A DEVELOPMENTAL STUDY OF INTERFERENCE AND FORGETTING

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by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES CONT'D

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ABSTRACT OF THESIS

The purpose of this study was to investigate possible interference effects of prior and interpolated learning on recall at three different age levels (4, 6 and 8 years). The investigation was intended to be of an exploratory nature since little experimental work in this field had been reported so far.

A paired associate learning situation of the A-B, A-C paradigm was employed. Two experimental groups and one control group were used at each of the three age levels. The control group learned one list which was recalled after 24 hours' rest. One of the experimental conditions was designed to produce Proactive Inhibition (PI), having the subjects learn two lists (A-B, A-C) in close succession and requiring them to recall the second list (A-C) after 24 hours. The other experimental group learned the same two lists but recalled the first list (A-B) as a test of Retroactive Inhibition (RI) effects. One further experimental group was incorporated into the design, involving a Modified Free Recall condition. This group learned the same material as the PI and RI groups, but recalled both list responses to the common stimuli after 24 hours to investigate any possible age differences in ability to discriminate between the two lists.

The analysis of data showed no significant differences

between the three age levels for either the PI or the RI conditions. Under the Rest condition there seemed to be an improvement in recall with increasing age, but it also was not statistically reliable. Analysis of PI, RI and Rest conditions at the individual age levels, however, showed an interesting trend. While the difference between the two experimental and the control groups was non-significant at the 4-year level, it increased at the 6-year level ($p < .01$) and in the 8-year group it reached a dependability beyond $p < .001$. It was concluded that while recall of one list generally appeared to improve with age, interference effects from a second list increased with age.

Analysis of Modified Free Recall showed no significant difference between recall of first and second list and between age levels. This seemed to agree well with the performance of the interference groups where no significant difference was observed between RI and PI, or between age groups. However, since the total number of items recalled was slightly lower at all age levels it was decided to replicate the MFR condition to investigate if the decrease in scores was a function of the stimulus cards employed. MFR under the second condition was conducted with all original stimulus cards spread out on a table with the response pictures covered up. Even though recall was slightly higher at the 6 and 8 year level and somewhat lower at the 4-year level than under the

MFR I condition, the difference was not statistically dependable.

CHAPTER I

HISTORICAL BACKGROUND

Most intimately related to the phenomenon of learning is the problem of forgetting. Since, in fact, retention constitutes a criterion of learning, forgetting is one factor which most consistently enters into all measurements of learning itself. It seems, therefore, natural that much attention has been given to the investigation and theoretical interpretation of decrements in memory over time.

THEORETICAL CONSIDERATIONS

Early theories, designed to explain the deficit in retention, generally proposed that neural traces faded over time until they were finally erased, thereby producing the phenomenon which is commonly known as forgetting. However, it was soon discovered that the total process was too complex to be answered by this simple decay theory.

Jenkins and Dallenbach (1924) proposed an interference theory suggesting that forgetting is a matter of interference, inhibition or obliteration of the old by the new. This hypothesis opened up new areas of study where attention was given to the events between original learning and recall. A number of variables evolved which seemed to determine the amount and degree of interference with retention: Time, similarity, amount and degree of interpolated learning. These were the factors that were found to be related to the interference effects, now generally referred to as Retroactive Inhibition (RI).

McGeoch (1932, 1942) proposed a competition-of-response theory to account for the RI phenomenon in its various aspects. Generally it was hypothesized that interference is introduced when two response systems compete with one another during recall. If one is stronger than the other it will win out over the weaker one which is then "forgotten". If both are of equal associative strength they may block each other so that neither response will be recalled, or they are both available to the subject who may be unable to distinguish between the correct and incorrect response.

The advantage of this new theory lay in its applicability not only to RI but also to the more recently discovered interference effects of prior learning, a phenomenon which is now commonly referred to as Proactive Inhibition (PI).

To illustrate this point in terms of an experimental setting, a paired-associate learning situation may serve as an example. A number of words are grouped in pairs with the first item of each pair serving as the stimulus and the second one as the response. The subject is presented with two lists of such word pairs, one list designated A-B and the other A-C, which he has to learn in close succession. "A" represents the stimuli, which are the same in both lists, while the response words, designated by "B" and "C" are different in the two lists. Whereas under the RI condition the subject has to recall the first learned list (A-B) under the PI condition recall of the second list (A-C) is measured.

McGeoch's competition-of-response theory makes the implicit assumption that both response sets remain intact, even though they may be of differential associative strength. Thus either response may be available to the subject on recall. If this were the case, however, it would be expected that the majority of incorrect responses would be intrusions from the other list, i.e. from the first list under the PI condition, and from the second list under the RI condition. But experimental data show that this is not the case. The majority of errors usually consist of failures to respond.

On the basis of these findings Melton (Melton and Irwin, 1940; Melton and von Lackum, 1941) proposed a modification of the competition-of-response theory through addition of an extinction factor. He asserted that during acquisition of the second list the first list Stimulus-Response associations become unlearned and gradually lose associative strength until they are eventually extinguished when interpolated learning reaches a high level. Under the A-B, A-C paradigm the A-B connections are extinguished during the learning of A-C, thus RI should be greatest at immediate recall and PI smallest, which is actually the case. A-B becomes available again, however, when recall is delayed. This, Underwood suggests (1948), is due to spontaneous recovery of the previously extinguished list. RI, therefore, decreases with time while PI increases until they are about equal in size after a twenty-four hour interval. Thus Melton's two-factor theory successfully handles the fact that RI is greater than PI after short retention intervals and, in conjunction with Underwood's notion of spontaneous recovery, it also accounts for the equating of RI and PI after longer intervals.

