DOCUMENT RESUME

ED 093 126 EC 062 247

AUTHOR	Stukuls, Henry I.
TITLE	Discrimination Learning and the Effects of Interference on Short and Long Term Retention Process of Retarded and Normal Children. Final Report.
INSTITUTION	State Univ. of New York, Cortland. Coll. at Cortland.
SPONS AGENCY	Office of Education (DHEW), Washington, D.C. Bureau of Research.
PUB DATE	30 Aug 74
GRANT	OEG-4-71-0039
NOTE	58p.
EDRS PRICE	MF-$0.75 HC-$3.15 PLUS POSTAGE
DESCRIPTORS	Adolescents; Childhood; *Discrimination Learning; Educable Mentally Handicapped; *Exceptional Child Research; *Factor Analysis; Learning Processes; Learning Theories; Memory; *Mentally Handicapped; Recall (Psychological); *Retention; Trainable Mentally Handicapped

ABSTRACT

Eighteen retarded Ss (mean IQ 50 and mean age 14 years) and 18 normal Ss (mean IQ 100 and mean age 7 years) participated in a study to isolate variables that differentially control discrimination learning and retention processes, and to evaluate contrasting theories on discrimination learning and memory processes of retarded and normal children. The experimental design contained the following six independent variables: IQ groups (retardates vs. normal Ss), retention intervals (seconds vs. hours), kinds of test problems (new vs. old), sources of interference (proactive vs. retroactive), types of interfering discrimination (new vs. old), and Ss. The dependent variable in all conditions was the S's response (on a discrimination test trial) expressed in terms of either percentage of correct responses or retention loss score in each level of the factorial experiment. Acquisition data showed that retarded Ss were slightly but significantly slower learners than normal Ss and required more trials to reach criterion on interference free discrimination problems. Retention data showed that retarded Ss had only a slight overall retention deficit compared to normal Ss, and that both groups displayed greatest retention loss on new test problems, long retention intervals, and interference conditions (retroactive conditions for the retarded Ss and proactive conditions for the normal Ss). The results indicated a dual memory process of retarded and normal children and therefore supported N. Ellis's 1970 Primary and Secondary Memory Theory and the data of D. Zeaman's 1973 Attention-Retention Theory. (Author/MC)

FINAL REPORT

Grant #OEG-4-71-0039

DISCRIMINATION LEARNING AND THE EFFECTS OF INTERFERENCE ON SHORT AND LONG TERM RETENTION PROCESS OF RETARDED AND NORMAL CHILDREN

April 30, 1974

U.S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE

Office of Education

Bureau of Research

DISCRIMINATION LEARNING AND THE EFFECTS OF INTERFERENCE ON SHORT AND LONG TERM RETENTION PROCESS OF RETARDED AND NORMAL CHILDREN

Grant #OEG-4-71-0039

Henry I. Stukuls

April 30, 1974

The research reported herein was performed pursuant to a contract with the Office of Education, U.S. Department of Health, Education and Welfare. Points of view or opinions stated by the author do not necessarily represent official Office of Education position or policy.

SUNY College at Cortland
Cortland, New York 13045

TABLE OF CONTENTS

List of Tables

List of Illustrations

Acknowledgements

This project was made possible through the continued support of students, SUNY College administrative staff and the administrative staffs of Syracuse State School and Rome State School. Among the students particularly deserving of merit in this project were Donna Dannenhoffer, Jerry Wiesnewski and Mary Cullen. Dr. Allen Willsey was particularly helpful during the inception of the project. Dr. Tom Toomey kindly gave us permission and help to run the normal children's portions of the study at the College Campus School in Cortland, New York. Dr. George Buchholtz most sympathetically let us run the retardate children's portions of the study at Syracuse and Rome State Schools. At Syracuse State School Dr. Byron Ward provided us with the most welcome aid and support. Dr. John Cole at Rome State School gave us the needed assistance to finish the project.

I would like to express a particular thanks to Dr. Nicholas Esposito for his assistance in statistical analysis of the data and similarly I would like to thank Nancy Dillon who brought this project to the light of day by patient and devoted typing.

Abstract

The objectives of this developmental study were to: first, isolate a set of variables that differentially control discrimination learning and retention processes of retarded and normal children; second, to evaluate contrasting theoretical positions regarding discrimination learning and memory processes of retarded and normal children. To accomplish these objectives the experimental design included six factors or independent variables.

The major independent variables were IQ Groups (retardates vs. normals), Retention Intervals (seconds vs. hours), Kinds of Test Problems (new vs. old), Sources of Interference (proactive vs. retroactive), Types of Interfering Discriminations (new vs. old), and Subjects. These variables were arranged in a 2 X 2 X 2 X 2 X 2 X 9 factorial design.

The dependent variable in all conditions was S's response, either correct or incorrect on a discrimination test trial. This major dependent variable was expressed either in terms of Percentage Correct Responses or in terms of a Retention Loss Score in each of the levels of the factorial experiment.

The acquisition data showed retardates as slightly but significantly slower learners than normals. On interference free discrimination problems, it took retarded children more trials to reach criterion than it did for normal children. In fact, the retardate vs. normal difference in learning was reliably established on the second discrimination trial. This difference in performance occurred in spite of considerable pretraining and consecutive similar problems which insured children's attentional responses.

The retention data demonstrated reliable differences in the memory processes of retarded and normal children. While retardates showed only a slight overall retention deficit when compared to normal children, the differences between the two groups were large and reliable

under conditions of new test problems, long retention intervals and proactive vs. retroactive interference. Retarded children showed greatest retention loss on new test problems, long retention intervals and retroactive interference conditions. In contrast, normal children showed greatest retention loss on new test problems, long retention intervals and proactive interference conditions. Overall the data supported specific retardate memory deficits. The results indicated a dual memory process of retarded and normal children and therefore supported Ellis' (1970) Primary and Secondary Memory Theory, but the data fit best the Fisher and Zeaman (1973) Attention-Retention Theory of learning and memory.

Introduction - Problem and Objectives

The concern with discrimination learning and the effects of interference on the retention processes of retarded and normal children has generated a number of unresolved issues. H.H. Spitz (1963) cites evidence and theory which indicate associative or learning differences between retarded and normal children, and he makes the assumption that both groups of individuals have comparable memory processes. In contrast, N.R. Ellis (1963) presents a theory and research which suggest that retardates, as compared to normals, have a short-term retention deficit. Some research and theories (Melton, 1963; Postman, 1963; 1961) indicate a single-process memory. Here, the same mechanism and constructs are used to account for short-term retention data (seconds) and for data from long-term retention studies (hours or days). In contrast, other theories and research (Hebb, 1949; Broadbent, 1958; Ellis, 1970; Fisher and Zeaman, 1973) support the view of a dual-process memory. The dualistic models postulate a separate short-term memory process (seconds) and long-term memory process (hours or days).

One of the major reasons for such controversies is the incomplete identification of variables that effect learning and memory. Three classes of variables are likely to produce forgetting.

First, variations introduced before the presentation of a test problem (proactive materials) are currently considered an important cause of differential retention (Underwood, 1957; Postman, 1961). The degree of training on the proactive material is a specific variable which may control forgetting. A number of long-term memory studies with verbal materials and normal subjects have investigated this relationship (Waters, 1942; Underwood, 1949; Postman and Riley, 1959). These studies indicate that increments in the degree of proactive training produce recall decrement when reliable retention loss is achieved from the proactive material. However,at least two studies (Knight, 1968; McBane and Zeaman, 1970) with retarded children showed decreased interference with well learned proacting items. Unfortunately, studies are not available for discrimination learning tasks with normal or retarded subjects.

Second, variations of the acquisition or task variable influence memory (Hovland, 1958). One such variable is the degree of training on the test problem. Increasing degrees of training on the test problem tend to facilitate retention (Briggs, 1957; Postman, and Riley, 1959; Richardson, 1956; Garscof, 1966). Four retardate vs. normal comparison experiments (Heber et al, 1962; O'Connor and Hermelin, 1963; Vergason, 1964; Lance, 1965) consider the retention effects from varied degrees of original learning. All but one of these studies (O'Connor and Hermelin, 1963) indicate that retention of the test problem is directly proportional to the degree of original learning, although the reported retardate-normal long-term memory differences are questionable (Belmont, 1966). Short-term memory studies have similar outcomes to those of long-term memory data (Peterson and Peterson, 1959; Hellyer, 1962). One short-term memory experiment involving degrees of original learning with retarded subjects (Klinman, 1964) shows ambiguous results. Another short-term memory study with retardates showed better retention with increasing item strength (Stukuls, 1968). There appear to be no retardate-normal comparison studies with respect to this variable.

Third, retention loss can be controlled by variations in the material presented after the learning task but before its recall (retroactive materials). A variable in this class which has a differential retention effect is the degree of training of the retroactive material. The majority of research indicates that with increasing degrees of retroactive training there occur decreasing retention of the test problems (Melton, 1941; Thune and Underwood, 1943; Archer and Underwood, 1951; Richardson, 1956; Briggs, 1957; Postman and Riley, 1959). The two available short-term memory studies with retardates (Klinman, 1964; Stukuls, 1968) report data which are in conflict with the long-term retention results, and there are no published retardate-normal comparison studies regarding this variable.

