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Long term retention differences as a function of subject ability/

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LONG TERM RETENTION DIFFERENCES AS A FUNCTION OF SUBJECT ABILITY

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The present study is an investigation of the retentive capacities of subjects with known differences in learning ability. Several recent studies (Gregory and Bunch, 1959; Stroud and Schoer, 1962; Shuell and Keppel, 1970; Shuell and Gigili, 1973) have suggested that such differences are minimal. This paper will review an experiment in which seventy-six subjects, equally divided into bright and average groups, learned a categorizable free-recall list of words. Unlike the several recent studies mentioned above, the experimental results suggested a superiority of retention ability in the higher ability subjects. These findings will be discussed in terms of the differences between the present and previous studies.

Intelligence test scores were used in this study as the criterion for the selection of high ability and average ability groups because the intelligence test score has had general acceptance among psychologists as an index of overall learning ability. Most will agree that the presence of intelligence is evidence of memory, while memory in itself is not proof of intelligence.

Memory and intelligence are two concepts that may be variously, but still aptly defined; the significance of both in learning is acknowledged, but their precise relationship to each other in the achievement of a learning task remains an important and unresolved question.

The analyses of many memory experiments have indicated quite conclusively that memory involves a minimum of three stages (acquisition, storage, and recall or recognition) and can be divided into two components, short-term memory, which covers an interval of seconds at most, and long-term memory, which may continue for hours, days, or indefinitely (Hebb, 1949; Broadbent, 1958; Waugh and Norman, 1965; Baddely and Dale 1966; Milner, 1967). Studies of memory primarily deal with the third stage, recall and recognition, because this stage lends itself to observation and measurement in the laboratory. Experimental evidence suggests that verbal material is encoded acoustically in short-term memory, while semantic factors are involved in long-term memory (Kintsch, 1970).

The exact nature of intelligence has been investigated extensively, defined variously, and disputed endlessly, but the complexity of the psychological functions involved in a single intelligent act have yet to be defined in a manner acceptable to all investigators. Nevertheless, there is considerable agreement that intelligence involves several demonstrable abilities; these factors are often described as verbal, word fluency, space, number, memory and reasoning factors (Thurstone, T. G., 1941; Spearman, 1904; Binet and Simon, 1905-1908; Thurstone, 1926; Wechsler, 1950; Cattell, 1957).

In his discussion of human intelligence Fleishman makes the necessary distinction between human abilities and skill (achievement); he describes the former as being observable in

the performance of several kinds of tasks, and skill as a level of efficiency attained in a specific area, such as reading, driving a car, etc. Fleishman urged that more attention be given to the discovery of the relationship that must exist between individual differences in intelligence and memory by learning researchers and theorists (Fleishman, 1969).

Jensen (1969) contended that "intelligence, like electricity, is easier to measure than to define." His suggestion that intelligence may be defined as that which is measured by I.Q. tests has not had the acceptance of others in the field. Humphreys, for example, offered this definition: "Intelligence is defined as the totality of responses available to the organism at any one period of time for the solution of intellectual problems" (Humphreys, 1962, 1970). He suggested that his definition eliminated the differences in kind between intelligence and achievement, and between aptitude and achievement. He specified three dimensions in which tests of intelligence, aptitude and achievement would differ: breadth, involvement with a particular educational program, and the recency of the learning sampled. Hunt and Kirk (1971) also affirm that intelligence, aptitude and achievement involve performances that basically depend upon previous learning, abilities, and motives, although minor differences exist.

Several researchers have provided empirical evidence in support of Hunphrey's theory that intelligence, aptitude and achievement tests provide indices of nearly identical

mental abilities (Stake, 1961; Stevenson and Odom, 1965; Stevenson, Hale, Kline and Miller, 1968). Stake reported that his testing program involving 240 seventh grade public school children in a wide selection of verbal and nonverbal tasks provided support of intelligence defined as the abi lity to learn. Students who began tasks well usually finished well. In addition, he did not find any evidence of a significant difference in their performances of rote learning and relational learning tasks.

Another comprehensive study (Stevenson and Odom, 1965) of the interrelationships of children's learning abilities was undertaken with 354 children in grades 4 and 5. The series of paper and pencil tasks included Paired Associates, Concept Discrimination, Abstract Discrimination, Concept Formation, and Anagrams. Stevenson and Odom (1965) found that Paired Associates and Anagrams were the only tasks that consistently correlated with the obtained intelligence measures of the children. They suggested that the ability to organize verbal material was the specific ability tapped in these two experimental tasks and in verbal intelligence tests.