New light was shed on the problem of forgetting when Underwood published his article on Interference and Forgetting (1957). Up to this time it was almost universally assumed that most forgetting was produced by RI, i.e. by material interpolated between original learning and recall. This can be readily understood since the majority of data had been derived from short-term retention studies where RI is accentuated and can be much more readily demonstrated than PI.

In the paper mentioned above Underwood pointed out the importance of previously learned material as a major source of interference. Reviewing a considerable amount of experimental data on recall of lists of words or nonsense syllables, he was able to show that the majority of these studies made use of practice lists and counterbalancing where one subject served in several experimental conditions on successive days. The data which showed up to 75% forgetting of a single list over twenty-four hours were, therefore, based on the performance of individuals who had learned a number of lists prior to the critical list whose recall was actually under investigation.

Underwood was also able to show that retention decreased progressively as amount of previous experimental learning increased. Naive subjects, on the other hand, who served in one experimental condition, learning and recalling only one list, showed far less deficit in retention (approximately 25% forgetting over twenty-four hours). After pointing up the detrimental effects of prior experimental learning on retention in experienced subjects, Underwood went further and proposed that the amount of forgetting observed in naive subjects over 24 hours was also mainly due to interference from prior learning outside the laboratory and not, as generally assumed, due to learning during the retention interval. As he pointed out, it seems much more likely that an individual should accumulate a fund of interfering stimulus-response associations over the years prior to the actual experiment rather than during the relatively short 24 hr interval between learning and recall.

Underwood's new hypothesis has stimulated theoretical thinking which resulted in some recent attempts to develop an interference theory along this line.

Postman (1961) asserts that two kinds of interference are operating in the long-term verbal recall. Returning again to the A-B, A-C paradigm let it be assumed that A-B constitutes a well established word association due to linguistic habits. In the course of learning A-C in the laboratory the well established A-B associations have to be extinguished. Due to their considerable associative strength, however, they are very resistant to extinction and experience a marked spontaneous recovery and thus constitute a source of substantial competition for the newly learned material. It follows from an associative learning theory that the more frequently such linguistic (A-B) word associations have been practiced the stronger they are, and the more they will interfere with the recall of relatively recent additions in word association learning.

Pursuing this line of reasoning further, it could be speculated that at younger age levels where linguistic habits are not as yet firmly established, less interference from previously learned extra-experimental material would be introduced to decrease the retention of newly learned associations. The possibility is then suggested that in the retention of laboratory learned paired-associates young subjects may experience less interference from previous non-laboratory learning than older ones.

The very general proposition which forms the core of this paper is that if extra-experimental prior learning is the important source of interference and forgetting, this may be evidenced in age differences in retention, since degree and amount of prior learning undoubtedly increase with age.

It must be pointed out that any developmental study of this kind at the present time can only be of an exploratory nature since very little work of this sort has been done with children which could serve as a guide for experimental methods and theoretical speculations.

There are a number of difficulties in attacking this proposition experimentally. By far the most important of these concern the isolating of the prior learning variable itself. In examining this variable developmentally there is the danger of confounding the experimental data with age variables other than prior learning such as the ability to discriminate between different lists.

Underwood (1948) has devised a technique which measures this ability to differentiate lists in adults. Under this so-called Modified Free Recall (MFR) condition subjects learn two lists of paired associates, A-B and A-C, and recall both response members B and C as a measure of response availability. Following this initial retention test, the subject is then asked to identify the particular list to which a given response item belongs (MMFR; Underwood and Barnes, 1959). The latter score then represents a measure of differentiation. This being an even more recent technique than the RI and PI paradigm, there are only few data available in adult retention and none for recall of children.

It would appear appropriate at this point to review briefly some of the publications on experimental studies in retention of children.

DEVELOPMENTAL STUDIES OF RETENTION

Developmental studies of retention and forgetting, conducted over the past sixty years, have made use of a variety of methods and materials. Most of the work involved recall of memorized prose passages, poetry or nonsense syllables, or recall after a single presentation of simpler material, such as digits, colours, pictures, narratives, geometric forms, etc. On the basis of early experimental findings a number of attempts were made to devise memory norms for the various age levels (Achilles, 1920; Bayley 1926; Hurlock and

Newmark 1931; Terman and Merrill 1937). The general result of these investigations was to show that retention increased with age, presumably due to maturational processes.

There is little mention made in this early work of interference effects as possible source of forgetting. Foster (1928), who presented her subjects with a number of narratives, briefly notes that interpolated stories had an interfering effect upon the relearning of previously learned material.

The only systematic developmental studies of interference effects of interpolated learning upon recall were reported by Foran (1937) and Lahey (1937). Foran investigated the differential effects of a variety of interpolated tasks and found that similarity of original and interpolated material maximized retroactive inhibition, but he observed no significant relation between age and amount of RI. Lahey, on the other hand, who varied amount of interpolation but held type of material constant, reported a decrease of RI with increasing age.