This brief review of the literature identifies some of the problems related to the process of memory and points toward the necessity of additional research. The current project is designed to accomplish the following objectives. The first objective is to determine if varied degrees of training on the proactive material, task material and retroactive material differentially control discrimination learning and retention processes. Second, is there a reliable difference between retarded and normal children regarding learning and memory processes? The third objective is to evaluate contrasting theoretical positions regarding discrimination learning and memory processes of retarded and normal children. The experimental results are expected to confirm Ellis' (1963) postulated retardate memory deficit and support Ellis' (1970) and Fisher-Zeaman (1973) dual-process theories of memory.

Description of Activities

Subjects - The project involved a group of 18 retarded children and another group of 18 normal children. The retarded children's mean IQ was 50; their mean MA was 7.0 yrs.; and their mean CA was 14.1 yrs. The normal children's mean IQ was $\approx$100; their mean MA was $\approx$7.0 yrs; and their mean CA was 7.4 yrs.

Of the eighteen retarded children, nine participated in the short-term memory study (mean IQ = 48; mean MA = 7.1 yrs.; and mean CA = 14.9 yrs.) and the other nine participated in the long-term memory study (mean IQ = 52; mean MA = 6.9 yrs.; and mean CA = 13.3 yrs.). In a similar manner nine normal children participated in the short-term memory study (mean IQ $\approx$ 100; and mean CA = 7.3 yrs.) and the other nine participated in the long-term memory study (mean IQ $\approx$100; and mean CA = 7.5 yrs.).

Looking at the characteristics of these groups it becomes apparent that the retarded children had lower intelligence quotients and higher chronological ages when compared to their counterpart normal children's groups. Hence the four groups were closely matched on their intelligence or mental age scores. The control for other subject variables, such as grade standing and socio-economic level was only approximate to the degree that all children were selected from the first 9 grades of public schools in the Cortland, Syracuse, Rome region of New York State. Although subjects were chosen without regard to their diagnostic category or previous experience, they had to be ambulatory and without obvious visual-motor defects.

Stimuli and Apparatus - The pretraining stimuli were two pairs of "junk objects" (e.g., a soap dish and a toy hat) and two pairs of "junk pictures" (e.g., magazine cut-outs of a car and a house) pasted on 3 1/2" X 3 1/2" cardboard bases. The stimuli for the main experiment were 36 pairs of unique form-relevant orange patterns (T, ◇, ⌂, O, ⬀, etc.). Using templates the patterns were each sprayed with orange enamel on 3 1/2" X 3 1/2" white cardboard bases and then covered with clear acrylic.

A modified Wisconsin General Test Apparatus was used throughout the experiment (Zeaman and House, 1963). The apparatus included a table and two chairs, with the experimenter (E) and the subject (S) sitting on opposite sides of the table and a one-way screened partition separating them. Below the screened partition there was a 30" X 12" sliding tray with two food wells (each 2 1/2" in diameter and 3/4" deep) embedded 12" (center to center) apart. The tray was invisible to the Ss in its retracted position. The E baited one food well with an M & M candy and then covered both wells with stimuli. The tray was pushed forward to begin a discrimination trial.

Procedure - In all cases Ss were brought individually to an isolated experimental room and they were seated in front of the discrimination apparatus. Behind a one-way screen of the apparatus, the E baited one food well of the stimulus tray with an M & M candy and covered both with stimuli. The stimulus tray was then pushed forward to begin a discrimination trial.

The only instructions to the S were: "See if you can find a candy under one of the objects." A discrimination trial was terminated after the Ss picked up one of the stimuli and E retracted the stimulus tray behind the one-way screen.

In the pretraining program Ss learned four unique discriminations. A "junk object" discrimination (e.g. a soap dish vs. a toy hat) was learned as the first and second problem and a "junk pattern" discrimination (e.g. a magazine cut-out of a car vs. a house) was learned as the third and fourth pretraining problem. Each of these problems were given on separate days and each consisted of twenty-five discrimination trials. The right or left position of reward was determined by a Gellerman (1933) series. Correction procedure ("see if you can find a candy under the other object") was used on the first two pretraining problems but it was changed to a non-correction procedure on all subsequent discriminations. The passing criterion for each problem was 20/25 correct responses and Ss who failed to reach criterion were dropped from the experiment. All Ss who successfully completed pre-training participated in thirty-two daily sessions of the main experiment. A daily session consisted of one experimental test problem followed by none, one or two unique, twenty-five trial, form problems. These twenty-five trial problems were used on some following days as the "old" or well-learned discrimination test problems. Ss performed on these problems until they reached a criterion of ten consecutive correct responses.

Design - The experimental design consisted of six independent variables and one major dependent variable. The independent variables were IQ Groups (retardates vs. normals), Retention Intervals (seconds vs. hours), Kinds of Test Problems (new vs. old), Sources of Interference (proactive vs. retroactive), Types of Interfering Discriminations (new vs. old) and Subjects. These variables were arranged in a 2 X 2 X 2 X 2 X 2 X 9 factorial design.

The dependent variable in all conditions was S's response, either correct or incorrect on a discrimination test trial. This major dependent variable was expressed either in terms of a Retention Loss Score or in terms of Percentage Correct Responses in each of the levels of the factorial experiment.

The experimental problems and their arrangements are presented in Table 1. The sequences of problems on consecutive days are presented in Table 2. Every subject received all thirty-two experimental problems.

Comment on Description of Activities - The entire project was conducted in two phases. The first phase (Summer & Winter of 1972) included one group of nine retarded children and one group of nine normal children who participated in the short-term retention interval (seconds) portion of the project. The second phase (Summer & Winter of 1973) included comparable groups of subjects, the same stimuli, apparatus and experimental design, but the retention interval was of long-term duration (hours). The subjects in this phase of the project were given the discrimination learning trials and then they were engaged in 1-4 hour long experimentally irrelevant activity before returning for the retention test-trial. Occasionally the children could not be obtained for the delayed retention test in which case they were tested immediately the next morning.

Table I

Arrangement of Experimental Problems

n = new discrimination   o = old discrimination

A, B, C, -, -, S = unique discriminations

Experimental Problems

I	II	III	IV	V	VI	VII	VIII
Proactive				Retroactive			
A_n	C_n	E_o	G_o	I_n	K_n	P_o	R_o
B_n	D_o	F_n	H_o	J_n	L_o	Q_n	S_o
B_{test}	D_{test}	F_{test}	H_{test}	I_{test}	K_{test}	P_{test}	R_{test}

Table II

Sequence of Experimental Problems

Days	Sequence							
1 - 8	I	VIII	VI	III	VII	II	IV	V
9 - 16	II	I	VII	IV	VIII	III	V	VI
17 - 24	III	II	VIII	V	I	IV	VI	VII
25 - 32	IV	III	I	VI	II	V	VII	VIII

Results

Learning Data - Retarded children learned more slowly than the normal children. Retardate and normal children's learning is pictorially presented in Graph 1. The graph represents children's performance on Interference Free Discrimination Problems. These problems were the second daily well learned discriminations which subjects were given on some days, and which were then used on the successive days as old discrimination test problems. Since these problems were preceded by another well learned discrimination the likelihood of proaction was minimized (Scott, 1966; Knight, 1968; McBane and Zeaman, 1970) and since these problems were the last ones in a daily session, they could have no retroactive interference effects.