In still another extensive study (Stevenson et al., 1968) among pupils (243 boys and 232 girls in grades 3 through 7) in a variety of learning tasks, high correlations were found: (1) within and among learning and problem solving tasks; (2) in performance in these tasks and in academic performance as measured by school grades, achievement test scores and teachers' ratings; (3) in performance in these tasks and intelligence.

However, while all of these studies yielded results that confirm the relationship between intelligence, abilities, and achievement, none of the researchers addressed themselves to the discovery of the specific relationship that may exist between memory and intelligence. Although the literature contains inferential statements about the role of intelligence in the acquisition of learning tasks (Spearman, 1927; Metcalfe, 1966), few empirical studies had been undertaken. Most measurements of intelligence included rote memory tasks, but the originators of these did not attempt to assign to memory itself any sifnificant weight. It was generally agreed that intelligence, when present, included memory, but that memory itself was not evidence of intelligence.

Historical Background

Arthur Melton, in a conference on Learning and Individual Differences, reflected that "the sooner our experiments and our theory on human memory consider the differences between individuals in our experimental analyses of processes in memory and learning, the sooner we will have theories and experiments that have some substantial probability of reflecting the fundamental characteristics of these processes" (Melton, 1967).

Melton's statement attested to the fact that historically only minimal attention had been given to this area of research. In fact, most studies avoided the question of individual

differences altogether. The initial experimental work in verbal learning was conducted by Ebbinghaus, a German psychologist, who investigated his own mental processes. His well-designed studies with himself as his only subject primarily used nonsense syllables and poetry as materials to show the increments in learning occurring with repeated trials and the loss of knowledge observed after a period of time following his original learning (Ebbinghaus, 1885). Another early study also examined the learning and retention of a single individual (Woodworth, 1914). One of his experiments involved the learning of an English-Italian vocabulary of 20 pairs of words; overlearning was precluded by the omission of a pair immediately after it had been learned. Woodworth reported that quick learning favored retention; he dismissed subjective associations as insignificant in their overall effect.

Just as the careful studies of Ebbinghaus dominated research theory in verbal memory for a half-century, so did the studies of Gillette (1936) have a similarly strong influence upon the investigation of differences in learning ability and the retention of verbal material. She undertook a comprehensive and critical review of the literature, beginning with Ebbinghaus, and concluding with her own studies of grade school and Barnard College students. Her conclusion that rapid learning favors retention remained unchallenged for nearly twenty years.

Recent Research

It was not until 1954 that Gillette's findings were scored by Underwood who offered an extensive corroboration of his hypothesis that there is no difference in the rate of forgetting of slow and fast learners when the appropriate methodology is employed (Underwood, 1954). He pointed out that many researchers, including McGeoch, Kingsley, Munn, Hilgard and himself had accepted Gillette's findings as a generalization; as late as 1949 Underwood himself had written, "when learning is rapid, forgetting will be slow, and when learning is slow, forgetting will be rapid (Underwood, 1949). In his 1954 paper, he supported Gillette's rejection of the Method of Equal Amount Learned, and then offered convincing evidence that the Method of Adjusted Learning (used by Gillette, and earlier by Woodworth) was equally inadequate for the task of the measurement of the differences between slow and fast learners. He introduced a Technique for Equating Degtee of Learning for all subjects; this technique became known and accepted as the successive probability analysis for determining the growth of the associative function for each item. Underwood's analysis of his data led him to assert that there was no significant difference in the forgetting of slow and fast subjects when all subjects were equated for the degree of original learning.

Underwood's study (1954) emphasized one of the most difficult methodological problems in the study of individual

differences in learning ability. This problem involves the determination of the degree of original learning. He advised that unless all subjects have reached the same level of performance before the beginning of the retention interval, the subsequent differences in retention may only indicate differences in degree of original learning.

Several methods have been used to equate performance. These include lists of varying length, study periods of differing duration, varying the number of learning trials and providing different presentation rates.

A number of more recent studies support Underwood's finding that slow and fast subjects forget at the same rate when all subjects are equated for the degree of original learning (Gregory and Bunch, 1959; Stroud and Schoer, 1959; Schoer, 1962; Shuell and Keppel, 1970; Shuell and Giglio, 1973).

