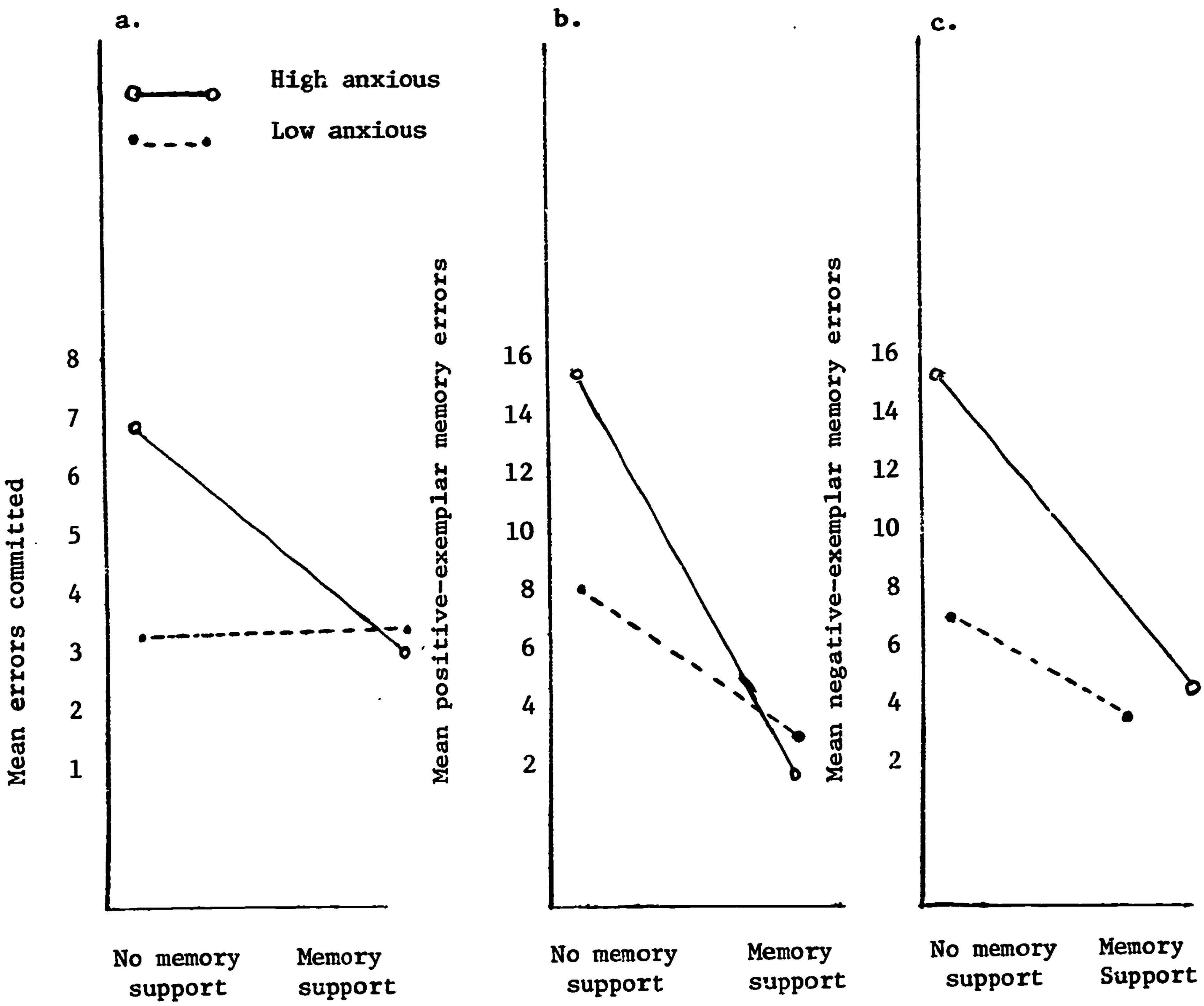

TABLE 1

Means and Standard Deviations of Raw Scores on Errors Committed and Potential Errors Recognized of High- and Low-Anxious Subjects as a Function of Memory Support in Experiment I.