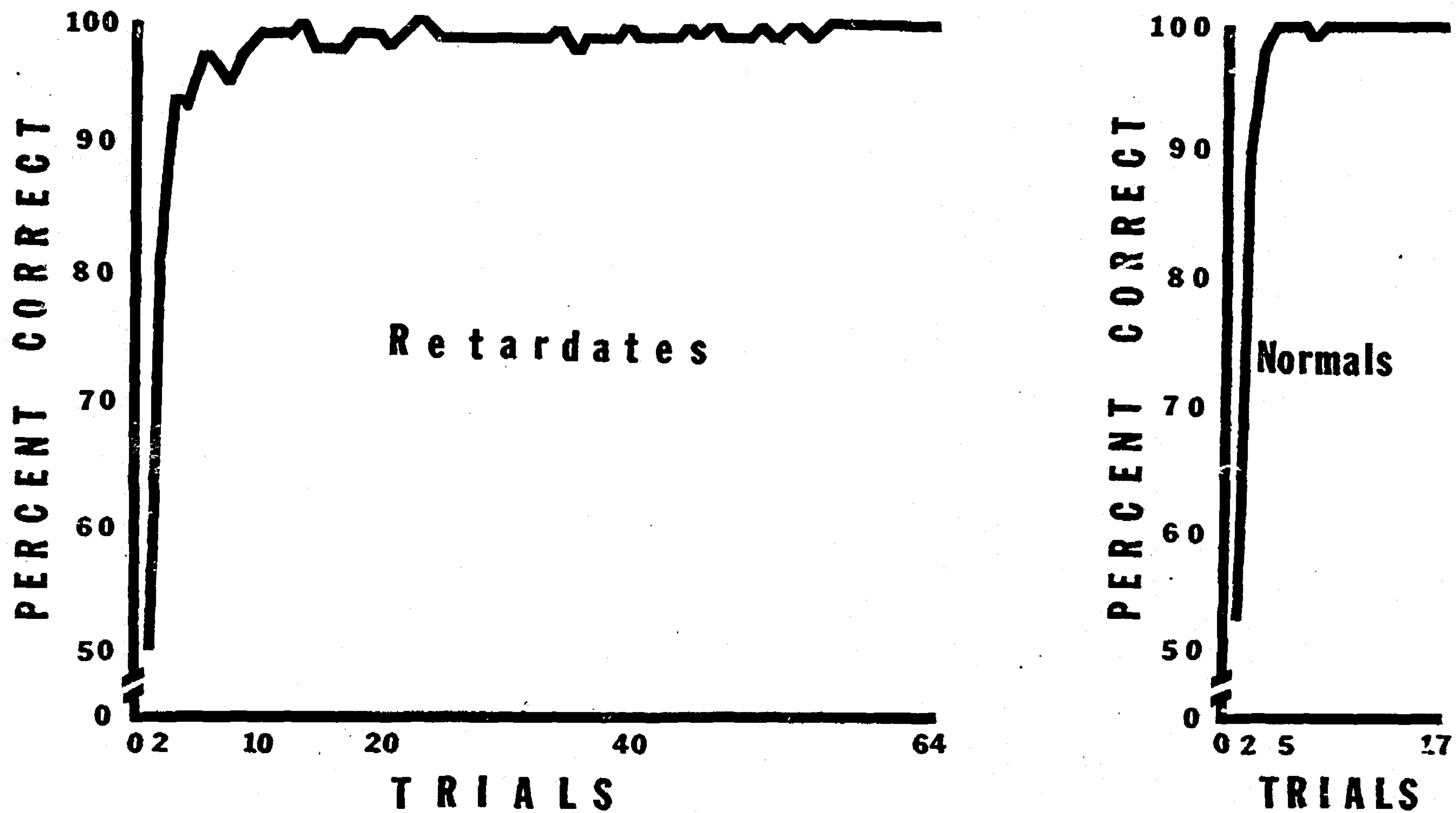
On these Interference Free Discrimination Problems, the mean number of trials to criterion learning for the retarded children was 22.9 trials and for the normal children the mean was 7.2 trials. The 15.7 trial difference was highly significant ($F = 8.70$; $df = 1/32$; $p < .01$).

Evidence for retarded vs. normal children's slower learning appeared already on the second discrimination trial. On the same Interference Free Discrimination Problems, the mean percent correct responses on the second discrimination trial by the retarded children was 81 percent and by the normal children it was 90 percent. The 9 percent difference was significant ($F = 4.38$; $df = 1/32$; $p < .05$).

Retention - First, the retention data were expressed as percent correct responses for each of the major independent variables of Groups, Retention Intervals, Kinds of Test Problems, Sources of Interference and Types of Interfering Problems. Performance on each of two levels of these five independent variables may be seen in Figure 2.

Second, the data were expressed in terms of corrected or pure retention loss scores. Retention loss has been defined in terms of amount learned minus the amount recalled

Figure 1


PERCENT CORRECT
100
90
80
70
60
50
0
Retardates
0 2
10
20
40
64
TRIALS
PERCENT CORRECT
100
90
80
70
60
50
0
Normals
0 2 5
17
TRIALS

(Underwood, 1963). Accordingly, the retention loss score for each subject and each of the conditions consisted of the percent correct responses on the second interference free learning trial minus the percent correct responses of the comparable retention test trial. Retention loss scores for each of the major independent variables of Groups, Retention Intervals, Kinds of Test Problems, Sources of Interference and Types of Interfering Problems may be seen in Figure 3. These same retention loss scores were used for inferential statistical analysis as well as to depict interactions among variables.

Main Effects - The first comparison (Figure 2A) represents normal vs. retardate children's differences in performance on the retention problems. Data in these comparisons were averaged over all independent variables except the Groups variation. Although performance on the retention test trial was higher for the normal subjects (83% correct) as compared to the retarded subjects (72% correct) the 11 percent difference was not statistically significant ($F < 1$; $df = 1/32$; $p > .10$). This non-significant difference becomes obvious in terms of the retention loss scores (Fig 3A). Hence, when corrected for differences in learning, the normal children still remembered better (6.7% retention loss) when compared to recall of retardates (8.1% retention loss), but the retention loss difference was obviously small (1.4%) and unreliable. As it will become evident, the retarded children showed poorer retention than normal children but the difference was reliable only under specific variable combinations.

The second comparison (Figure 2B) represents performance on retention tests under conditions of short (seconds) vs. long (hours) Retention Intervals. Clearly, more was remembered after short retention intervals. Correct responses on retention test trials after short retention intervals was at the 80 per cent level, but performance on comparable test problems after long retention intervals dropped to a low 74 per cent level. An analogous picture emerged with retention loss scores (Figure 3B) where recall after short retention intervals showed a loss of

Figure 2

Percent Correct on Retention Tests Under Conditions of Five Major Independent Variables

Each Bar-Graph Represents Percentage Correct of 576 Responses

A	B	C	D	E
Groups	Retention Intervals	Kinds of Test Problems	Sources of Interference	Types of Interfering Problems
Normals vs. Retardates	Short vs. Long	Old vs. New	Proactive vs. Retroactive	Old vs. New
		(Many training trials) (One training trial)		

Figure 2

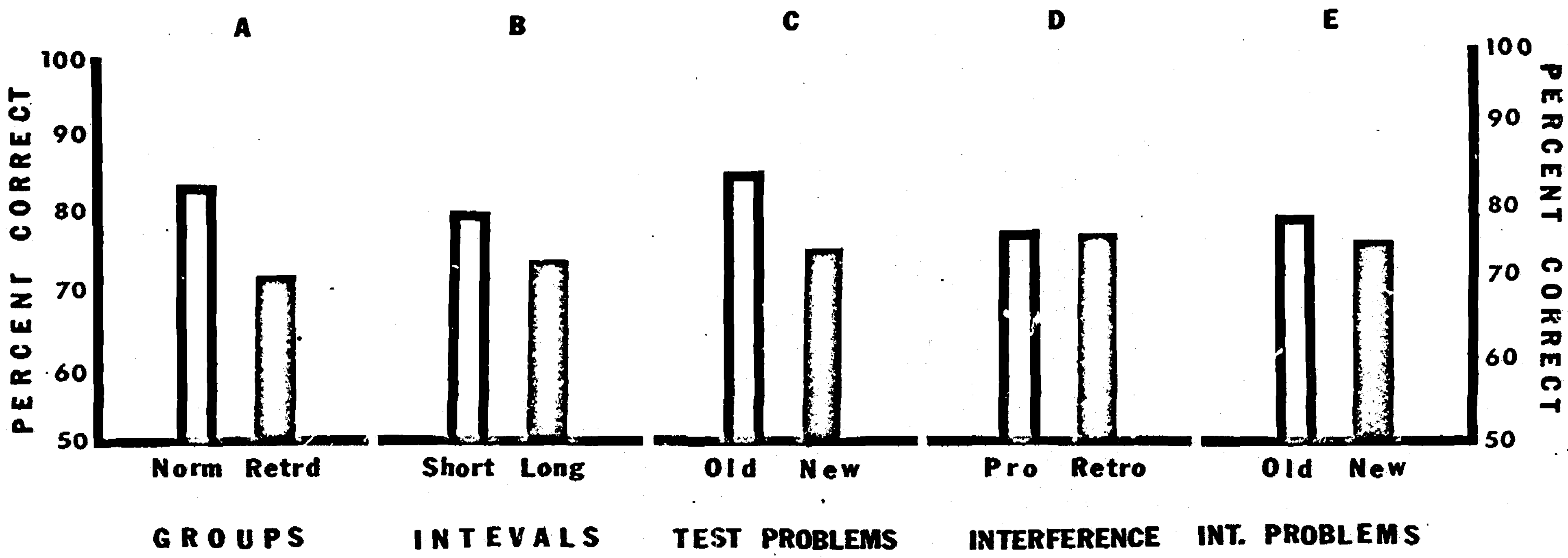

A
B
C
D
E
PERCENT CORRECT
100
90
80
70
60
50
Norm Retrd
GROUPS
Short Long
INTEVALS
Old New
TEST PROBLEMS
Pro Retro
INTERFERENCE
Old New
INT. PROBLEMS
PERCENT CORRECT