In their study measuring differences between slow and fast learners, Gregory and Bunch used geometric drawings; their subjects were asked to recall the numbers (1-10), which they had arbitrarily assigned to each drawing. They found that the fast subjects mastered the task in less time, needed fewer trials and made fewer errors; their superiority was significant at the .05 level. In the retention task (24 hours later), the fast group again needed fewer trials and made fewer errors; however, this difference was not significant at the .05 level. They concluded that rapid learning of the initial task was not

a predictor of performance in retention trials (Gregory and Bunch, 1959).

Similarly, Stroud and Schoer (1959), in a study involving paired adjectives and paired picture names with 149 subjects, found at best only a slight relationship between rate of learning and recall, although their slow-learning subjects had required more trials to master the original learning task.

Schoer, using a method of intact lists of paired adjectives, found that increasing list length added more trials to learn for the slow learner than for the fast learner. He also reported that interpolated learning affected both slow and fast learners, but not to significantly different degrees; he suggested that one explanation of the latter might be that slow learners overlearned some items (through repeated trials to learn) and that some of these items were subsequently impervious to interference (Schoer, 1962).

Shuell and Keppel (1970) concluded that there are only minimal differences in retention between slow and fast learners when the degree of original learning is equated for all subjects. Their experiment involved the free recall performance of fifth grade subjects; presentation rates were adjusted for slow and fast learners and retention was measured at 24 and 48 hour intervals. They reported that the increased study time for slow learners enabled them to perform close to the level of the fast learners in the initial learning tasks, and that there

were no significant differences between the two groups in the retention trials.

In another study with fifth grade subjects, Shuell and Giglio (1973) found no differences in the performance of slow and fast learners that could be directly attributed to differences in short-term memory. Following a pre-test to determine the identity of the slow and fast learners, all subjects were randomly assigned to different retention intervals and different orders of testing. No interaction was obtained between learning ability and retention interval. The authors concluded that individual differences in learning ability are not related to differences in either short-term memory or long-term memory and suggested that other factors, such as learning styles and earlier learning experiences, may be the more significant factors.

Present Study

The research reviewed suggests that certain variables, such as learning ability of subjects, speed of presentation, and categorization of materials are important factors in free recall learning experiments. All of these studies suggesting that there are no differences between memory and ability to learn employed lists of unrelated words, strings of consonants, geometric drawings, or paired adjectives. None involved the categorizing of items nor dealt with the possible associative relationships formed by the subjects at the time of initial learning or in the retention task. The present study differs

from the earlier ones in that it used a list of words from four specific categories, and a retention interval of several weeks, rather than an interval of hours or days.

The present study is most similar to that of Shuell and Keppel (1970) in that upper elementary school children (grade 5 in the 1970 study; grade 6 in this one) were the subjects, and that different presentation rates (five seconds for slow learners and one second for fast learners) were used to equate the degree of original learning for both groups. Differences between the Shuell and Koppel study and this one include: (1) the subjects in this study were placed in slow and fast groups on the basis of I.Q. test scores rather than on pretest learning rates; category cues were provided to one-half the subjects in each of the two groups; no category cues were given in the Shuell and Keppel study; (3) visual and verbal presentations were combined in this study to preclude errors due to reading difficulties; responses were required to be oral only; (4) all subjects were tested individually in this study rather than in groups; (5) the retention interval in his study was five weeks rather than 24 or 48 hours as in the earlier study.

Method

Subjects and Design. Ninety-eight sixth-grade students participated in this experiment, but complete sets of data were obtained for only seventy-six of the original ninety-eight. Ten subjects were absent on the thirty-fifth day and thereby missed the recall phase of the experiment. Five subjects were eliminated

because they were unable to master the list of words in the initial phase, and seven others were randomly removed to equalize the number of subjects in each of the four experimental groups. The final analysis included nineteen subjects in each of the four experimental groups. One-half of the subjects were classified as bright (mean I.Q. = 125.8, range 117-141) and the other half were classified as average (mean I.Q. = 95.9, range 89-106) on the basis of group Lorge-Thorndike Intelligence tests administered at the end of fifth grade. One-half of the bright and average subjects were randomly chosen to receive instructions to recall the lists in category order and were given the names of the four categories; the other half of the subjects were not told the categories and were only given the standard free-recall instructions (i.e., recall the words in any order you choose). Thus the experimental design was a 2 (bright vs. average) X 2 (instructions vs. no instructions) factorial.

Materials. The free recall list contained 16 words (four were from each of these categories: musical instruments, birds, ships and states) taken from the lower frequency half of the Battig And Montague (1969) category norms.

The words were printed on index cards, a single word per card. Several sets of cards were available to insure the random presentation of each trial.