In both studies original learning involved silent memorization of 25 verbs for five minutes, at the end of which a four minute retention test was given. The score on this test served as a measure of original learning. Different interference groups of the same age were equated on the basis of mean original learning scores. Degree of original learning was not held constant between age levels and Lahey concedes that the eight and nine year groups attained comparatively low scores on the initial test. Interpolated material was a list of nouns, studied from four to seventeen minutes depending upon the respective experimental condition. Delayed recall of original learning took place seventeen minutes and twenty-four hours after the first retention test for all groups. In the Foran study delayed recall of original learning occurred fifteen minutes after the first criterion test. Since the latter study reports data on an experimental condition very similar to that of Lahey's it seems appropriate to present them together in Table I for comparison.

TABLE I

Percent of RI on recall as a function of age, from two early studies

	AGE					
	8	9	10	11	12	13
FORAN (recall after 15 min.)	34.7	50.9	40.0	41.8	42.3	23.8
LAHEY (recall after 17 min.)	45.1	40.8	49.3	45.5	42.5	39.3
LAHEY (recall after 24 hrs.)	58.5	44.9	47.3	47.5	40.2	38.8

All data are given in per cent RI; those of Lahey's study represent a mean of the RI percentages reported for different lengths of interpolated learning.

The validity of Lahey's statement that RI decreased with increasing age must be questioned. Examination of Table I indicates that RI does not show a consistent change between the ages of eight and twelve. Only beyond the ages of 13 was a progressive drop in RI with increasing age noticeable, and it seems likely that Lahey's conclusions were mainly based upon the performance of these older age groups.

The most significant fact about these two studies, however, was the lack of any control over degree of original or interpolated learning, both of which undoubtedly varied with age. Since these two variables are now known to be powerful determinants of interference effects, no conclusions from these data about the effects of age on interference can be reached with confidence.

STATEMENT OF THE PROBLEM

Unfortunately no other work has been done in this area and we are relatively in the dark with regard to interference effects in retention of children. The problem with which we are confronted is twofold in nature: First, a thorough developmental study of retroactive and proactive inhibition effects on a purely empirical basis is of a necessity. Second, an attempt can then be made to isolate any possible age effects and incorporate these findings into a theoretical framework, particularly the recent theoretical emphasis on prior extra-experimental learning as the basis of interference and forgetting.

It is self-evident that a great deal of experimental work in this field is required before either of these two problems can be dealt with satisfactorily. One investigation can only hope to probe a few aspects of the large area to be explored by future research.

CHAPTER II

EXPERIMENTAL METHODS AND RESULTS

I. METHOD

The main problem of a developmental study of retention arises from the necessity of holding the amount and degree of original learning constant, i.e. to design a task that can be mastered by children below the public school level and, on the other hand, still constitute a learning problem for older age groups. A study on transfer in the paired-associate learning situation by Norcross and Spiker (1958) served as a guide, particularly with regard to materials and apparatus employed. In this experiment pairs of simple pictures clipped from a picture stamp book were presented in the Hunter Card Master to subjects (Ss) from the Kindergarten and first grade level. Three lists consisting of six pairs each were learned with a time interval of one week between each list. Since it was intended to present the Ss of this present experiment with two interfering lists in one experimental session, it was decided upon to reduce the number of items per list to four pairs so that four year olds could still be expected to learn two lists in one session. Preliminary work indicated that most four year olds could be expected to do so and that a four-pair list still presented a reasonable learning problem for children up to at least nine years of age.

MATERIALS

The apparatus used was the Hunter Card Master No. 340, similar to the one described by Norcross and Spiker (1958). It consisted of a gray metal box with a 3" x 6" apperture, two halves of which were covered by two shutters whose functions were controlled by electronic timers contained in a separate metal box. The length of time either shutter was open or closed could be manipulated independently.

Plastic cards 3½" x 6½" in size were inserted into the apparatus and exposed through the apperture at a pre-determined speed. Half the cards were sprayed with black paint while the other half retained their original white colour. This procedure facilitated the distinction between the two lists to be learned in one experimental session. The lists were identified as "day" or "night" lists depending upon their white or black background. Mounted on these cards were pictures taken from the "Sticker Fun" collection, each representing a single, familiar object. The lists were designed according to the A-B, A-C paradigm so that both the black and white cards bore the same stimulus picture while the response items were different and of estimated low associative strength with each other as well as with the stimulus. An attempt was made to keep similarity and association between all pictures in an A-B, A-C set at a minimum. Two sets of A-B, A-C lists were used, with half the Ss in each condition. Names of the stimulus and response objects of each set are given in Table II.

TABLE II

	SET I			SET II	
	"Day" List White	"Night" List Black		"Day" List White	"Night" List Black
Stimulus A	Response B or C	Response C or B	Stimulus A	Response B or C	Response C or B
Jacket	Horse	Drum	Dress	Tree	Ball
Doll	Flower	Kitten	Chair	Gun	Bird
House	Train	Apple	Bear	Key	Airplane
Boat	Sofa	TV	Truck	Glove	Hat

To avoid serial learning three orders of presentation of each list were alternated on successive trials. The presentation of "day" and "night" lists was also counter-balanced so that half the Ss in interference conditions learned the white list first, the other half the black list first.

