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ABSTRACT

Five studies were conducted to investigate the relationship between short term memory (STM) and long term memory (LTM), and the relationship between STM and problem solving. In study I, the necessity of postulating separate learning processes for tasks which are traditionally classified as STM tasks as opposed to LTM tasks was investigated. Results indicate, for both Study I and Study II, that the same storage system is involved in learning a span series, requiring only one presentation and in learning a supra-span series, requiring multiple presentations. In Study III an investigation was made of the relationship between memory span and the retention of a sub-span series of numbers following a period of intervening activity. Results showed that large memory span subjects (Ss) show better recall after intervening activity than small span memory Ss. In Study IV two experiments were performed to determine whether memory capacity measured by a digit span (DS) test is the same memory capacity involved in solving syllogistic reasoning problems mentally. Conclusions bore out the above hypothesis, however, training in solving problems reduces the load that is placed on STM. Two experiments in Study V showed that memory capacity measured by a DS test is also involved in storing "Meaningful" English words when the words are stored verbatim. (Author/KJ)

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The Importance of Memory Span and Training in Reasoning Ability.

Arthur Whimbey

California State College
at Hayward
Hayward, California

Nov. 1968

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Summary

Five studies were conducted to investigate the relationship between short term memory and long term memory, and the relationship between short term memory and problem solving. In study I two experiments were performed to investigate the necessity of postulating separate learning processes for tasks which are traditionally classified as STM tasks as opposed to LTM tasks. Digit span (DS) and serial learning (SL) were selected to represent STM and LTM respectively and two transition tasks were created which had intermediate values on the dimensions that define the descriptive differences between DS and SL. Both transition tasks involved successive presentations of supra-span series of two-digit numbers. In the first study 27 series varying between 6 and 8 numbers in length were presented aurally twice in succession. The second study used 10 series of 7 numbers, and each series was presented 5 times in succession. In both studies, performance on the transition tasks were highly related to performance on a DS test. These data were interpreted to indicate that the same storage system is involved in learning a span series, requiring only one presentation and in learning a supra-span series, requiring multiple presentations. Furthermore, a learning strategy used by one of the Ss served to illustrate the possibility that task-specific learning strategies are largely responsible for the low correlations that have been found among various learning tasks.

The DS test was found to correlate very highly with a mental addition test in study II. The items of the mental addition test were presented by tape recorder and the S was required to remember two lines of numbers and then add the numbers in his head. The results suggested that the ability measured by a digit span test may be important in any task requiring information storage for a very short period of time, while other information is being received and processed. A span test apparently measures an important intellectual ability in spite of the fact that digit span and other learning measures have not been found to correlate highly.

In study III an investigation was made of the relationship between memory span and the retention of a sub-span series of numbers following a period of intervening activity. Memory span was measured by a DS test. The sub-span retention test involved the following procedure. A series of 4 single digit numbers was presented aurally which the S was required to repeat back immediately. The S then read 6, two-digit numbers from a sheet of paper after which recall of the original 4-digit series was attempted. A high relationship was found to exist between the two tests. It was concluded that large memory span Ss show better recall after intervening activity than small memory span Ss. Original learning of the sub-span series may have been stronger for the former group and may have been responsible for the observed difference.

Study IV consisted of two experiments performed to determine whether the memory capacity which is measured by a DS test is the same memory capacity that is involved in solving syllogistic reasoning problems mentally. In one study Ss were trained to solve syllogistic reasoning

problems using a Venn diagram method, for three days. An aurally presented syllogistic reasoning test was then administered, but the scores on the test did not show a relationship to scores on a DS test. In a second study, an aurally presented syllogistic reasoning test was administered to a group of Ss before training. The Ss were then trained for four days after which a parallel form of the syllogism test was administered. Scores obtained on the pre-training test were found to be highly related to DS scores, whereas, scores on the post-training test again bore no relationship to DS. It was concluded that the DS test does measure the memory capacity involved in solving syllogistic reasoning problems mentally, but that training in solving the problems reduces the load that is placed on STM.