			Memory Support	No Memory Support
Errors Committed	Low Anxious	M	3.30	3.10
		SD	2.54	2.88
	High Anxious	M	3.00	7.00
		SD	2.58	2.62
Potential Errors Recognized	Low Anxious	M	.70	.70
		SD	.48	.48
	High Anxious	M	.30	0
		SD	.48	0

TABLE 2

Means and Standard Deviations of Raw Scores on Trials to Criterion of High- and Low-Anxious Subjects as a Function of Memory Support in Experiment II.

		Memory Support	No Memory Support
Low Anxious	M	3.00	5.38
	SD	1.64	5.48
High Anxious	M	3.46	10.08*
	SD	3.59	10.43

*Significantly different from the other three mean scores, ($t = 3.96$, $df = 92$, $p < .001$).

TABLE 3

Mean Number of Positive- and Negative-Exemplar Memory Errors for the Four Experimental Conditions and X^2 Values for Comparisons: Overall X_t^2, Low-Anxious Non-Memory Support *vs* both Memory-Support Conditions X_1^2, and High-Anxious No-Memory Support *vs* All Other Conditions X_2^2.

	Memory Support		No Memory Support		Total	X_t^2	X_1^2	X_2^2
	Low Anxious	High Anxious	Low Anxious	High Anxious				
Positive exemplar memory error	3	2	8	15	28	29.89**	4.07*	17.21**
Negative exemplar memory errors	4	5	8	15	33	12.60**	1.11	11.22**
N	24	24	24	24	96			

*$p < .05$ **$p < .01$

Experiment II

The means and standard deviation of trials-to-criterion are presented in Table 2. In an analysis of variance performed on $\log_{10}$ transformations of these scores, memory ($F = 10.95$, $df = 1,92$, $p < .01$) and anxiety ($F = 2.54$, $df = 1,92$, $p < .25$) main effects were found. However, there was no effect of sex.

The hypothesis that memory support reduced the undesirable effects of anxiety was tested by a planned comparison (Hays, 1963) between the no-memory-support group and the remaining three groups. This comparison was significant ($t = 3.76$, $df = 92$, $p < .001$).

Chi-square analyses were performed on both the number of positive-exemplar memory errors and the number of negative-exemplar memory errors of the four treatment groups. (Positive-exemplar memory errors consisted of hypotheses involving stimulus dimensions that had been absent in the prior positive exemplar. Negative-exemplar memory errors consisted of hypotheses involving stimulus dimensions that had been present in the prior negative exemplar). Data were partitioned according to a technique developed by Kimball (1954). Means and chi-square values are shown in Table 3. As shown in Figures 1b and 1c, high-anxious persons with no memory support made more positive- ($p < .01$) and more negative-exemplar memory errors ($p < .05$) but such a difference was not observed in negative-exemplar memory errors.

Discussion

These experiments lend support to the hypotheses that (a) test anxiety has a disruptive effect on the functioning of short-term memory during problem solving and (b) provision of memory support diminishes the difference in performance between high- and low-anxious persons.

It is important to note that these tasks were primarily tests of ability to transform and use information stored in short-term memory (or provided by the memory support). They were not tests of learning. Each S had successfully completed one or more trials prior to the trials on which data were collected. This training procedure controlled for prior experience in these tasks, and for other variables (e.g., having the correct alternative in one's response repertory, understanding the rules, or believing that a solution really existed) which otherwise might have accounted for success. Hence, the major determiner of success in these tasks was ability to recall stimulus characteristics on which a correct response could be based.

It is not surprising that short-term memory processes are readily disrupted by anxiety. Posner (1965) has pointed out that short-term memory is an active process that is particularly subject to disruption. However, the relation of anxiety to information loss in short-term memory has not been studied extensively. Keller (1957) and Hafner, Pollie, and Wapner (1960) found that high- and low-anxious Ss did not differ in WISC digit-span scores. However, the digit-span task is a simple problem in which the stimuli to be remembered are central to Ss' attention and need not be transformed, a condition under which anxious Ss may be expected to outperform their nonanxious counterparts (Easterbrook, 1959). The debilitating effect of anxiety is more likely to appear in more complex tasks (Hilgard, Jones, & Kaplin, 1951). It would be expected, therefore, that anxiety would interfere with short-term memory when complex information processing was required, as in the present experiments and in a recent study by Borkowski and Mann (1968).