Each stimulus was exposed for a 6-second anticipation period (left shutter open only) during which the S was to make his response. Next both the stimulus and response pictures were shown for three seconds (both shutters open), after which both shutters were closed for two seconds while the card was exchanged for the next one. At the end of each trial a blank card was exposed for the same amount of time as one stimulus-response card, i.e. a total of nine seconds.

DESIGN

Table III presents the basic interference and forgetting design which was replicated at each of three age levels.

TABLE III

Experimental design, replicated at three age levels

Condition	Learning*	Retention Interval	Recall
Rest	A-C	24 hours	A-C
PI	A-B A-C	24 hours	A-C
RI	A-C A-B	24 hours	A-C
MFR	A-B A-C	24 hours	A-(B & C)

* Of two lists in a set, each was used equally often as "A-B" and "A-C" within each condition.

The design included two experimental groups, one each for the PI and RI condition. Both learned two lists in close succession on the first day, but recalled either the first list for the RI condition or the second list under the PI condition. One control group was run under the rest condition learning only one list (white or black) and recalling the same list after 24 hours.

Since there was a possibility that the age groups would differ in ability to differentiate between the two lists, a fourth condition, Modified Free Recall (MFR), was included in which Ss were asked to recall both responses to the common stimuli. While this group viewed the same material as the PI and RI groups in the learning situation, grey cards had to be introduced in the recall condition, since it is not possible to present both original stimuli (one white and black cards) simultaneously in the Hunter Card Master.

Anticipation time was not limited for the MFR group whereas it was set at ten seconds for all other recall conditions. There was only one recall trial in all conditions.

SUBJECTS

The Ss were 144 children, drawn from private nurseries, kindergartens and from five grade III public school classes in a middle-class residential section of metropolitan Winnipeg. There were 48 Ss at each age level. The mean ages of the three levels were 4 yrs 5.76 months, 5 yrs 8.98 months, and 8 yrs 7.03 months. To avoid an overlap between groups, cut-off ages were observed as follows in the selection of Ss:

4 yr level - from 4 yrs 0 months to 4 yrs 10 months
6 yr level - from 5 yrs 6 months to 6 yrs 1 month
8 yr level - from 8 yrs 1 months to 9 yrs 1 month

The mean age in each of the twelve sub-conditions is given in

Table IV.

TABLE IV

Age means at four experimental conditions

	PI		RI		REST		MFR	
	Yrs	Mos	Yrs	Mos	Yrs	Mos	Yrs	Mos
4 yr level	4 -	5.16	4 -	5.29	4 -	7.04	4 -	5.54
5 yr level	5 -	9.00	5 -	8.87	5 -	8.96	5 -	9.04
8 yr level	8 -	7.00	8 -	7.25	8 -	7.08	8 -	6.79

Within each age level 12 Ss were assigned to each of the four experimental conditions, PI, RI, MFR, and Rest. An attempt was made to assign an equal number of girls and boys to each condition, as well as to keep the mean age of the conditions constant. Otherwise assignment of Ss was random. All Ss were naive to the test and apparatus. Four Ss at the four year level and two Ss at the six year level had to be replaced because they could not learn the task.

PROCEDURE

On the first day the S was conducted from the classroom to the experimental room by the experimenter to "play a guessing game". Before the beginning of the actual learning period the S was shown the first list of cards outside the apparatus and each picture was identified by the child. If the S did not have a name readily available the experimenter suggested one. Then the first list of cards was inserted into the apparatus and the second list was shown in the same manner and then put out of sight. Without further instructions the apparatus was set in motion. The first card to appear in the apperture was always a blank, either black or white, which was to introduce the S to the list category. The experimenter pointed out the card with the following remarks:

> "Do you see this white (black) card? This is to show you that it is daytime (night time) and that we are now going to look at the pictures in day light (at night)."

When the first stimulus picture appeared E said:

> "This is a ...."

upon which S usually filled in the name of the object. If he failed to do so E would give the correct term. The children quickly understood what was required and usually named the objects without further urging by the second trial. As soon as the stimulus was identified E asked S what was behind the closed door. When the right shutter opened, the response item was identified.

After presentation of all four stimulus-response pairs another blank card appeared accompanied by E's remark:

> "And here is a white (black) card again to remind you that it is still day time (night time) and that we are looking at these pictures in day light (at night)."

This procedure was continued until the first list was learned to criterion, which was one errorless trial. The child was praised for every correct response. The child was urged to guess and assured that there was no harm in making a wrong guess.

As soon as the subject had learned the first list to criterion, the apparatus was stopped and the cards were exchanged while E provided the following information:

> "You are certainly very good at guessing; but our troubles are not yet over. You see, while it was dark (or when it got dark) somebody exchanged all the things on this side (pointing to the right shutter). Now there will be different things behind this door and we have to start guessing all over again."

The apparatus was then set in motion and learning of the second list proceeded in the same manner as list no.1. When the second list was learned to criterion the subject was praised again and dismissed with the assurance that it had been great fun to play this game with him. At no time was the child told that he had to return the following day for a recall trial.

When S returned after 24 hours he was again seated before the apparatus and asked:

"Remember yesterday, when we looked at some pictures in day time and at others at night? Now today we are going to look at the day (or night) cards again to see what you can still remember."