Two experiments were performed in study V to determine whether the STM which is measured by a DS test is the same memory that is involved in storing the information of an aurally presented verbal analogies (VA) test. The VA test consisted of four-choice problems in which the four alternatives were presented first, followed by the problem. The two tests were found to correlate significantly when the alternatives of the VA test were presented at a 1/sec. rate so that the alternatives had to be stored verbatum and without rehersal. The correlation dropped to zero however when the alternatives were presented at the rate of 3 sec./alternative and the Ss were instructed to try to form pictorial or verbal associations among the alternatives, and to reherse them. It was concluded that the memory capacity measured by a DS test is also involved in storing "meaningful" English words when the words are stored verbatum.

Introduction

A number of psychologists have assigned a major role to memory in their analyses of different types of human thinking and intelligence (Garrett, 1928; Jensen, 1964; Miller, 1956). George Miller (1956) for example described the role of memory as follows:

"The intimate relation between memory and the ability to reason is demonstrated every time we fail to solve a problem because we fail to recall the necessary information. Since our capacity to remember limits our intelligence, we should try to organize material to make the most efficient use of the memory available to us. We cannot think simultaneously about everything we know. When we attempt to pursue a long argument, it is difficult to hold each step in mind as we proceed to the next, and we are apt to lose our way in the sheer mass of detail."

In contrast to this theoretical interest, few studies have obtained a significant correlation between reliable memory measures and problem solving. In fact a number of studies investigating the relationship between different memory measures have obtained only very low correlations among memory measures themselves (Jensen, 1962). This has resulted in distinctions being made between long term memory and short term memory, memory for meaningful material and memory for meaningless material, memory capacity involved in serial learning as opposed to memory involved in paired associate learning, etc.

In this paper five studies are reported which investigated the relationship between different memory measures, and the relationship between memory measures and problem solving. Each of the studies was directed at a slightly different aspect of the problem and therefore each will be presented separately. The five studies do have one thing in common; each study has investigated the relationship between short term memory as measured by a digit span (DS) test and some other memory or problem solving variable. The DS test was used as a common starting point in this series of studies because of the recent interest in short term memory (Ellis, 1963; Jensen, 1964) and because a DS test has been included in many major intelligence tests.

STUDY I

Memory Span, Serial Learning and Learning Strategies

In experimental and psychometric studies of learning and memory a distinction is made between short term memory (STM) and long term memory (LTM). Melton (1963) has observed that the distinction is generally based either on the time interval between presentation and recall of the material with some arbitrary point separating STM from LTM, or on whether there is single or multiple presentation of the material. Experimental results have generally indicated that STM and LTM are continuous and are both subject to the same laws (Melton, 1963). Correlational research however has supported a sharp distinction between span memory (presumably STM) and other memory variables (e.g. French et al, 1963).

Although span tests have been found to correlate very low with tasks that are considered LTM measures, LTM measures have often been found to have very low correlations with each other. For example, Jensen (1962) reported a near zero correlation between serial learning and P-A learning, both of which might be regarded as LTM tasks. This suggests that the low correlation of span tests with other measures should not be explained as STM vs LTM until more systematic research is carried out.

Underwood (1967) has suggested that experimental psychologists use transition tasks to study the relationship between traditional learning tasks. Transition tasks seem very appropriate to correlational studies of learning and memory also. By systematically varying the dimensions along which tasks differ, the variables which lower the correlation between them can be isolated.

In the present research digit span and serial learning have been chosen to represent STM and LTM respectively in accordance with Melton's distinction based on single vs. multiple presentation. These two tasks differ in the following ways. A Ss span memory is basically the number of items that can be remembered correctly, in order, after only one presentation; serial learning involves a supra-span series requiring multiple presentations for mastery. Span tests require recall of the entire series whereas in serial learning each item is the nominal stimulus for the succeeding item. Finally, span tests generally use digits whereas nonsense or real words are generally used in serial learning.

This study includes two experiments using digit span and transition tasks based on the above differences between digit span and serial learning.

Experiment 1

The first experiment investigated the relationship between a digit span test and a transition task involving two successive presentations of supra-span series of numbers.

Method

Subjects

The Ss consisted of 21 students from a Tests and Measurement class and 30 students from an Individual Differences class at Cal State.

Tests

Digit Span (DS) Test. This test is described in detail in a previous publication (Whimbey and Leiblum, 1967). Basically it consisted of 30 series of numbers varying between five and nine digits in length. Each series was followed by one of six words. The S was required to listen to the series, look up a letter corresponding to the word on a reference sheet, write the letter, and then attempt to write the series. A S was given credit for a series only if it was recalled completely correctly in order.