It is not clear how anxiety interferes with short-term memory, however. One hypothesis is that anxiety itself may become a source of information input. This was suggested by the finding of Sarason et al.(1960) that test-anxious children frequently experience intrusion of irrelevant thoughts. Such an intrusion of additional information may overload short-term memory beyond the limit of human channel capacity (Miller, 1956) or disrupt the organization of remembered information. Thus, the hypothetical information content of anxiety may serve as an "interpolated activity" which, as Posner and Rossman (1965) have shown, would increase the rate of forgetting from short-term memory.

A second hypothesis is that the drive component of anxiety has a detrimental effect on complex-memory processes. This hypothesis was derived from Spence and Spence's extension of the theory of emotionally based drive to complex-learning phenomena (1966). Under this theoretical position, it is assumed that the excitatory potential of a response tendency (E) is a multiplicative function of the initial strength of the response tendency (H) and the level of drive (D). It follows from this formulation that when the correct response tendency is initially strong, performance should be positively related to drive. However, if the correct response tendency is initially weaker than one or more of the competing response tendencies, then the higher the drive, the poorer the performance. If memory traces may be equated with response tendencies, then the Spencian explanation may be extended to state that high-drive or -anxiety states reduce the relative availability of weaker memory-traces. Thus, in learning to perform a complex task, thoughts or implicit symbolic responses which are not the dominant responses to that task may become less available under conditions of high drive.

The mechanisms by which anxiety interferes with short-term memory remain to be elucidated. And such elucidation might imply new ways of reducing interference with short-term memory. Nevertheless, the present findings have practical implications as they stand.

If the present findings are generalizable, then high-anxious persons may benefit from learning to use various external aids such as diagrams or notational systems. In addition, mnemonic (internal) memory aids or information-coding strategies may be learned, permitting efficient information processing without external aids.

A second possibility is that possession of various external memory aids may be reassuring to an individual and thereby reduce his level of anxiety.

And a third possibility is that possession of memory aids may reduce interfering cognitive components of anxiety (e.g., threatening intrusive thoughts) without reducing the drive or activation component. This hypothesis is in accord with Watson's (1967) observation that the more internal one's self-appraised locus of control, the more his performance is facilitated by anxiety. Accordingly, high-anxious persons who have learned to use memory aids may gain a greater sense that they can control their environment. As a result, their anxiety may serve to increase vigilance and productive thinking, rather than producing fear and disruptive behavior.

Further research is required to investigate the range of intellectual tasks to which these findings generalize. The tasks used in the present experiments were not representative of all problems encountered in school. Both tasks entailed a limited number of possible responses, the discovery of which required little imagination, and the execution of solutions was relatively simple. In some problem-solving situations, however, alternative choices are not obvious [e.g., mathematics problems, reading comprehension, Luchin's (1942) water-jar problem, or Maltzman's (1960) Unusual Uses Test]. In such cases, high-anxious persons may have difficulty generating many appropriate response alternatives, as Spence and Spence's theory (1966) implies. Some means of increasing ideational fluency may constitute successful treatment in this case. In other kinds of problems, the correct solution strategy is a multistaged one; some intrinsic structure of the problem must be recognized and the required sets of behavior must be learned and integrated in a correct sequence. In addition to learning to use notational systems and other kinds of memory support to track the results of his planning and testing, the anxious person may need training and experience in the formation and testing of plans.

Various other treatments which would improve problem-solving performance of high-anxious persons may be discovered through: (a) task analysis of problems on which high- and low-anxious persons perform differently and (b) analysis of differences in problem-solving strategies in relation to anxiety level.

References

Borkowski, J. G., & Mann, T. Effects of anxiety and interference on short-term memory. Journal of Experimental Psychology, 1968, 78, 352-354.