Procedure. Each subject was randomly assigned to the instruction or no instruction group and tested individually

by the same experimenter in both phases. The subjects in the instructions group were given general instructions and then were told that the list to be memorized included words from the four categories, which were named, and were asked to recall the words in category order. The subjects in the no instruction group were simply given general instructions and were told to recall the words in any order. Following the instructions, the words were presented, one card at a time, the experimenter saying each word as it was shown. Subjects in the bright group were presented the words at a one-word-per-second rate and subjects in the average group were presented the words at a five-second-per-word rate. (A similar variation in presentation rate according to subjects' ability level was used by Shuell and Keppel, 1970, and resulted in an approximately equal number of words acquired by both groups after a single presentation trial.) Word presentation rate was controlled via an audio tape recording with blips at the appropriate intervals.

Immediately after each presentation trial, the subject was asked to say the alphabet backwards from a letter randomly chosen by the experimenter until thirty seconds had passed; the purpose of this interpolated material was to assure that the subject's recall would come from long-term memory. At the end of the thirty-second interval, the subject was asked to recall all the words he remembered from the sixteen word list. After the recall trial, subjects in the instruction group were reminded to give the words in category order and were then given another study

trial. No instruction subjects continued to the next trial with no instructions. This procedure continued until each subject reached a criterion performance of 14 out of 16 words.

Exactly thirty-five days after the acquisition trials, the subjects participated in the second phase of the experiment. Their initial task was to recall, within three minutes, in any order, all the words possible from the original list of 16 words. After this recall trial, a card with the names of the four categories was placed before each subject who was told that these category names might be helpful; a second three-minute trial was then given. Following the cued recall trial, all subjects were given a maximum of three relearning trials under the conditions that prevailed during the initial phase of the experiment.

Results

Acquisition. In this phase of the experiment, two independent variables, trials to criterion and clustering scores, were analyzed via a 2 X 2 analysis of variance. The results of the trials to criterion analysis indicated that ability was not a significant source of variance ($F < 1$). This confirmed that varying the presentation rates for bright and average subjects led to overall statistical equivalence in trials to criterion. However, the instructions variable proved to be a significant source of variance. Subjects who were asked to recall the 16 words in category order required fewer trials to reach criterion than did those subjects who had not been given special

instructions, $F(1,72) = 5.16$, $p < .05$. There was also a significant ability X instructions interaction, $F(1,72) = 5.16$, such that instructions to categorize for bright subjects led to fewer trials to criterion than no instructions.

The Bousfield and Bousfield SCR (stimulus category repetition) formula (1966) was used to determine the degree to which the order of each recall sequence differed from the order that could be expected on the basis of chance. When analyzed, these clustering scores indicated that the bright students clustered to a significantly greater extent, $F(1,72) = 5.61$, $p < .05$, than did average students. In addition, subjects instructed to categorize their recall clustered to a significantly greater extent than those subjects who were not given category recall instructions, $F(1,72) = 8.93$, $p < .01$.

Retention. Exactly 35 days later, all subjects were asked to recall as many as possible of the words in the original list. Ability proved to be the only significant source of variance in these recall scores. $F(1,72)$ 12.63, $p < .01$. Neither instructions nor the interaction effect were significant sources of variance. The cued learning trial and the relearning trials did not yield any new information of value. Subjects in all four groups averaged less than one additional word in the cued trial; all of the subjects were at or near criterion after a single relearning trial.

The retention test clustering scores did not show that either ability or instructions were statistically significant

Table 1

Performance on dependent variables as a function of treatment conditions

	Bright		Average	
Dependent Variable	Instructions	No Instructions	Instructions	No Instructions
Trials to criterion	3.4	5.1	4.1	4.1
Acquisition clustering	.64	.43	.47	.30
Retention words recalled	7.7	7.8	6.1	5.1
Retention clustering	.57	.34	-.07	.41

variables. There was, however, a significant interaction between these two variables, $F(1,72)$ $p < .05$. While there was little difference in the clustering scores of bright and average subjects when they were not given instructions to categorize during acquisition trials, category recall instructions during acquisition produced considerably higher scores in the retention trial for the bright students than for the average subjects.

Discussion

The results of the present study yield unequivocal evidence that there are retention differences between bright and average subjects, in favor of the bright, when the degree of original learning is taken into account. This finding is in conflict with the outcomes of several recent studies (Gregory and Bunch, 1959; Stroud and Schoer, 1959; Schoer, 1962; Shuell and Keppel, 1970; Shuell and Giglio, 1973) which conclude that there are no retention differences between subjects with different learning abilities.