Transition Task 1 (TT1). This test consisted of 27 series of two-digit numbers. The series varied between six and eight two-digit numbers in length. Each series was repeated twice in succession. The Ss heard the series once and then wrote down as many of the numbers as could be recalled. They then turned to another answer sheet, heard the series a second time and again wrote as many as could be recalled. None of the Ss in the experiment recalled any of the series completely correct on trial 1, so all of the series were supra-span for these Ss. In the instructions it was emphasized that the Ss should try to recall as many numbers as possible on trial 1 rather than use any strategy which would increase the score on trial 2 at the expense of trial 1. The test proper was preceded by four practice trials. Each series was scored by counting the total number of two-digit numbers correctly recalled, irrespective of the ordinal position. The total score for each S was the total correct over all 27 series. A separate score was obtained for trial 1 and trial 2.

Procedure

The tests were given during two class periods, separated by two weeks, with the DS test administered first.

Results

To avoid the possibility of the correlations being inflated by a mean difference between the test scores of the two classes, correlations were computed separately for each class. Weighted averages were then obtained using the Fischer Z transformation, and these are reported below.

The correlation of DS with trials 1 and 2 of TT1 were .71 and .60 respectively. The stepped-up odd-even reliabilities of DS, trial 1 and trial 2 were .88, .77, and .75. Correcting for attenuation due to unreliability, the correlation of DS with trial 1 was .86 and with trial 2 .74.

As expected, Ss recalled significantly more numbers on trial 2 than on trial 1 (t = 11.8, p .01). To determine whether high DS Ss gained more from the second presentation than low DS Ss, the gain scores were computed for the Ss above the 75th percentile or below the 25th percentile (12 Ss in each group) on the DS test. The mean gain scores were 16.4 and 22.3 for the two groups respectively. For the high DS group four Ss had gain scores of -3, -2, 2, and 6, and the remaining eight ranged from 14 to 34. For the low DS group the scores ranged from 15 to 33. Thus the mean difference between the two groups was produced by four low gain scores in the high DS group. For the remaining eight Ss in the high DS group, the mean gain score was 22.7.

Discussion

The high correlation of DS with trial 1 of TT1 indicated that the processes involved in learning a sub-span or span length series do not differ from the processes involved in attempting to learn as many numbers as possible from a supra-span series. The correlation between DS and trial 2 performance seemed to be due to the initial advantage that high DS Ss had over low DS Ss on trial 1. High DS Ss did not gain more between trial 1 and 2 than did low DS Ss. Actually, however, based solely on a consideration of PI, the high DS Ss might have been expected to gain less from the second presentation than the low DS Ss. All of the Ss above the 75th percentile of the DS test did recall more numbers on trials 1 than any of the Ss below the 25th percentile and were therefore more susceptible to PI on trial 2. Since most of the Ss in the high DS group gained as much as the low DS group, the high DS group may have actually gained more if differential PI were taken into account. More detailed laws of PI are needed before this possibility can be tested.

Experiment 11

This study began as an experiment to extend the findings of experiment 1. It was terminated before completion when data were obtained which indicated a flaw in the procedure. However, this flaw provided an extremely clear illustration of a learning strategy which would tend to reduce the correlation between DS and serial learning.

Method

Subjects

The Ss were introductory psychology students at Cal State who were required to participate in several experiments. Ss were selected who were below the 25th percentile or above the 75th percentile on the DS test. Ten low DS Ss and four high DS Ss were used.

Tests

Digit Span (DS) Test. This test was exactly the same as the DS test used in experiment 1.

Transition Task 11 (TT11). This test consisted of 10 series of seven two-digit numbers presented at a 2/sec. rate. Each series was presented five times in succession and the S wrote as many numbers as could be recalled, in order, after each presentation. All 10 series were supra-span for the Ss used in this experiment.

Procedure

For both tests the Ss were group tested. Between one and eight weeks intervened between the tests for various Ss.

Results

Of the four Ss in the high group, one S recalled eight of the 10 series correctly on the fifth recall trial, one recalled six, one recalled five and one recalled four. Of the Ss in the low DS group, one recalled five series, one recalled three, one recalled one, and seven didn't recall any of the series correctly after the fifth presentation.