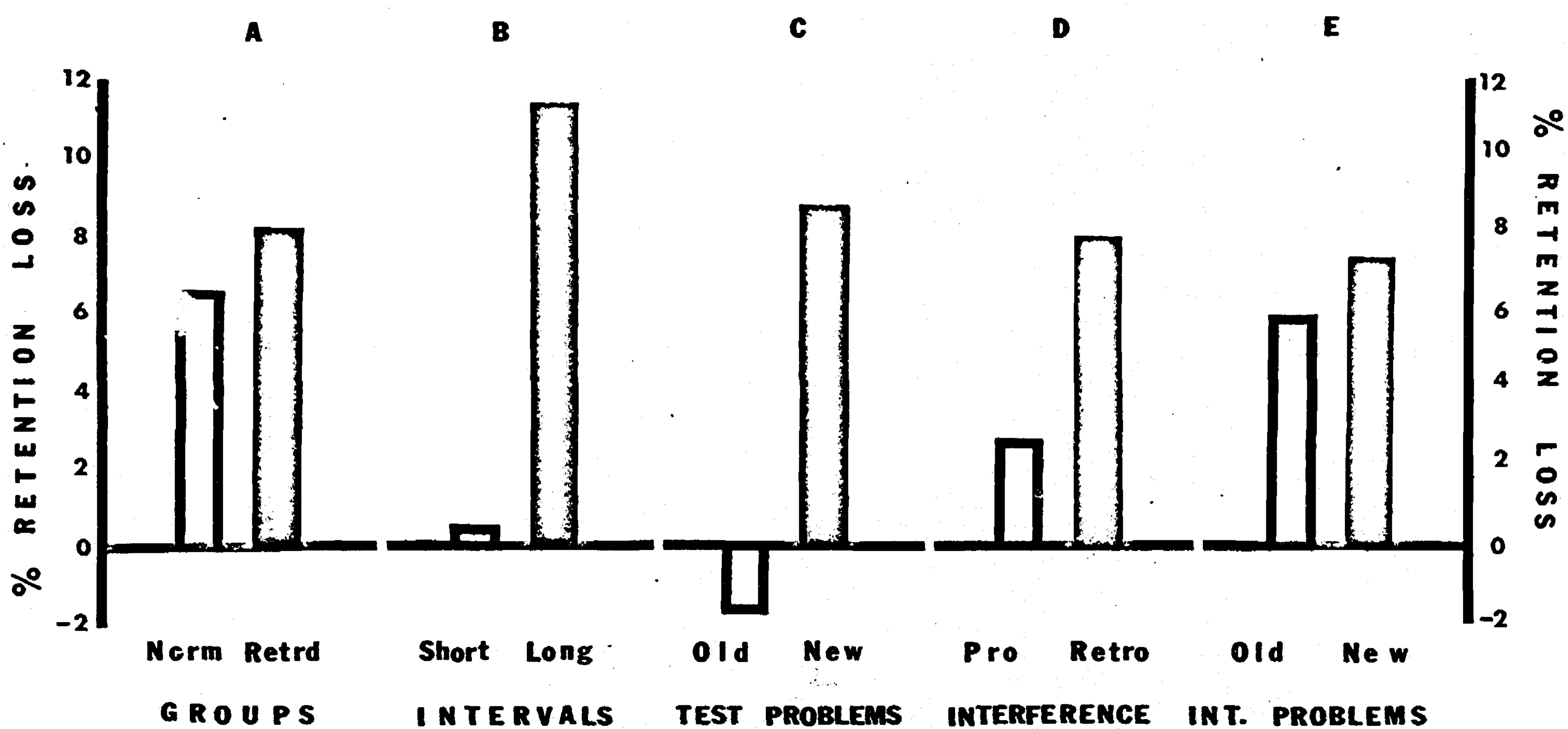
Figure 3

Retention Loss Under Conditions of Five Major Independent Variables

Each Bar-Graph Represents Percentage Retention Loss Calculated on Basis of 576 Responses

A	B	C	D	E
Groups	Retention Intervals	Kinds of Test Problems	Sources of Interference	Types of Interfering Problems
Normals vs. Retardates	Short vs. Long	Old vs. New	Proactive vs. Retroactive	Old vs. New

Figure 3


A
B
C
D
E
% RETENTION LOSS
12
10
8
6
4
2
0
-2
Norm Retrd
GROUPS
Short Long
INTERVALS
Old New
TEST PROBLEMS
Pro Retro
INTERFERENCE
Old New
INT. PROBLEMS

only .6% vs. an 11.6% loss after long retention intervals. Both percentage differences (80% - 74% = 6% and 11.6% -.6% = 11%) were significant ($F = 5.01$; $df = 1/32$; $p < .05$).

The third comparison (Figure 2C) involves evaluation of performance on old test problems (problems that had been well learned and then exposed once more for recall) vs. new test problems (problems that had been never learned and were exposed once for recall). As expected, old problems were recalled better (85% correct) than new problems (69% correct), with a difference of 16 percentage points. The same pattern emerged with the retention loss scores (Figure 3C). While performance on old test problems was even slightly higher than on interference free learning problems (hence negative 2.0% retention loss) the performance on new test problems showed a recall decrement (8.9% retention loss), with a difference of 10.9 percentage points. The 16 and 10.9 per cent differences were highly reliable ($F = 9.42$; $df = 1/32$; $p < .001$).

The fourth comparison represents performance under conditions of proactive and retroactive interference. See Figure 2D and 3D. Neither uncorrected nor corrected retention measures indicated obvious visible nor reliable interference differences between the two conditions ($F < 1$; $df = 1/32$).

The fifth main effect evaluation compares Types of Interfering Problems (See Figures 2E and 3E). Old interfering problems did not produce as much retention loss (79% correct and 6.0% loss) as did new interfering problems (75% correct and 7.6% loss) but the differences were not statistically significant.

Interactions - First, retarded and normal children appeared to differ in retention under conditions of proactive and retroactive interference (See Figure 4). While proactive interference took an approximately equal toll of retardate and normal children's memory (7.1% loss vs. 8.2% loss), retroactive interference produced considerably greater memory loss of retardates than normals (11.4% loss vs. 6.9% loss). Although this Groups - by - Sources of

Figure 4

Retention Loss of Retarded and Normal Children Under Conditions of Proactive and Retroactive Interference. Each point on the graph represents 288 measures.

Figure 5

Retention Loss Due to New and Old Interfering Problems Under Conditions of Proactive and Retroactive Interference. Each point on the graph represents 288 measures.

Figure 4

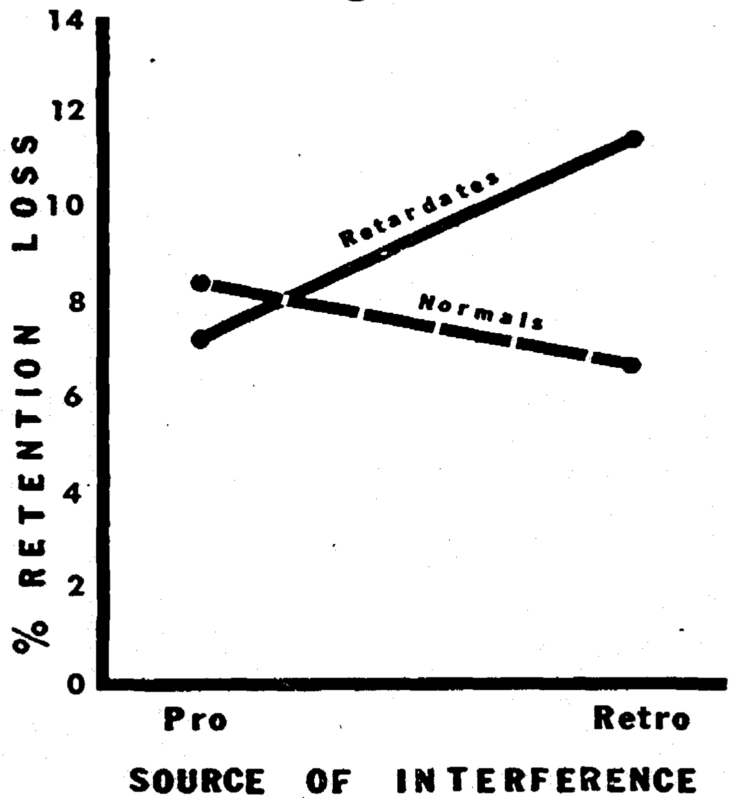
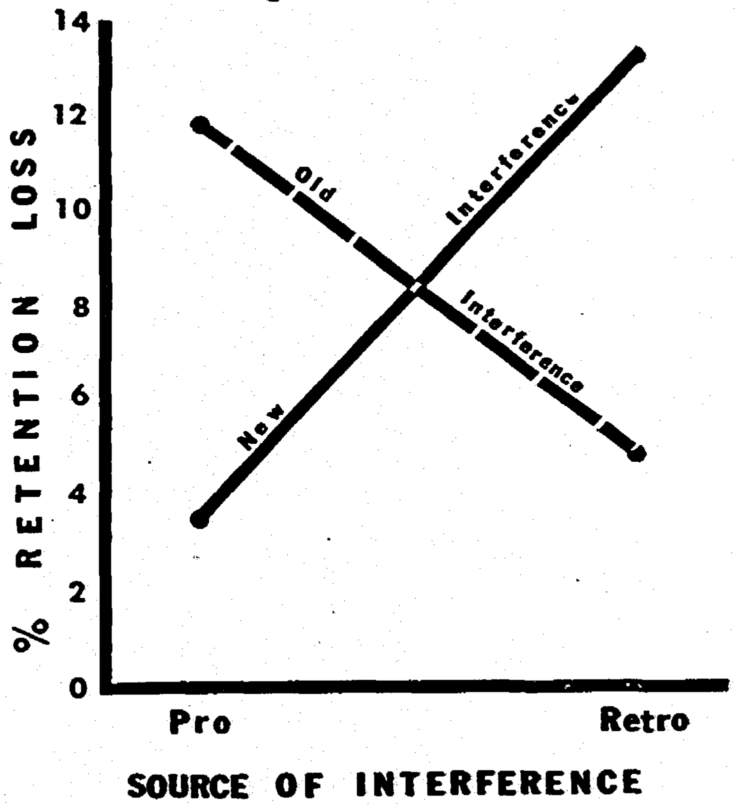