Again the first presentation involved a blank card to introduce the subject to the list category which he was required to recall. The child was praised for every correct recall and when an error occurred he was reassured that he was not expected to remember everything correctly since the task was very difficult.

II. RESULTS

In this study the analysis dealt with both learning and recall. Analysis of learning was important as the number of learning trials to criterion constitutes a variable which has a bearing upon interference and recall. Since the younger Ss seemed to have taken more trials to criterion on the average than the older ones, it was important to establish if the difference was statistically reliable, and if there were discernable effects on retention.

LEARNING EFFECTS

The mean number of trials to criterion for first and second lists at the three age levels is shown in Table V. Using the data from the RI, PI, and MFR conditions, an analysis of variance was run on age level (between Ss) x list order

(1st or 2nd; within Ss).

TABLE V

First vs. second list learning.
Mean number of trials to criterion.

AGE Years	PI		RI		MFR		REST
	1st	2nd	1st	2nd	1st	2nd	
4	6.00	5.08	6.75	5.58	5.08	5.00	6.25
6	4.75	4.42	4.83	4.83	5.42	5.17	5.25
8	5.42	4.67	5.08	4.17	5.85	5.25	5.17

The resulting F's (appendix, Table Ia) showed no significant difference in learning between age levels, but the positive transfer effects from first to second list were significant at $p < .01$. The data (Table V) indicate that facilitation was experienced by all groups at all age levels with the exception of the six year olds under the RI condition.

The positive transfer effects on second list learning should have produced reliable differences between conditions in trials to criterion on the critical list (the list to be recalled), as this is the first list learned in the RI and Rest conditions, and the second list learned in the PI condition. To check on this further, an analysis of variance of critical list trials to criterion with condition (RI, PI, Rest) x age level, was conducted. The results (Table IIa, appendix) revealed no significant effects of experimental condition, but a significant age effect.

Although the results of the two analyses were somewhat contradictory, it seemed best to conclude that both the transfer and age effects were real but small. This is the conservative conclusion since the real concern here is with the interpretation of retention data, and the aim is not to attribute retention differences to the age or interference variables when they are possibly related instead to speed of original learning.

To investigate this latter possibility the recall scores of fast and slow learners were compared. The twelve fastest and the twelve slowest learners in trials to criterion on the critical list were selected at each age level from the Rest, RI, and PI conditions combined. The mean number of trials to criterion of critical list learning for the 36 fastest learners was 3.64 and for the 36 slowest learners it was 7.22. The difference between these two groups was significantly larger than the difference between 1st and 2nd list learning for PI, RI and MFR conditions (1st list = 5.46, 2nd list = 4.91) or the difference between age groups (4 years = 5.68, 6 years = 4.95, 8 years = 5.09). The mean recall scores of the 36 fast learners was 2.78 and of the 36 slow learners it was 2.61. A t-test showed that the difference in retention between these two groups was statistically non-significant ($t_{(df\ 70)} = .789$). It can, therefore, be concluded that speed of learning had very little, if any, effect on recall and that the effect was certainly not large enough to seriously confound identification of the effects of other variables.

RECALL AND INTERFERENCE EFFECTS

The mean number of correct responses at specific-list recall are given in Table VI. Recall in the PI and RI conditions decreased slightly with age while retention under the rest condition improved with increasing age. These two diverging trends are also shown in Figure 1.

TABLE VI

Mean Recall Scores

AGE Years	PI	RI	REST
4	2.58	2.50	3.25
6	2.75	2.17	3.58
8	2.08	2.17	3.83

The ceiling of the task under the rest condition was evidently too low for the eight year group where ten out of twelve Ss recalled all items correctly. This caused the variances to differ significantly and prohibited a parametric statistical analysis of these scores. The angular transformation (Walter and Lev, 1953), usually successful with