Discussion

The data indicate that Ss who have a large memory span will tend to learn faster on a multiple presentation learning task. Of major interest, however, is the low DS S who recalled five series correctly. The junior author, who scored the DS test, noticed that the DS answer paper of this S was unique among the 500 or so Ss that had been tested. In the instructions for the DS test, the Ss are told to attempt to get each series completely correct; it is emphasized that no partial credit is given. The Ss are also told to guess when they are uncertain. With these instructions the answers vary in length, corresponding roughly to the variation in the length of the items. Furthermore, for the items which are not completely correct, correct digits are found across all positions of the items. However, for this one unique S, 28 of the 30 answers were four digits in length. In 20 of these, the four digits corresponded correctly to the first four digits of the respective series; the other eight had small errors. The remaining two of the 30 answers were five digits in length. These were answers to items which were actually five digits long, but both answers were incorrect.

The four digit answers to 28 items indicated that this S did not attempt to recall each series completely, but concentrated only on recalling the first four digits correctly. While this procedure did not raise the DS score, it was evidently an effective strategy for learning a supra-span series over a number of trials. Inspection of this S's TT11 answer sheets showed that the first few numbers were learned well on trial 1 and were seldom missed on later trials. A few more numbers were systematically added on each successive trial. This was in contrast to the answers of most other Ss which showed some resemblance to a serial-position curve.

Experiments 1 and 11 together indicate that Ss who score high on a DS test have an advantage on trial one of a multiple presentation task, and this advantage tends to be maintained in later trials. Apparently the same storage system is involved in a DS task and a multiple presentation task. The data also indicate the powerful effect of learning strategies. With longer lists and a greater number of trials, task-specific learning strategies might actually account for the major portion of the individual differences of learning tasks. These learning strategies would be especially important in research using college sophomores who are quite homogeneous with respect to "general learning ability." This would explain the low correlations that have been obtained even among LTM tasks. With better control of learning strategies, very high correlations might be found among different learning tasks, and the STM-LTM distinction would be seen as artificial.

Study II

Memory span has generally emerged as a separate and fairly independent factor in factor analytic studies of memory (Kelly, 1954; French et al, 1963). Low correlations have also been found between span tests and other cognitive abilities (Wechsler, 1958, p. 70). Together these studies suggest that span tests measure a fairly narrow ability which is involved in few other cognitive functions. However, rationally this does not seem plausible. Many problem solving tasks appear to involve the capacity to store some information for a short period of time while other information is being received or processed; and span tests appear to be the purest measure of this capacity.

Jensen (1964) has pointed out that the span tests used in many previous studies were very unreliable and therefore could not be expected to correlate highly with other measures. In a previous study (Whimbey and Leiblum, 1967), reliable tests of memory span were developed and it was found that a span test which involved an intervening activity between the presentation and recall of the digit series correlated very highly with a span test which did not involve intervening activity. However, even if a reliable span test is used, its correlation with a problem solving task might not be impressively high since such tasks usually involve additional abilities which are unrelated to span. In order to show conclusively that the capacity measure by a span test is involved in certain other information processing and problem solving activities, a mental addition test was developed for the present experiment. This task seemed to involve storing information for a short period of time, while not requiring any other abilities in which college students would be expected to differ greatly.

Experiment I

Method

Subjects

The sample consisted of 40 students in Introductory Psychology.

Tests

The digit span test is the same as that used in study I.

The mental addition test consisted of 30 items of the following type: "You have 8A, 3B, 2C, and 5D and you add to this 2B and 5D. How many of each category do you now have?" The correct answer is 8A, 5B, 2C, and 10D. The items varied in the number of quantities presented and the number of necessary arithmetic operations. The items were presented by a tape recorder and the *Ss* were not permitted to write anything except the final answer. The *Ss* were provided with special answer sheets which had the letters A, B, C, and D printed on them so that in answering each item the *S* merely wrote the quantity in each category and left blank any category which was not used in that item. Before taking the test, the *Ss* received detailed instructions, including 2 demonstration examples and 4 practice problems.

In scoring the test, an item was counted only if the answer was completely correct. Furthermore the items were given different weights according to the number of quantities which had to be retained and the number of necessary addition operations. For the example presented above, there are six numbers to be remembered and 2 addition operations so it was assigned a weight of 8.