Figure 5



Interference interaction was considerable it did not reach the $\alpha = .05$ level of significance. The 4.3% difference between retardates' retention loss on proactive and retroactive interference conditions approached significance ($F = 3.25$; $df = 1/16$; $p < .09$).

Second, old interfering problems did most damage under conditions of proactive interference (11.8% retention loss) and new interfering problems did most damage under retroactive interfering conditions (13.3% loss). This second order interaction may be seen in Figure 5. The sources of Interference - by - Types of Interfering Problems interaction was highly reliable ($F = 9.7$; $df = 1/32$; $p < .01$).

Third, the data revealed an important third order interaction. Groups - by - Kinds of Test Problems - by - Sources of Interference interaction is visible in Figure 6. While retarded children poorly recalled new test problems under conditions of proactive interference (12.5% loss), the normal children did even worse (19.0% loss) under the same conditions. In contrast, although normal children recalled relatively poorly new test problems under conditions of retroactive interference (12.8% loss), the retarded children did even worse by demonstrating even greater retention loss (20.8% loss) under the same conditions. This Groups - by - Kinds of Test Problems - by - Sources of Interference interaction was significant ($F = 5.4$; $df = 1/32$; $p < .05$).

Fourth, the results showed another significant third order interaction. The Retention Intervals - by - Types of Interfering Problem - by - Sources of Interference interaction is plotted in Figure 7. Clearly retention suffered under conditions of long retention intervals, new interfering problems and conditions of proactive interference (7.3% retention loss), but retention was even worse with new interfering problems under conditions of retroactive interference (19.1% loss). In contrast, retention after long intervals was relatively poor with old interfering problems and retroactive interference (7.9% loss), but memory suffered even more with old interfering problems and proactive interference (23.9% retention loss). This Retention Intervals - by - Types of Interfering Problems - by - Sources of Interference inter-

Figure 6

Retention Loss by Normal and Retarded Children Under Conditions of New and Old Test Problems and Proactive and Retroactive Interference. Each point on the graph represents 72 measures.

Figure 7

Retention Loss Under Conditions of Short and Long Retention Intervals, Proactive and Retroactive Interference with Old and New Interfering Problems. Each point on the graph represents 72 measures.

action was significant ($F = 4.3$; $df = 1/32$; $p < .05$).

Finally, the data showed two critical fourth order interactions. For sake of clarity the visual plots of these interactions were simplified and they include only those levels of the variables that most clearly demonstrated the fourth order interactions. Performance on short retention intervals was omitted for simplicity of visual analysis. However, a sub-analysis of the data indicated that normal children showed less retention loss on short retention intervals (2.7% loss) and more on long retention intervals (12.0% loss), the 9.3% retention loss difference was significant ($F = 5.1$; $df = 1/16$; $p < .05$). In contrast, retarded children demonstrated a 3.3% retention loss on short retention intervals and a 15.4% retention loss on long retention intervals. But, this larger 12.1% difference was not significant. In spite of the trend, due to large variance among retarded subjects the Groups - by - Retention Intervals interaction was not significant.

Figure 8 visually demonstrates the Groups - by - Retention Intervals - by - Kinds of Test Problems - by - Sources of Interference interaction. Notice that retarded children did relatively well on old test problems under conditions of retroactive interference (4.5% loss). They demonstrated more retention loss under conditions of proactive interference (16.6% and 18.4% loss) and retardates did by far the worst on new test problems under conditions of retroactive interference (26.7% loss). But, the opposite was true for normal children. They did best on old test problems under conditions of proactive interference (.3% loss). Furthermore, normal children retained intermediate amounts under conditions of retroactive interference (7.2% and 8.1% loss) and they did worst on new test problems under conditions of proactive interference (32.2% loss). This fourth order interaction was highly reliable ($F = 7.6$; $df = 1/32$; $p < .01$).

Figure 9 visually demonstrates Groups - by - Kinds of Test Problems - by - Types of

Figure 8

Retention Loss by Normal and Retarded Children on New and Old Test Problems Under Conditions of Proactive and Retroactive Interference. Each point on the graph represents 36 measures.

Figure 8

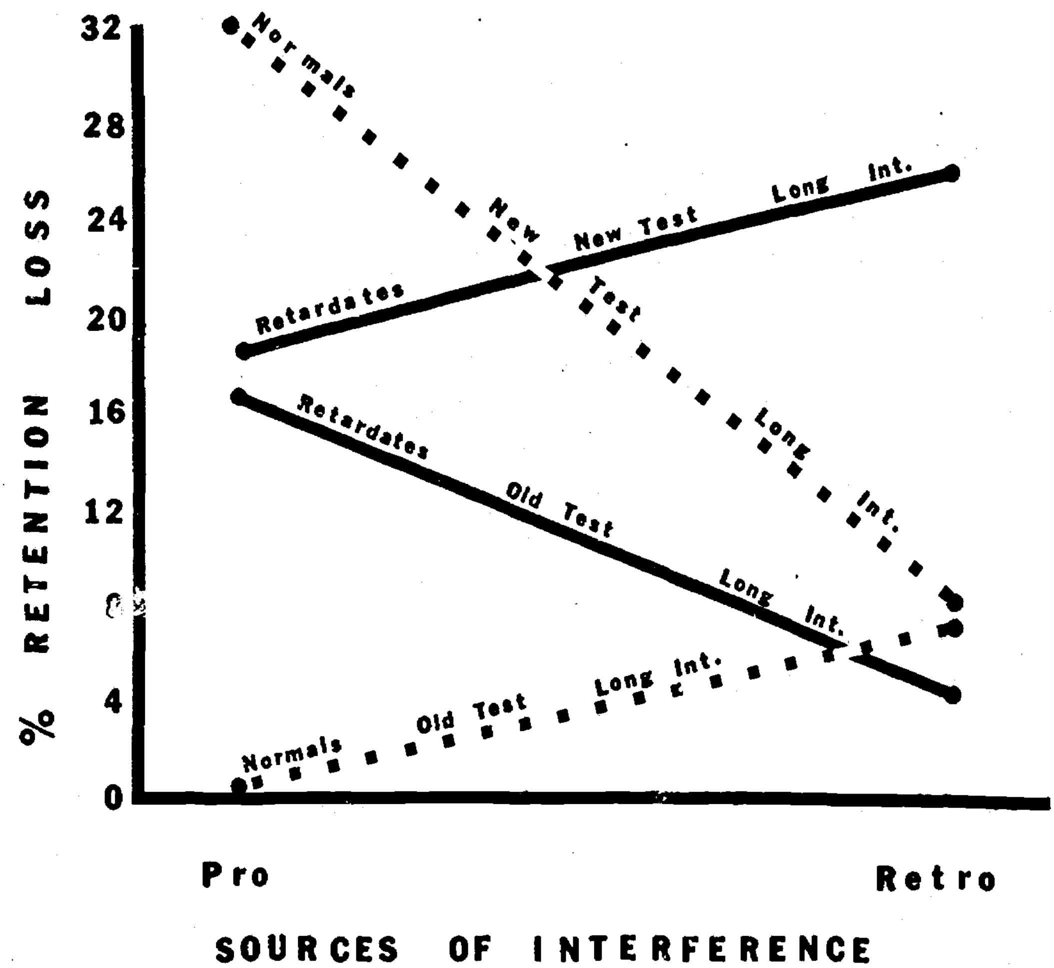
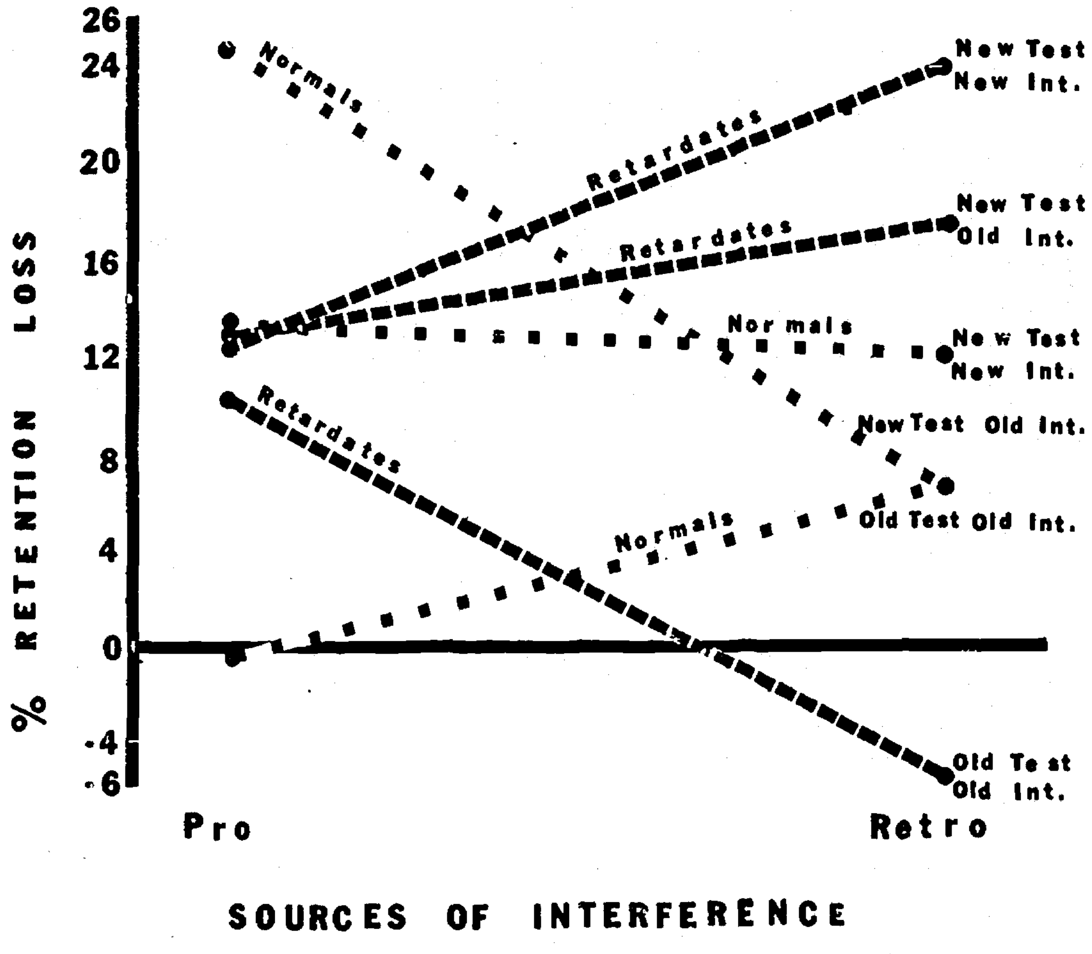