The design of the experiment most closely resembles the Shuell and Keppel (1970) study, in that the learning materials consisted of a free recall list of nouns; the other studies employed various learning materials, including geometric shapes, paired adjectives, and paired picture names.

Another similarity to the Shuell and Keppel study involved the method of equating the degree of original learning (a one-second presentation rate for fast learners and a five-second rate for slow learners).

There were, however, several differences between this study and the 1970 one of Shuell and Keppel. In the latter experiment, subjects were given two pre-tests (to determine the slow and fast learners), which may be viewed as practice exercises, but were administered only one test trial; three different lists were used in each of these sessions, so that the only possible gain from the pre-tests was the benefit of experimental practice, available to both groups. The present study did not require any pre-testing; however, all subjects were given the necessary number of trials to reach the criterion of 14/16 words recalled.

The repeated trials permitted those subjects provided with category cues more opportunity to use them, and also allowed the remaining subjects (without category cues) to develop independent organizational strategies. Whether the Shuell and Keppel lists of 30 words each readily lent themselves to mediational strategies is unknown, but the two pre-tests might be expected to encourage a mind set open to this eventuality; however, none of the Shuell and Keppel subjects were given category cues and clustering was not included as a variable.

Still another noteworthy difference between the two studies is the length of the retention intervals. Shuell and Keppel retested after 24 and 48 hour periods, while the retention period in this study was five weeks. If one accepts, as so many memory researchers do (Hebb, 1949; Broadbent, 1958;

Waugh and Norman, 1965; Baddely and Dale, 1966; Milner, 1967) that long term becomes operative after twenty or thirty seconds, the differences in the retention intervals should not affect storage, but could have varying influences upon retrieval processes. In the present study interpolated material (reciting alphabet backwards from a random letter chosen by experimenter) was used to assure that recall would come from long term memory. Shuell and Keppel did not provide for this; their subjects were instructed to write as many words as they could recall after the thirtieth word was presented.

The present study's use of intelligence test scores to define the groups as bright and average is another difference from the recent studies mentioned above. The reasons for choosing I.Q. test scores rather than the learning rates obtained in a laboratory experiment include: (1) the latter is a very limited sample of behavior while I.Q. scores measure general learning ability and have a known relationship to academic achievement; (2) the correlation of individual differences in learning rates with intelligence measures could be more effectively applied in educational situations; (3) the existing differences among individuals' overall intelligence levels suggest that should be continued systematic investigation of the specific components of general ability. Leicht suggests that the need to establish general laws of learning and statistical models has been a deterrent in the study of individual differences (Leicht, 1972). However, an increasing

number of learning researchers (Jensen and Rohwer, 1968; Gagne, 1967; Lemke, Klausmeier, and Harris, 1967) are studying the relationships between ability and learning components.

Individual differences in ability proved to be the determining factor in the retention of a free recall test in this study. Category cues, the instructions variable, did not give any advantage to average students as had been anticipated; further studies of this variable across mental ages could provide valuable information. The results of this study suggest that continued research in this area of the differences in learning abilities should eventually lead to educational programs that would be adapted to meet individual learning styles and thus preclude academic failure.

Bibliography

Baddeley, A. D., and Dale, H. C. The effects of semantic similarity on retroactive interference in long- and short-term memory. Journal of Verbal Learning and Verbal Behavior, 1966, 5, 417-420.

Battig, W. F., and Montague, W. E. Category norms for verbal items in 56 categories. Journal of Experimental Psychology, 1969, 80 (3, Pt. 2).

Binet, Alfred, and Simon, Theophile. The development of intelligence in children. In Studies in Individual Differences. Edited by Jenkins, James L., and Patterson, Donald G. New York: Appleton-Century-Crofts, Inc., 1961.

Bousfield, A. K., and Bousfield, W. A. Measurement of clustering and of sequential constancies in repeated free recall. Journal of Educational Psychology, 1966, 19, 935-942.

Broadbent, D. E. Perception and Communication. New York: Macmillan, 1958.

Cattell, Raymond G. Fluid and crystallized intelligence. In Studies in Individual Differences. Edited by Jenkins, James L., and Patterson, Donald G. New York: Appleton-Century-Crofts, Inc., 1961.

Fleishman, Edwin A. Human Abilities. Annual Review of Psychology, 1969, Vol. 20, 349-380.

Gagne, R. H. Contributions of learning to human development. Psychological Review, 1968, 75, 177-191.