Procedure

The span test and the mental addition test were both given in one 50 minute session. The span test was administered first, and the mental addition test followed immediately without any rest. Ss were tested in groups of 13 or 14.

Results

The correlation between the digit span and the mental addition test was .67, which again is very high in view of the reliabilities of the tests. Furthermore, in other experiments using samples of Ss from the same population, the digit span test did not correlate with several other measures of learning such as serial learning and free recall of a list of words. This is in agreement with the results obtained in previous research (Kelly, 1954) and indicates that other variables such as motivation are not responsible for the observed correlation.

Discussion

Although it is true that the mental addition test used in the present experiment was designed to put a strain on span memory, this appears to be a characteristic of many real-life problem solving situations. Most psychometric tests are of the paper and pencil variety and the facts of the problem remain available and can be referred to. But in situations such as the classroom, where a problem is presented a single time verbally, information storage does become an important factor. Moreover, if the details of the problems are presented in a form which can be referred to, having to refer back frequently can be quite inefficient and time consuming.

Study III

Memory Span and Retention of a Subspan Series

A Ss memory span (MS) is the number of items (usually digit) that can be recalled correctly, following one presentation of the material. In several studies a digit span test has been found to correlate highly with simple problem solving tasks. In each of these tasks the procedure has been to present items of varying length aurally and to not allow the Ss to write any portion of the answer until the item is completely presented. One of the tasks for example was a mental addition task requiring the addition of a variable number of quantities after the presentation of the complete item.

One obvious possible reason for the inferior performance of low MS Ss is that the longer problems could not be recalled perfectly by the time the presentation was completed. The question that remains is whether low MS Ss also perform more poorly on shorter problems, which can be recalled perfectly immediately after presentation. Lower MS Ss might tend to forget the facts presented in the original problem more readily during the period of thinking that intervenes between the presentation and the solution.

In order to test this Ss were presented material which could be recalled perfectly immediately after presentation. They were then retested for recall after a short period of intervening activity, and these recall scores were correlated with scores on a memory span test.

Method

Subjects

The Ss were 39 students taking an introductory psychology course and serving in the experiments as a course requirement.

Tests

Digit Span (DS) Test. Same as study I.

Intervening Acitvity (IA) Test. This test consisted of 30 items which were similar to a task used previously by Peterson and Peterson (1959). A series of four single digit numbers were presented aurally at a 2/sec. rate and the S was required to repeat the series back immediately. Six two-digit numbers were then presented aurally at a 2/sec. rate and the S was required to read these numbers aloud as they were being presented, from a sheet given him at the beginning of the experiment. The S then attempted to recall the series of four single digit numbers. The entire test was presented by tape recorder with a 2 sec. repeat interval and a 13 sec. recall interval. The S's score was the total number of four digit series recalled correctly after the intervening activity. It may be noted that the intervening activity used in this test differed slightly from that used by Peterson and Peterson (1959). It produced greater uniformity with regards to both rate of intervening acitvity and lack of rehersal, which is extremely important in an individual differences study.

Procedure

The DS scores were obtained in a group testing situation, with about 15 Ss tested per group. The Ss were brought back to the laboratory and individually tested to obtain the IA scores. From one to eight weeks intervened between the time that the two measures were obtained for various Ss.

Results

It was expected from previous research that four single digits would be sub-span for this population, and in fact all of the Ss in the experiment were able to correctly repeat all of the series presented in the IA test immediately after presentation.

Regarding the recall after the intervening activity, the correlation between the DS and IA tests was .55. This is a high correlation in view of the fact that between one and eight weeks intervened between administrations; reliability estimates obtained under these conditions would probably not be much higher.

A more concrete indication of the relationship between the two tests is obtained by noting the IA test performance of the Ss who scored below the 20th percentile, or above the 80th percentile on the DS test. The former group recalled an average of only 9.5 items correctly after the intervening activity, whereas the latter group recalled an average of 22 items. Furthermore, none of the Ss below the 20th percentile on the DS test scored above the 80th percentile on the IA test.