32
28
24
20
16
12
8
4
0
% RETENTION LOSS
Normals
New Test
Long Int.
Retardates
New Test
Long Int.
Retardates
Old Test
Long Int.
Normals
Old Test
Long Int.
Pro
Retro
SOURCES OF INTERFERENCE

Figure 9

Retention Loss by Normal and Retarded Children on New and Old Test Problems and New and Old Interfering Problems Under Conditions of Proactive and Retroactive Interference. Each point on the graph represents 36 measures.

Figure 9


26
24
20
16
12
8
4
0
-4
-6
% RETENTION LOSS
Normals
Retardates
Retardates
Normals
Retardates
Normals
New Test
New Int.
New Test
Old Int.
New Test
New Int.
New Test Old Int.
Old Test Old Int.
Old Test
Old Int.
Pro
Retro
SOURCES OF INTERFERENCE

Interfering Problems - by - Sources of Interference interaction. The conditions of old test problems and new interfering problems were omitted in the plot because there was a similar trend demonstrated by retardates and normals on this variable combination. Looking at Figure 9, notice that retardates showed no retention loss on old test problems with old interfering problems under conditions of retroaction (- 5.1% loss). Retardates demonstrated intermediate levels of retention loss under conditions of proaction (10.1% and 12.1% and 12.9% losses), and they showed greatest losses in memory on new test problems under conditions of retroactive interference (18.4% and 26.7% loss). But, the opposite picture emerged for the normal children. They showed no retention loss on old test problems with old interfering problems under the conditions of proaction (- .4% loss). Normal children showed intermediate amounts of memory loss under conditions of retroactive interference (6.5% and 6.5% and 11.5% losses) and they demonstrated greatest amounts of retention loss of new test problems under conditions of proactive interference (13.4% and 24.6% losses). This fourth order interaction was reliable ($F = 6.72$; $df = 1/32$; $p < .05$).

DISCUSSION

Interpretation of Results

Acquisition data. - Retarded children learned more slowly than comparable mental age normal children. In fact, the difference in acquisition was already significant on the second discrimination trial. These results suggest a positive relationship between IQ and the rate of discrimination learning. Historically more studies than not seemed to support this finding (See review of literature by Zeaman and House, 1965). Historically even theories predicted such findings (Spitz, 1963). However, more recent data and theories have provided a basis for interpreting such findings not in learning terms but rather in terms of an attentional process. According to the Attention-Retention Theory (Fisher and Zeaman, 1973) IQ parameter controls children's attention. More specifically, differences between normals and retardates should occur in the lengths of original plateaus of non-learning rather than in the slopes of the rising portions of the learning curves. To demonstrate this, the acquisition data were reanalyzed, in terms of backward learning curves (Zeaman et.al., 1963) to obviate averaging errors, and plotted in Figure 10. Notice that normal children began to learn sooner than retarded children and the rates of learning were approximately the same for both IQ groups. Voilá, the plots matched the expectations of the Attention-Retention Theory and confirm a positive relationship between IQ and the attention process. The higher the IQ the more likely a child is going to select the relevant dimensions of an assigned task and the more quickly he is going to begin learning that task.

Developmental Retention data. - When compared to normal children, the retarded children showed only a trend in the direction of an overall memory deficit. Formerly, both data and theory (Ellis, 1963) were published supporting a general retardate memory deficit. This deficit was believed to occur in retardate short-term and long-term memory processes.

Figure 10

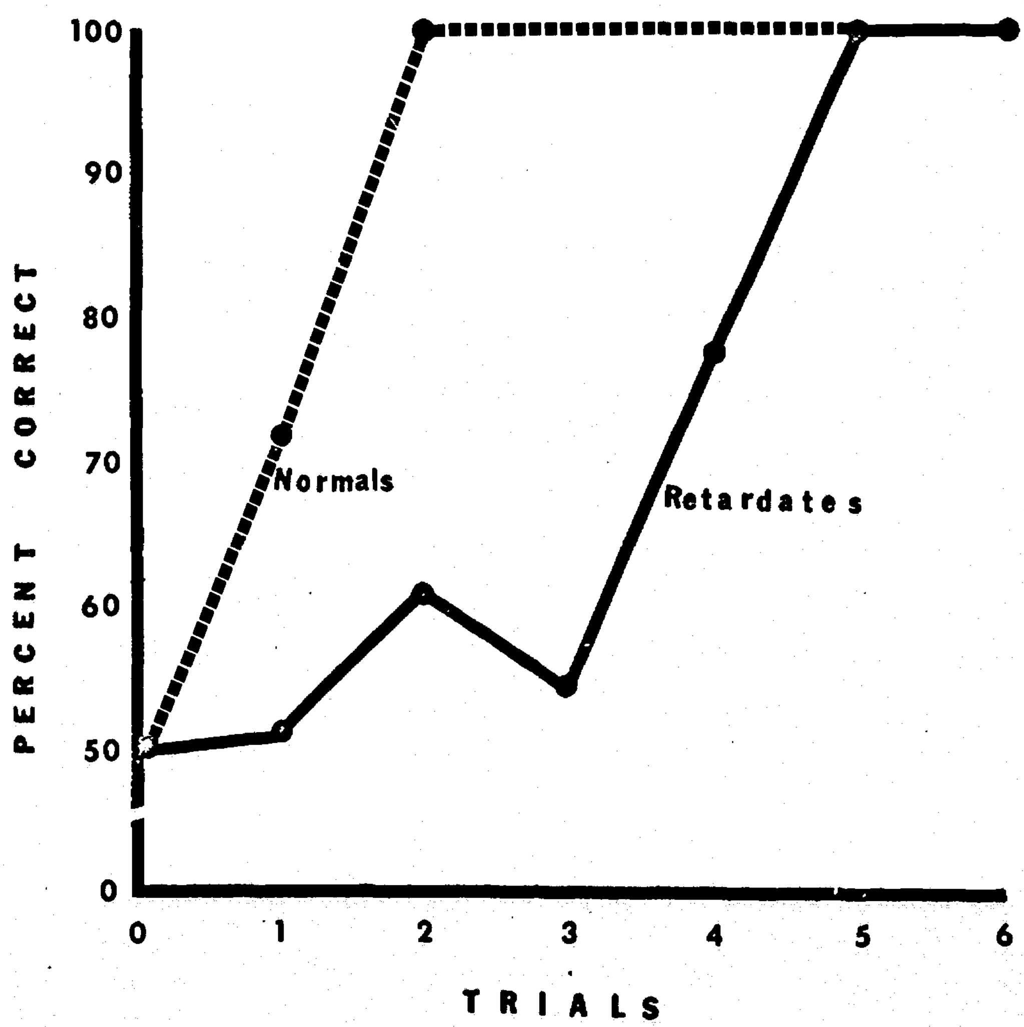
Backward Learning Curves

of Normal and Retarded Children

(Data Averaged Over 3 Trials and Plotted Backward

From Group Median Trial to Criterion)