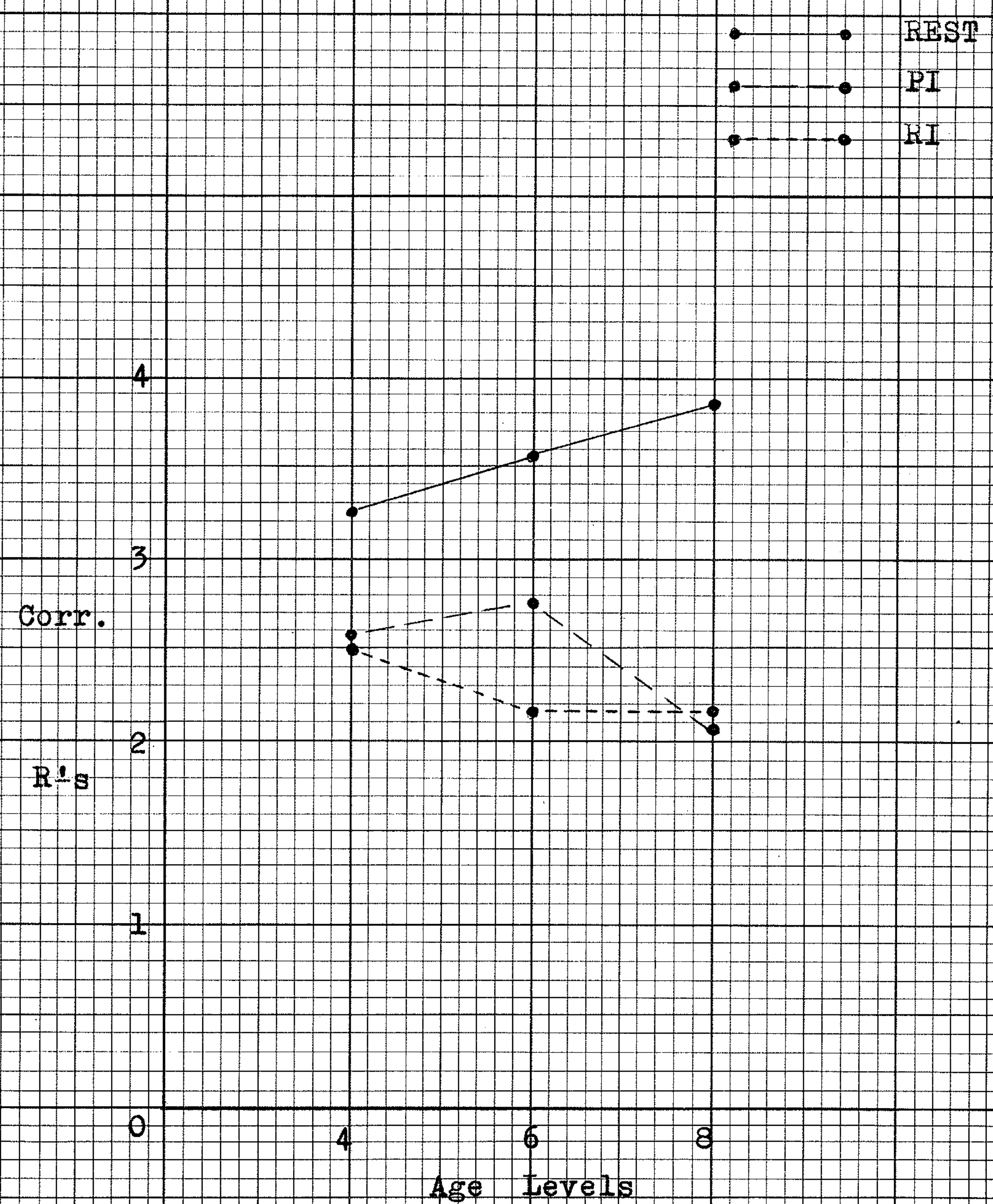

Figure 1. Mean number of correct responses on recall under PI, RI, and Rest conditions at three age levels.

proportion scores, could not be used because of the low *N* (number of possible recalls) for each score. It appeared best to use non-parametric statistics with the present scores. The Wilson test (1956) which yields an interaction term in a two-way analysis was rejected because of recent criticism of its marked lack of power (Lubin, 1962). The solution finally settled upon was to use several Kruskal-Wallis sum of rank tests, analogous to one-way analyses of variance, and to interpret the results somewhat cautiously because of the concurrent computation of a number of probabilities.

The Kruskal-Wallis *H* was computed first across conditions (RI, PI, Rest) for each age level separately, and then across age levels for each interference condition separately. The results produced a more meaningful picture than might be expected from this complicated analysis.

Table VII shows the Kruskal-Wallis *H*'s of the separate analyses. The difference between RI, PI and Rest conditions in the 8-year groups was significant at the .001 level. In the 6-year group the *p* dropped to a level of .01 while $p > .05$ in the four year group.

At the 6-year level further analysis of the data became necessary because of the difference in mean scores between the RI and the PI groups, as well as their deviation from the Rest condition. Three separate Sum-of-Ranks tests for pairs of the three conditions at this age level showed that the difference between RI and Rest was significant beyond the .002 level, while the PI-Rest and the PI-RI differences produced z's below the level of significance (RI-Rest: $z = 3.04$, PI-Rest: $z = 1.79$, PI-RI: $z = 1.24$).

TABLE VII

Kruskal-Wallis *H* across conditions PI, RI, and Rest at three age levels and across age levels for each of three conditions.

Conditions:	PI, RI, Rest	*H*	
	4 yr group	4.30	
	6 yr group	10.08	$p < .01$
	8 yr group	18.26	$p < .001$
Age Levels:	4, 6, 8 years	*H*	
	PI	2.81	
	RI	.23	
	Rest	4.66	

Further analysis of the data at the 8-year level seemed unnecessary since the RI and the PI means were almost identical and it could therefore be concluded that the significant *H* established for this group emerged from the difference between RI and PI on the one hand and the Rest condition on the other.

H tests of age effects under the three experimental conditions showed no significant differences, although it must be suspected that the results are somewhat distorted by the low ceiling of the task under the Rest condition. That is, given a higher ceiling the 8-year Rest Ss may well have recalled significantly more than the younger Rest groups.

Although the results of the statistical analyses will not permit firm conclusions, there is some support for the hypothesis that while 24 hour retention of a single list increases between 4 and 8 years of age, the interference effects from a second list also increase over this age interval.

INTRUSIONS

Table VIII shows the number of specific inter-list intrusions compared with the total number of errors. These intrusions refer to responses learned to the given stimulus, but stemming from the interfering list. For example, a child learned in the first list the pair "house-train" and in the second "house-apple". When asked to recall the first list he responds to "house" with "apple" instead of "train". Total numbers of errors include these intrusions plus failures to respond at all, and a few misplaced stimuli and other responses from the same list.