Discussion

The results indicate that high MS Ss will show better recall after a short period of intervening activity than low MS Ss, following one presentation and repetition of the material. Of course it cannot be concluded from the present experiment that the difference would be obtained if the two groups were brought to the same level of original learning. It is possible that the original learning of the sub-span series was stronger in the high MS Ss than in the low MS Ss and that this difference was maintained over time. The results do however point out the two fold advantage that a high MS S has in solving problems which require storing some information for a short period of time. Not only can the information of larger problems be grasped after only one presentation, but the information of smaller problems can also be remembered better in spite of intervening activity.

If it is assumed that after one presentation, original learning of a sub-span series is stronger for high MS Ss, than for low MS Ss the observed difference following the intervening activity is very consistent with, and seems even predictable from, previous experimental research (Underwood, 1964). Confirmation in an actual pyschometric study is however reassuring, especially in view of the number of different "memory factors" that have been found in factor analytic studies of memory (French et al, 1963; Jensen, 1964).

Study IV

The Role of STM and Training in Solving Reasoning Problems Mentally

Although a number of psychologists have postulated that STM is a factor in problem solving, few studies have obtained a significant correlation between these two variables. In a previous study a high correlation was found between a digit span (DS) test and a mental addition (MA) test. The MA test was presented aurally and consisted of two rows of numbers varying in length which were to be added together when the presentation of the item was completed. It was concluded from the data that the memory capacity which is measured by a DS test is the same memory capacity that is involved in storing some information for a short period of time while other information is being received and processed in a simple problem solving task. The MA test was used in the study because it was believed that college students would not vary greatly in numerical ability as measured by an untimed paper and pencil addition test. Thus, any possible relationship between the memory capacities involved in the two tasks would not be attenuated by other sources of variance.

Experiment I

Experiment I of the present study was an attempt to extend these findings by investigating the relationship between DS and the ability to solve more complex problems mentally. It was hypothesized that in order for a possible relationship to be exhibited, it would be necessary to pre-train the _Ss_ to reduce individual differences due to differential experience with the type of complex problems used. Certain types of syllogistic reasoning problems were chosen since an effective method of solving these problems, using Venn diagrams, could be taught in a short period of time. The study consisted of first training the _Ss_ so they could all solve the problems easily when the problems were presented in written form and the _Ss_ were permitted to draw Venn diagrams. Under these conditions, memory is externalized and solving the problems places little strain on the _S_'s STM. Syllogistic reasoning problems were then presented aurally and the _Ss_ were required to solve the problems mentally. It was expected that performance under the latter conditions would be related to scores on a DS test.

Method

Tests

DS Test. Same as study I.

Syllogistic Reasoning (SR) Test. This test consisted of 40 four-choice syllogistic reasoning problems. Nine items involved two premises, 28 involved three premises, and three involved four premises. The SR test was administered to the _Ss_ twice, once in aural form and once in written form. For the aural administration the _Ss_ were given a booklet which only contained the four alternative answers for each question. The premises were presented by tape recorder, and the Ss were not allowed to write or draw anything except circle one alternative. The time allowed for each solution varied at the ratio of five seconds per premise. For the written administration the premises and alternatives were both printed in booklets and the Ss were allowed to draw Venn diagrams.

Training

In three 50-minute sessions the Ss were trained to use a Venn diagram to represent the premises of a problem and to draw the correct conclusion from the diagram. During the first training day, the Ss were taught to represent the "all", "some" and "none" relationship between two sets. Examples of real life relationships (all men are human) as well as nonsense relationships were used. The Ss were then taught to represent three or more sets presented in two or more premises. Training on days two and three consisted of giving the Ss booklets containing 10 four-choice problems. For each problem the Ss attempted to draw the diagram and select the correct conclusion. After all of the Ss completed a given problem, and S was chosen at random and was asked to tell E how to draw the diagram on the blackboard and to explain why each of the alternatives was correct or incorrect. At the end of the session on day two, the Ss were given a 6-item quiz in which both the premises and the alternatives were printed. Those were scored, returned and reviewed on day three. At the end of the day three session, the Ss were given booklets with five sets of four alternative answers, but no premises. The premises were read by E and repeated as often as necessary, and the Ss were allowed to draw a Venn diagram before selecting an answer. Each of the problems was reviewed and explained by E after all five had been presented.