Figure 10


100
90
80
70
60
50
0
PERCENT CORRECT
Normals
Retardates
0
1
2
3
4
5
6
TRIALS

A few years later Belmont (1966) convincingly argued against retardate long-term memory deficit. The results of this study support specific rather than general retardate vs. normal children's memory differences, and they lead to the inference that short- and long-term memory processes interact differently for retarded and normal children.

The first indication of memory differences between normal and retarded children came from the data plotted in Figure 4. As compared to normals, retarded children suffered considerable retention loss under conditions of retroactive interference. The Mult-Process (M-P) retention theory of Ellis (1970) and the Attention-Retention (A-R) Theory of Fisher and Zeaman (1973) explain retroaction by limited capacity and destructive read-in models of short term memory. Accordingly, retroactive items replace previous test items in a limited capacity system. If retardates as compared to normals had a smaller capacity short term store, then they should have demonstrated greater retroaction and greater retention loss. They did. Further evidence for this came from retroactive data plotted in Figure 6. As before, retardates showed greater retroactive interference effects than did normal children. But, the opposite was true on new test problems and proactive interference conditions. Here retardates showed less retention loss than normals. This inversion of retention loss probably occurred because the retardates had a more limited ability to rehearse multiple items (McBane, 1972). The M-P Theory of Ellis postulated poor rehearsal strategies of retardates to account for proaction effects. The A-R Theory of Fisher and Zeaman assumed that retardates as compared to normals have a smaller capacity rehearsal system. Hence, the fewer the items which can be rehearsed or the poorer rehearsal strategy, the less chance for proactive interference. As predicted, retardates suffered less proaction than normal children.

Two additional sets of data support retardate vs. normal differences in memory processes. In Figure 8 notice that retarded children, recalling after long retention intervals suffered significant retroaction effects on new test problems, but showed no retroactive interference effects on old test problems. In contrast, normal children suffered reliable proactive interference effect on new test problems but indicated no such interference effect on old test problems. Old test problems theoretically were stored in long term memory, while new test problems were stored in short term memory or in buffer storage. Hence, the retardates' long term memory store was not susceptible to retroaction and the normals' long term memory was immune to proaction. In contrast, retardates' short term memory suffered from retroaction because of their limited rehearsal strategies (M-P Theory) or their limited capacity and destructive read-in mechanism (A-R Theory). Normals' short term memory suffered from proaction because of their better rehearsal strategy system (M-P Theory) or their larger capacity rehearsal system (A-R Theory), both of which increase the number of items available for interference to take its toll. Looking back at Figure 8, notice that retarded children showed intermediate proaction effects for old and new test items on long retention intervals. These increasing proaction effects with longer retention intervals corroborate Knight's (1968) data and can be handled by Fisher and Zeaman's A-R theory. With increasing retention intervals the theory predicts long term store and rehearsal system interaction which would increase the number of items in active memory and therefore increase the likelihood of interference. In all its apparent complexity, Figure 9 illustrates additional differences between normal and retarded children's memory. Retarded children suffered no retroaction effects on items stored in long term memory (old test, old interfering problems), they demonstrated intermediate amounts of retention loss with proactive interference, and retardates suffered most from retroaction on items handled by short term memory process (new test, new interfering problems). In contrast, normal children showed no proaction effects on items stored in long term memory, they demonstrated intermediate amounts of retention loss with retroactively interfering problems, and normal children suffered most from proaction on items handled by rehearsal system (new test, old interfering problems).

Summarizing, both normal and retarded children showed minimal retention loss and interference effects on test items stored in long term memory. Normal children with their larger capacity rehearsal system showed most retention loss from proactive interference effects. Retarded children demonstrated most retention loss from retroaction and this probably was due to their low capacity short term memory process.

Related memory data. - First, the study clearly showed that longer retention intervals resulted in more retention loss. While this was already known to Ebbinghous (1885) more recent evidence suggests that longer retention intervals increase the likelihood that interference will take its toll on items processed or stored in memory (Knight, 1968; Stukuls, 1968).

Second, the results clearly demonstrated that increased amounts of training on test items facilitate their retention. While not surprising, this finding supports data which showed that strong habits do not succumb to proactive or retroactive interference effects (Stukuls, 1968).

Third and perhaps the most exciting outcome of the study came from data plotted in Figure 5. Note that poorly learned interfering problems (new interference) produced small amounts of proaction and relatively large amounts of retroaction. In contrast, well learned interfering problems (old interference) caused small amounts of retroaction but sizable amounts of proaction. These data strongly support multi process memory models. The Attention-Retention Theory of Fisher and Zeaman (1973) predicted this outcome. The A-R theory postulated that retroactive interference effects are mostly derived from limited capacity, destructive read-in short term memory process. Old items which reside in long term memory therefore should not produce retroaction. They did not. But, new retroactive items should replace items in limited capacity short term memory with resultant memory loss. They did. In addition,the A-R theory postulated that proactive interference effects are mostly derived from limited capacity rehearsal system. Accordingly, rehearsal of new proactive items would be minimized with the arrival of test items in the limited capacity system and therefore they should not produce much proaction. They did not. The opposite would be expected with old proactive items. More thoroughly rehearsed old proactive items would not be likely replaced by the arrival of test items in the rehearsal system and therefore they would be expected to produce proaction and cause retention loss. They did.

Finally, as may be seen in Figure 7, most of the above mentioned interference effects occurred reliably only during long retention intervals. Such data supported findings of Knight (1968) and Stukuls (1968) and they were predicted by the Multiple-Process Theory of Ellis and by the Attention-Retention Theory of Fisher and Zeaman. Both data and theories strongly indicate that it takes time for interference to take its toll on memory.

Educational Implications

The results of this and numerous other studies have indicated that normal children begin learning more quickly than retarded children. The retardates suffer from poor control over their attentional process. They seem relatively unable to select the reinforced dimensions and cues on learning tasks. This attentional deficit of retardates may be overcome by initially choosing tasks tailored to their cue preferences (Campione and Wentworth, 1969) and their dimensional preferences (Brown, 1970). Retardate attentional deficit may be overcome by teaching successive tasks within the same dimension or category (intra-dimensional shift) and by avoiding extra-dimensional shift conditions (Campione et. al., 1965). Another way to overcome the attentional deficit would be to make stimuli more salient (Shepp and Zeaman, 1966) and more redundant (Zeaman and Denegre, 1967). Additionally, reducing the number of irrelevant task dimensions (Zeaman et. al. 1965) should reduce the attentional deficit of retarded children and permit a more rapid onset of their learning.

The results of this study also demonstrated a retardate short term memory deficit. Their short term memory appeared to have limited capacity and it was particularly susceptible to retroactive interference effects. This and at least one more study suggest that these strong retroactive effects can be reduced through overtraining (Stukuls, 1968).

Finally, this study corroborated evidence that interference effects occur mostly in short term memory and in the limited capacity rehearsal system of memory. These interference effects became most obvious after long retention intervals. To reduce memory loss after long retention intervals the material from short term memory and rehearsal system of memory must be transferred to long term memory store. Repeated trials and task overlearning should decrease proactive interference (Knight, 1968) and retroactive interference (Stukuls, 1968). Strong habits survive even long retention intervals and they do so equally well for normal and retarded children.

BIBLIOGRAPHY

Archer, E.J., & Underwood, B.J. Retroactive inhibition of verbal association as a multiple function of temporal point of interpolation and degree of interpolated learning. Journal of Experimental Psychology, 1951, 42, 283-290.

Belmont, J.M. Long-term memory in mental retardation. In Ellis, H.R. (Ed.), International review of research in mental retardation. New York: Academic Press, 1966.

Briggs, G.E. Retroactive inhibition as a function of the degree of original and interpolated learning. Journal of Experimental Psychology, 1957, 53, 60-70.

Broadbent, D.E. Perception and communication. New York: Pergammon, 1958.

Brown, A. The stability of dimensional preference following oddity training. Journal of Experimental Child Psychology, 1970, 9, 239-252.