Cahill, H. E., & Hovland, C. I. The role of memory in the acquisition of concepts. Journal of Experimental Psychology, 1960, 59, 137-144.

Castaneda, A., Palermo, D. S., & McCandless, B. R. Complex learning and performance as a function of anxiety in children and task difficulty. Child Development, 1956, 27, 327-332.

Easterbrook, J. A. The effect of emotion on cue utilization and the organization of behavior. Psychological Review, 1959, 66, 183-201.

Frick, F. C. The effect of anxiety--a problem of measurement. Journal of Comparative and Physiological Psychology, 1956, 46, 120-123.

Hafner, P. J., Pollie, D. M., & Wapner, I. The relationship between CMAS and WISC functioning. Journal of Clinical Psychology, 1960, 16, 322-323.

Hays, W. L. Statistics for Psychologists. New York: Holt, Rinehart, and Winston, 1963.

Hilgard, E. R., Jones, L. V., & Kaplan, S. J. Conditioned discrimination as related to anxiety. Journal of Experimental Psychology, 1951, 42, 94-99.

Hill, K. T., & Sarason, S. The relation of test anxiety and defensiveness to test and school performance over the elementary school years: a further longitudinal study. Society for Research in Child Development, 1966, 31, (104, Whole No. 2).

Hovland, C. I. A "communication analysis" of concept learning. Psychological Review, 1952, 53, 461-472.

Hovland, C. I., & Weiss, W. Transmission of information concerning concepts through positive and negative instances. Journal of Experimental Psychology, 1953, 45, 175-182.

Keller, J. The relationship of auditory memory span to learning ability in high-grade mentally retarded boys. American Journal of Mental Deficiency, 1957, 61, 574-580.

Kimball, A. W. Short-cut formulas for the exact partition of X^2 in contingency tables. Biometrics, 1954, 10, 452-458.

Lanzetta, J. T. Information acquisition in decision making. In O. J. Harvey (Ed.), Motivation and social interaction. New York: Ronald Press, 1963.

Luchins, A. R. Mechanization in problem solving. Psychological Monographs, 1942, 54, (6, Whole No. 248)

Maltzman, I. On the training of originality. Psychological Review, 1960, 67, 229-242.

Miller, G. A. The magical number seven, plus or minus two: some limits on our capacity for processing information. Psychological Review, 1956, 63, 81-97.

Porteus, S. D. The Porteus Maze Test and intelligence. Palo Alto: Pacific Books, 1950.

Posner, M. I. Memory and thought in human intellectual performance. British Journal of Psychology, 1965, 56 197-215.

Posner, M. I., & Rossman, E. Effect of size and location of informational transforms upon short-term retention. Journal of Experimental Psychology, 1965, 70, 496-505.

Sarason, S. B., Davidson, K. S., Lighthall, F. F., Waite, R. R., & Ruebush, B. K. Anxiety in elementary school children. New York: Wiley, 1960.

Spence, J. T., & Spence, K. W. The motivational components of manifest anxiety: drive and drive stimuli. In C. D. Spielberger (Ed.), Anxiety and behavior. New York: Academic Press, 1966.

Sieber, J. E. A paradigm for experimental modification of the effects of test anxiety on cognitive processes. American Educational Research Journal, 1969, 6, 46-61.

Spielberger, C. D. The effects of manifest anxiety on the academic achievement of college students. Mental Hygiene, 1962, 46, 420-426.

Spielberger, C. D. (Ed.) Anxiety and behavior. New York: Academic Press, 1966.

Stevenson, H. W., & Odom, R. D. The relation of anxiety to children's performance on learning and problem-solving tasks. Child Development, 1965, 36, 1003-1012.

Waite, R. R. Test performance as a function of anxiety and type of task. Unpublished doctoral dissertation, Yale University, 1959.

Wallach, M. A., & Kogan, N. Modes of thinking in young children. New York: Holt, Rinehart and Winston, 1965.

Watson, D. Relationship between locus of control and anxiety. Journal of Personality and Social Psychology, 1967, 6, 91-92.