Subjects

The Ss were introductory psychology students at Cal State. From the students who had previously taken the DS test, those scoring in the top and bottom quarter were contacted and offered $1.25/hr. to participate in this 5-hour experiment. They were also told that they would receive three cents per item for every item correct on the tests administered on days four and five. Ten Ss in the upper quarter of the DS test (HDS) and 13 Ss in the lower quarter (LDS) began the experiment. Two HDS Ss and one LDS S were lost before completion, leaving eight and 12 Ss in the two groups respectively.

Procedure

The Ss were trained and tested in three groups of about seven Ss per group. Training required three days. On the fourth day the aural form of the SR test was administered and the written form was administered on day five.

Results

On the written form of the SR test almost all of the Ss scored very highly. One HDS S got only 31 of the 40 items correct. For the remaining Ss the frequency distribution of scores was: 38-3, 39-4, 40-12.

For the aural administration the scores of the HDS Ss ranged from 17 to 33 with a mean of 26.6 and the scores of the LDS Ss ranged from 17 to 35 with a mean of 27.5.

Discussion

When the experiment was begun, it was expected that only HDS Ss would be able to remember the premises while mentally drawing the diagram and seeking the correct solution. The Ss were questioned after the experiment to determine why negative results were obtained. It appeared that the training had two effects. First, as a result of familiarization with the syllogistic problems, immediate verbatim recall of the premises became easier. Secondly, it was no longer necessary to actively construct the Venn diagrams. The diagram patterns corresponding to various premise patterns were already stored in long term memory and were visualized as the premises were presented. Having to construct the diagrams would have been detrimental to the recall of the premises, just as other activities intervening between presentation and recall have been shown to be detrimental to recall (Conrad, 1960). Having the diagram patterns stored in LTM not only reduced this intervening activity, but actually aided the recall of the premises by allowing the premises to be stored in visual form as well as verbal form.

The above explanation of the negative results is of course ad hoc. Experiment II was performed to make a direct test of the hypothesis that the memory capacity which is measured by a DS test is the same capacity that is involved in mentally solving syllogistic reasoning problems, but that training can in fact reduce the load on memory.

Experiment II

A syllogistic reasoning test was administered aurally to a group of Ss before they were trained in the use of the Venn diagram method, and a parallel form of the test was administered after training. Scores on both tests were compared to scores on a DS test.

Method

Tests

DS Test. Same as in Experiment I.

Logical Reasoning (LRI & LRII) Tests. An aurally presented syllogistic reasoning test was needed which would produce a distribution of scores among college students who had not recently been trained in syllogistic reasoning. Pilot research indicated that the SR test was too difficult under these conditions, but the Logical Reasoning (LRI) Test (Hertzka and Guilford, 1955) seemed appropriate. This test consists of 40 two-premise syllogisms. The syllogisms were recorded on magnetic tape and the four choices for each item were printed in booklets. A parallel form (LRII) of the test was constructed by substituting different words into each of the premises and then rearranging the order of the items.

Subjects

The Ss were 36 students taking a Differential Psychology course at Cal State.

Procedure

The DS test was administered to all of the Ss in one group session. Two weeks later, the LRI test was administered to the entire group. The Ss were then trained for four days. The training was similar to that described in Experiment I, except that one more day of practice and discussion was added. The LRII test was administered on the day following training.

Results

The scores on LRI ranged from 16 to 38. A high relationship between the tests was indicated by the fact that none of the 12 Ss scoring in the top third of the LRI distribution score in the bottom third of the distribution of DS scores. This relationship is statistically significant at the .01 level. Of the 12 Ss scoring in the bottom third of the LRI test seven were in the bottom third of the DS scores, three were in the middle third, and two were in the top third. These results support the hypothesis that the memory ability measured by the DS test was necessary but not sufficient for good LRI performance. Questioning revealed that about one-half of the Ss scoring in the top third of LRI and one-half the Ss in the bottom third of LRI had taken a formal logic course in college, but that none of the Ss had taken such a course within the previous three months.

Regarding the performance after training, all Ss were able to solve syllogistic reasoning problems by drawing the appropriate Venn diagram, by the fourth day of training. Some of the Ss were actually able to do this on training day two, whereas other Ss were still making some errors on day three. Thirty-two Ss were present for all four training sessions and took the LRII test. The distribution of scores for this test was: 33-1, 35-3, 36-5, 37-3, 38-8, 39-7, 40-5. Although there was obviously very little variation among these scores, they were related to the DS test as follows. Among the Ss scoring in the top third of the LRII test, three were in the bottom third of the DS test, three in the middle third, and five in the upper third. Of the Ss who scored in the lower third of the LRII test five were in the bottom third of the DS test, four in the middle third, and two in the upper third.