Campione, J.C. & Wentworth, C. Differential cue habit strength as a determinant of attention. Journal of Experimental Psychology, 1969, 82, 527-531.

Ebbinghous, H. Memory: A contribution to experimental psychology: 1885 (H.A. Roger & C.E. Bussenius, Tr.) New York: Teachers College, Columbia University, 1913.

Ellis, N.R. The stimulus trace and behavioral inadequacy. In Ellis, N.R. (Ed.), Handbook of mental deficiency. New York: McGraw-Hill, 1963.

Ellis, N.R. Memory processes in retardates and normals: Theoretical and empirical considerations. In N.R. Ellis (Ed.), International review of research in mental retardation. Vol. 4. New York: Academic Press, 1970.

Fisher, M.P. & Zeaman, D. An Attention-Retention Theory of retardate discrimination learning. In N.R. Ellis (Ed.), International review of research in mental retardation. Vol. 6. New York: Academic Press, 1973.

Garscof, B.E. & Bryan, T.M. Unlearning as a function of degree of original learning and retention test. Psychonomic Science, 1966, 8, 391-399.

Gellermann, L.W. Chance orders of alternating stimuli in visual discrimination experiments. Journal of Genetic Psychology, 1933, 42, 206-208.

Hebb, D.O. The organization of behavior: A neurophysiological theory. New York: Wiley, 1949.

Heber, R.F., Prehm, H., Nardi, G., & Simpson, N. Learning and retention of retarded and normal children on a paired associates task. Paper read at the annual meeting, Amer. Assn. Ment. Defic., New York, May, 1962.

Hellyer, S. Supplementary report: Frequency of stimulus presentation and short-term decrement in recall. Journal of Experimental Psychology, 1962, 64, 650.

Hovland, C.I. Human learning and retention. In Stevens, S.S. (Ed.), Handbook of experimental psychology. New York: John Wiley & Sons, Inc., 1958.

Klinman, C.S. Short-term memory in the discrimination learning of retardates. Doctoral dissertation, University of Connecticut, Storrs, Conn., 1964.

Knight, M. The effects of intertrial interval duration on short-term retention of a two choice visual discrimination task by retarded children. Journal of Experimental Child Psychology, 1968, 6, 241-253.

Lance, W. Effects of meaningfulness and overlearning on retention in normal and retarded adolescents. American Journal of Mental Deficiency, 1965, 70, 270-275.

Lindquist, E.F. Design and analysis of experiments in psychology and education. Boston: Houghton-Mifflin Co., 1953.

McBane, B. Short term memory capacity and parallel processing. Unpublished doctoral dissertation, University of Connecticut, 1972.

Melton, A.W. Implications of short-term memory for a general theory of memory. Journal of Verbal Learning and Verbal Behavior, 1963, 2, 1-21.

Melton, A.W., & Von Lackum, W.J. Retroactive and proactive inhibition in retention: evidence for a two-factor theory of retroactive inhibition. American Journal of Psychology, 1941, 54, 157-173.

O'Connor, N., & Hermelin, B. Recall in normals and subnormals of like mental age. Journal of Abnormal and Social Psychology, 1963, 66, 81-84.

Peterson, L.R., & Peterson, M.J. Short-term retention of individual verbal items. Journal of Experimental Psychology, 1959, 58, 193-198.

Postman, L. The present status of interference theory. In Cofer, C.N. (Ed.), Verbal learning and verbal behavior. New York: McGraw-Hill, 1961.

Postman, L. Does inference theory predict too much forgetting? Journal of Verbal Learning and Verbal Behavior, 1963, 2, 40-48.

Postman, L., & Riley, D.A. Degree of learning and interserial interference in retention. Univ. Calif. Publ. Psychol., 1959, 8, 271-396.

Prehm, H.J., & Crosson, J.E. The mentally retarded. Review of educational research, 1969, 39, 16-17.

Richardson, J. Retention of concepts as a function of degree of original and interpolated learning. Journal of Experimental Psychology, 1956, 51, 358-364.

Scott, K.G. Some parameters of short-term recall. Doctoral dissertation, University of Connecticut, Storrs, Conn., 1966.

Shepp, B.E., & Zeaman, D. Discrimination learning of size and brightness by retardates. Journal of Comparative and Physiological Psychology, 1966, 62, 55-59.

Silberberg, N.E. & Silberberg, M.C. Myths in remedial education. Journal of learning disabilities, 1969, 2, 34-42.

Spitz, H.H. Field-theory in mental deficiency. In Ellis, N.R. (Ed.), Handbook of mental deficiency. New York: McGraw-Hill, 1963.

Stukuls, H. Discrimination learning and effects of proactive and retroactive interference on the retention of mental retardates. Dissertation Abstracts, 1968.

Thune, L.E., & Underwood, B.J. Retroactive inhibition as a function of degree of interpolated learning. Journal of Experimental Psychology, 1943, 32, 185-200.

Trabasso, T. Pay attention. Psychology Today, 1968, 2, 30.

Underwood, J.J. Proactive inhibition as a function of time and degree of prior learning. Journal of Experimental Psychology, 1949, 39, 24-346.

Underwood, B.J. Interference and forgetting. Psychological Review, 1957, 64, No. 1, 49-58.

Vergason, G.A. Retention in retarded and normal subjects as a function of amount of original training. American Journal of Mental Deficiency, 1964, 68, 623-629.

Waters, R.H. Degree of learning and proactive inhibition in retention. Psychological Bulletin, 1942, 39, 495-496.

Zeaman, D., & House, B.J. The relation of IQ and learning. Manuscript for Conference on Learning and Individual Differences, 1965.

Zeaman, D., & House, B.J. The role of attention in retardate discrimination learning. In Ellis, N.R. (Ed.), Handbook of mental deficiency, New York: McGraw-Hill, 1963.

APPENDIX

Analysis of Variance of Mean Number of Trials to Criterion Learning on Interference Free Discrimination Learning Problems

A = IQ Groups (retarded vs.normal children)

B = Retention Interval Groups (short term vs. long term)

Source of Variation	df	MS	F
A	1	27.33	8.70**
B	1	9.64	3.07
A X B	1	7.45	2.37
Within	32	3.14	

**p < .01

Analysis of Variance of Percent Correct Responses on Second Trial of Interference Free Discrimination Learning Problems

A = IQ Groups

B = Retention Interval Groups

Source of Variation	df	MS	F
A	1	.070	4.38*
B	1	.030	1.88
AB	1	.005	<1
Within	32	.016	

*p < .01

Analysis of Variance of Retention Loss Scores

A = Subjects (36)

B = IQ groups (retarded vs. normal children)

C = Retention Intervals (seconds vs. hours)

D = Kinds of Test Problems (old vs. new)

E = Types of Interfering Problems (old vs. new)

F = Sources of Interference (proactive vs. retroactive)

The Table Includes Only Main Effects & Interactions

With Significant Outcomes and Pooled Error Variances

Source of Variation	df	MS	F	*p*
A	8	2048.03		
B	1	217.01	<1	
C	1	10829.01	5.01	<.05
Error Term	32	2159.55		
D	1	17734.72	94.19	<.001
Error Term	32	188.28		
E	1	0.35	<1	
Error Term	32	294.40		
F	1	153.13	<1	
Error Term		287.02		
E X F	1	4917.02	9.27	<.01
C X E X F	1	2278.13	4.29	<.05
Error Term	32	530.51		
B X D X F	1	1422.22	5.36	<.05
B X C X D X F	1	2005.56	7.55	<.01
Error Term	32	265.54		
B X D X E X F	1	2112.50	6.72	<.05
Error Term		314.32		

Sub-Analysis of Variance of Retention Loss Scores

A = Subjects (18)

D = Kinds of Test Problems (old vs. new)

C = Retention Intervals (seconds vs. hours)

E = Types of Interfering Problems (old vs. new)

F = Sources of Interference (proactive vs. retroactive)

The Table Includes Only Main Effects and Interactions

With Significant Outcomes and Pooled Error Variances.

Sources of Variation	df	MS	F	p
Retardates				
A	8	2964.86		
C	1	5160.03	1.61	> .10
Error Term	16	3209.16		
D	1	7802.78	43.57	< .01
Error Term	16	179.08		
E	1	25.00	< 1	
Error Term	16	369.62		
F	1	667.36	3.25	< .09
Error Term	16	205.12		
E X F	1	3306.25	5.16	< .05
Error Term	16	642.19		
D X E X F	1	1284.03	6.18	< .05
Error Term		207.64		
Normals				
A	8	697.23		
C	1	5675.11	5.11	< .05
Error Term	16	1109.93		
D	1	10000.00	50.64	< .01
Error Term	16	197.48		
E	1	17.36	< 1	
Error Term	16	219.20		
F	1	69.44	<1	
Error Term	16	368.90		
E X F	1	1736.11	4.15	< .07
C X E X F		1406.25	3.36	< .09
Error Term	16	418.84		