Gillette, Annette L. Learning and retention; a comparison of three experimental procedures. Archives of Psychology, 1936, 28, No. 198.

Gregory, S. C., Jr., and Bunch, M. E. The relative retentive abilities of fast and slow learners. Journal of General Psychology, 1958, 60, 173-181.

Hebb, D. O. The Organization of Behavior. New York: John Wiley and Sons, Inc., 1949.

Humphreys, Lloyd G. Theory of intelligence. In Intelligence and Genetic and Environmental Influences. Edited by Cancro, Robert, M.D. New York and London: Grune and Stratton, 1971.

Hunt, J. McV., and Kirk, Girvin E. Social aspects of intelligence: evidence and issues. In Intelligence and Genetic and Environmental Influences. New York and London: Grune and Stratton, 1971.

Jensen, Arthur R. How much can we boost I.Q. and scholastic achievement? Harvard Educational Review, 1969, 39, 1-123.

Jensen, Arthur R., and Rohwer, W. D., Jr. Mental retardation, mental age, and learning rate. Journal of Educational Psychology, 1968, 59, 402-403.

Kintsch, Walter. Learning, Memory, and Conceptual Processes. New York: John Wiley and Sons, Inc., 1970.

Leicht, Kenneth L. Methods for inferring process similarity in different learning tasks. In Human Memory: Festschrift in Honor of Benton J. Underwood. Edited by Duncan, Carl P., Sechrest, Lee, and Melton, Arthur W. New York: Appleton-Century-Crofts, Inc., 1972.

Lemke, Elmer A., and Klausmeier, Herbert J. Relationships of selected cognitive abilities to concept attainment and information processing. Journal of Educational Psychology, 1967, 1, 27-35.

McGeoch, John A. The Psychology of Learning. New York: Longmans, Green and Co. Revised by Arthur L. Orion, 1952.

Melton, Arthur W. Relations between short-term memory, long-term memory and learning. In The Organization of Recall, Vol. 2. Edited by Kimble, Daniel P. New York: New York Academy of Sciences, 1967.

Metcalfe, Maryse. Problems of memory in man. In Aspects of Learning and Memory. Edited by Richter, Derek. London: William Heinemann Medical Books Unlimited, 1966.

Milner, B., Taylor, L., and Sperry, R. W. Lateralized suppression of dichotically presented digits after commissural section in man. Science, 1968, 161, 184-186.

Schoer, Lowell. Effects of intralist item similarity on paired associate learning by learners of high and low verbal ability. Journal of Educational Psychology, 1963, 54, 5, 249-252.

Shuell, Thomas J., and Giglio, John. Learning ability and short-term memory. Journal of Educational Psychology, 1973, Vol. 64, No. 3, 261-266.

Shuell, Thomas J., and Keppel, Geoffrey. Learning ability and retention. Journal of Educational Psychology, 1970, Vol. 61, No. 1, 59-65.

Spearman, Charles. General intelligence objectively determined and measured. In Studies in Individual Differences. Edited by Jenkins, James L., and Patterson, Donald G. New York: Appleton-Century-Crofts, Inc., 1961.

Stake, Robert E. Learning parameters, aptitudes, and achievements. Psychometric Monographs, 1061, No. 9.

Stevenson, Harold W., Hale, Gordon A., Klein, Robert E., and Miller, Leon K. Interrelations and correlates in children's learning and problem-solving. Monograph of the Society for Research in Child Development. Serial No. 123, 1968, Vol. 33, No. 7.

Stevenson, Harold W., and Odom, Richard D. Interrelationships in children's learning. Child Development, 1965, Vol. 36, 7-19.

Stroud, James B., and Schoer, Lowell. Individual differences in memory. Journal of Educational Psychology, 1959, Vol. 50, No. 6, 285-292.

Thurstone, L. L. The mental age concept. In Studies in Individual Differences. New York: Appleton-Century-Crofts, Inc., 1961.

Underwood, Benton J. Degree of learning and the measurement of forgetting. Journal of Verbal Learning and Verbal Behavior, 1964, Vol. 3, 112-129.

Underwood, Benton J. Speed of learning and amount retained. Psychological Bulletin, 1954, No. 51, 276-282.

Waugh, N. C., and Norman, D. A. Primary memory. Psychological Review, 1965, 72, 89-104.

Wechsler, D. Wechsler Adult Intelligence Scale, Manual. New York: Psychological Corp., 1955.

Woodworth, R. S. A contribution to the question of "Quick learning, quick forgetting." Psychological Bulletin, 1914, 11, 58-59.