TABLE VIII

Number of intrusions compared with total number of errors

AGE LEVEL Years	PI Intrus.	PI Tot. E.	RI Intrus.	RI Tot. E.
4	9	17	10	18
6	12	15	6	22
8	9	23	8	22

At the 4 and the 8 year level the number of intrusions was almost equal for the RI and the PI condition, but the percentage of intrusions over total number of errors was generally higher for the younger age group. At the 6 year level the intrusions under the PI condition were considerably higher than those under the RI condition.

In general, however, the number of intrusions did not vary greatly between conditions. As in studies of adult retention, where intrusions are also not numerous, only very large variations deserve serious consideration.

MODIFIED FREE RECALL

Under this condition the Ss first recalled both responses to a given stimulus without specific attention to list identity. The latter was established after the actual recall when the S was asked to identify the list to which each response he had given belonged (MMFR).

The mean number of 1st and 2nd list responses are given in Table IX (under "MFR I") by age level. Since the variances of the three age groups were found to be homogeneous (2.16, 2.22 and 2.24) analysis of variance was conducted. The source table (Appendix Table IIIa and IVa for correct identifications) shows that neither the difference between 1st and 2nd list nor the difference between age groups was statistically significant.

TABLE IX

Mean scores of modified free recall (MFR I), correct list identification (MMFR I) and misidentifications

	MFR I		MMFR I		Misident.	
	1st L.	2nd L.	1st L.	2nd L.	1st L.	2nd L.
4 yr group	2.08	1.92	1.75	1.50	.33	.42
6 yr group	2.42	2.58	1.67	1.75	.75	.83
8 yr group	2.08	2.17	1.83	2.00	.25	.17

Under "MMFR I" of Table X are given the number of 1st and 2nd list responses which had been correctly identified with the appropriate list. Table X also gives the number of list misidentifications, derived as difference scores between MFR I and MMFR I. The greatest number of such misidentifications occurred among the 6-year group while the 4 and 8-year olds had an approximately equal amount. However the overall number of misplacements was too small to warrant a statistical analysis. In fact, the most striking phenomenon evident from Table IX was the high degree of accuracy of list identification in all age groups. If the response was available, it was usually correctly assigned to the proper list.

TABLE X

Mean scores of modified free recall (MFRII), and misidentifications

	MFR II		Misidentifications	
	1st L.	2nd L.	1st L.	2nd L.
4 yr group	1.50	1.75	.37	.37
6 yr group	2.38	2.38	.38	.38
8 yr group	2.38	2.88	.50	.38

There was some doubt with regard to the effect of the stimulus cards used under the MFR condition. A number of Ss indicated surprise at the grey background and, especially, at the absence of a picture on the right (the response) side of the cards. This change in the stimulus situation may well have been responsible for the consistently lower scores under this condition compared with the specific list recall (Table VI) where the recall trial was identical to the original learning trials. The MFR condition was, therefore, replicated with 24 Ss, eight at each age level, comparable to the original sample. While the learning procedure was the same as in the first experiment, the recall technique was changed. The original black and white cards were presented simultaneously outside the apparatus. They were arranged on a table with the identical stimuli side by side and the response items covered up with blank cards of the respective black or white colour.

The mean scores obtained under this MFR II condition were given in Table X, column 1. Column 2 gives the number of misplacements.

It must be understood here that due to the procedure employed the recall could not be divided into a Modified Free Recall (MFR) and a List Identification (MMFR) session because all the stimuli were present at the time and the children would usually name the item and at the same time point with their finger indicating where it ought to be placed. This technique seemed to put the younger subjects at a disadvantage. They appeared to be confused by the simultaneous presentation of all stimuli. This may account for the somewhat lower scores at the 4 year level. However, the difference was not large enough to be statistically significant (Appendix Table Va).

In retrospect it must be conceded that neither of the two procedures (MFR I and MFR II) was technically adequate to allow valid conclusions as to the effect of the varied stimuli in the recall situation.

CHAPTER III

DISCUSSION

Before entering into the discussion of the developmental aspects of this investigation it seems appropriate to deal with phenomena that were similar to those in adult retention under comparable experimental conditions.

Usually, after 24 hours RI and PI reach equal proportions (Underwood 1957). This was also the case in the present study, especially among the four and eight year groups. Although a difference seemed to exist between PI and RI at the six year level, it was not statistically dependable. These findings were further supported by the results of the Modified Free Recall (MFR) where the differences between first and second list responses were all small and non-significant. It can, therefore, be assumed that the associative strengths of the two lists were about equal for all conditions.

From a developmental point of view the results of the present study indicate that retention of one list of paired associates improves with increasing age. This increase was statistically non-significant in this study. However, it seems likely that this was a genuine effect which would have reached statistically significant proportions had it been possible to raise the ceiling of the task so that higher scores could have been achieved by the older Ss. This observed increase in retention conforms with the generally accepted fact that memory span in children improves with age (e.g. digit span, retention of sentences etc.; Hurlock, 1931, Terman 1937 and others) and as a function of mental growth. Unfortunately, this seemingly simple fact presents some considerable problems which will be discussed in connection with the theoretical considerations of experimentally introduced interference effects.