Discussion

The results indicate that the STM which is measured by a DS test is the same memory capacity that is involved in solving syllogistic reasoning problems mentally. The high scores that were obtained by all of the Ss on the LRII test shows that training does compensate for a poor STM in solving problems mentally. This latter conclusion is subject to the following qualification. First, the problems used in this study could all be solved by applying a limited number of specific rules. Second, the training was very recent so the procedures and possible problem patterns were readily available to the Ss. Third, the items were only two-premise problems which, following training, could be recalled by the Ss after one presentation. It is possible that difference between high and low STM Ss would appear again if three or four-premise problems were used. This possibility was not adequately tested in Experiment I; the SR test was not designed with this question in mind. Finally, all of the Ss in the study were college students and were thus, presumably, above a certain level in terms of short-term and long-term memory capacity.

Study V

The basic rational of this experiment was to compare the correlation of the DS test with two forms of an aurally presented, multiple-choice verbal analogies (VA) test. For one group of Ss the four alternatives of the VA test were presented at a rapid rate so that rehersing and forming visual or verbal association among the alternatives would be difficult or impossible. A second group was instructed in the use of the above strategies and took a VA test in which the alternatives were presented at a slower rate.

Method

Tests

The DS test is the same as that used in Study I.

Verbal analogies (VA) Test. This test consisted of 30, four-choice verbal analogies of the following type: a. Telephone, b. Woman, c. Chair, d. Book; Boy is to man as girl is to ? The items were presented aurally by tape recorder with the alternatives presented first as illustrated above. In the fast form of the VA test the alternatives were presented at the rate of one/sec. In the slow form the alternatives were presented at the rate of three sec./alternatives. Furthermore, the group of Ss to whom the slow form was administered were instructed to try to form pictorial or verbal associations among the alternatives of each item.

Subjects

The Ss were students taking a course in introductory psychology. Twenty-nine Ss took the DS test and the fast form of the VA test and 30 different Ss took the DS test and the slow form of the VA test.

Procedure

The Ss were tested in groups of about 8. Both the DS and VA test were administered in one, 50-minute session with the DS test administered first.

Results

The group taking the fast form of the VA test had a mean score of 13.35 whereas the group mean for the slow form was 16.78. The correlation between the DS test and the fast form of the VA test was .57. The DS test and the slow form of the VA test correlated .05. This difference is statistically significant at the .02 level.

Discussion

The results indicate that short term memory for a series of unrelated numbers correlates highly with memory for English words when the words are stored in a fairly verbatim manner, without rehersal. The data further indicate that the load on memory can be reduced by rehersing the material and by forming associations. However both of these strategies require time, attention and effort and to the degree to which these are not available individual differences in short term memory will be important.

Regarding the strategy of forming associations, verbal and visual associations can be formed more readily with some material (e.g., English words) than with other material (e.g., unrelated numbers). This combined with individual differences in the ability to form various types of associations and individual differences in motivation to make the necessary effort could be responsible for the apparent distinction between memory for meaningful and for meaningless material. An experiment is necessary to determine the correlation between verbatim memory and memory for material to which associations have been made, under the condition that all Ss use basically the same types of associations, with about equal facility.

In the present experiment the effects of rehersing and of forming associations were not evaluated separately and Ss reported using both techniques on the VA test. Evaluating these strategies separately would be difficult since rehersal becomes possible when presentation rate is decreased in order to allow time for associations to be formed. In fact, considering and reconsidering the material, while attempting to form associations, is a form of rehersal.

Conclusions and Recommendations

In spite of all this positive evidence certain qualifications must be made regarding the importance of memory. Studies I, IV, and V illustrated the powerful effects of mnemonic strategies and training. Because of this, memory variables may not account for a large proportion of the variance in cognitive tests when a fairly homogeneous group such as college students is used; IDs in memory will only be very evident in comparisons of extreme groups such as normals vs. retardates. It is however possible that memory would be the limiting factor on intelligence, if variance attributable to mnemonic strategies, strategies for problem solving, critical attitudes, interests, etc. were reduced through education.

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