When two lists of paired associates are learned in close succession, recall of either of these lists after 24 hours did not improve with age. In fact, the 8-year old Ss had a slightly lower score than the 4-year olds under the same condition. The difference between the scores under the Rest condition on the one hand and the PI and RI conditions on the other was statistically non-significant at the 4 year level. It increased for the 6-year group and reached a high level of dependability for the 8-year olds. This led to the conclusion that learning of a second list produced considerably more interference among the older Ss than among the younger age group. The data of the Modified Free Recall (MFR I and MMFR I, Table X) lent further support to this assumption, in as far as there was no significant difference in recall scores between the younger and the older Ss. However, the consistently lower retention figures for all age groups under the MFR conditions call for further investigation. That this loss was merely a function of the stimulus material involved (see page 27) is doubtful and it is conceivable that some other factor is introduced into the recall situation when both response members have to be reproduced. The recall of one item serves as a re-learning condition which strengthens this specific stimulus-response connection and helps to extinguish the competing response member from the other list, thus making recall of the second response immediately after the first one more difficult. Unfortunately there are no comparable figures from adult MFR available which would allow us to explore this assumption further.

A theoretical interpretation of the findings of the present study could be attempted with the use of Underwood's notion of interference effects coming from prior extra-experimental learning (1957) and Underwood and Postman's hypothesis of Gradients of Interference (1960).

It can be assumed with some degree of certainty that of the three age groups employed in this study the 4 year olds had, on the average, the least prior extra-experimental learning relevant to the experimental task. Linguistic habits were also undoubtedly less firmly established in the younger subjects than in the older ones.

Following this line of reasoning it could be expected that older children who commanded many more word associations with such common terms as "house, chair, dress, boat" than younger Ss would also experience more interference in recall. The problem, however, is that in the rest condition recall increased with age. That is, there was no simple effect of prior extra-experimental learning, rather this variable interacted with experimentally manipulated interfering learning.

A suggestion, recently put forward by Koppenaal and O'Hara (1962), may apply here. In their study of PI and RI effects on retention of paired associates with adults these authors found an interaction effect between prior and interpolated learning. The experimental design of this investigation included a condition (RIP) in which the subjects learned three lists of paired associates in close succession and recalled the second list after twenty minutes. It was found that learning of the third list caused stimulus-response associations from the first list to come to the fore and interfere with retention of the second, the critical list.

From a theoretical point of view, Koppenaal and

O'Hara propose the hypothesis of a gradient of extinction for first and second list through learning of the third list. Unlearning of the first list reaches an asymptote during learning of the second list. Learning of the third list in turn causes extinction of the second list but has little or no effect on the first list which has already been unlearned. Thus, after learning of the third list the first and second list are almost equal in associative strength, and interference on retention of the second list by the first list is therefore increased by third list learning.

If we apply the RIP paradigm to the RI condition of this experiment, prior extra-experimental learning would correspond to first list learning of the above experimental condition. These extra-experimental word associations are extinguished during learning of the first list under the RI condition. Learning of the second list would not only extinguish the first experimental list but would also produce an interaction effect with prior extra-experimental learning and thereby increase the interference effects. Since older age groups have more prior extra-experimental associations, these interference effects are greater than among the younger groups. In the Rest condition, however, where there is no second list to interact with prior extra-experimental learning these interference effects do not operate and retention does not decrease with increasing amount of prior extra-experimental learning.

Unfortunately, this hypothesis cannot account for the proactive inhibition which was found to be equal in amount to retroactive inhibition for the four and the eight year group. The indication is that the interaction of prior extra-experimental learning and experimentally manipulated interference learning may be based on processes other than those suggested by Koppenaal and O'Hara.

CHAPTER IV

SUMMARY AND CONCLUSIONS

This investigation was intended as an exploratory study of retroactive and proactive inhibition in the retention of verbal materials by children.

Thirty-six Ss at each of three age levels (4 yrs, 6 yrs and 8 yrs) were randomly assigned to one of three experimental conditions (PI, RI and Rest). The PI and RI groups learned two lists of four paired associates in close succession and recalled either the first list (RI) or the second list (PI) after 24 hours. The rest group learned only one list which was recalled after 24 hours.

While recall under the Rest condition improved slightly with age, there was no significant difference in retention when a second list was introduced. RI and PI were about equally large at all age levels, but the difference in retention between RI and PI on the one hand and Rest on the other increased with age. It was, therefore assumed that the older Ss (8 year olds) experienced more interference from learning of a second list than did the younger Ss.

One further experimental group of 12 Ss at each of three age levels was run under the Modified Free Recall

(MFR) condition. These Ss learned the same two lists as the RI and PI groups but recalled both lists after 24 hours. Retention under MFR was not significantly different for the three age groups. However, overall retention was consistently lower than under the RI and PI conditions. No definite suggestions could be made with regard to the variables which were possibly the cause of the decreased retention of the MFR groups.

The increase in interference with age may be attributable to the difference in amount of extra-experimental learning which exists between the three age groups. It is assumed that this material interacts in some way with experimentally introduced interference. The larger the fund of prior extra-experimental learning the greater will be the interference. Since the 8 year old Ss are most likely to have the greatest amount of such prior extra-experimental learning, it would follow that they also experience the most interference.

APPENDIX

TABLE Ia

ANALYSIS OF VARIANCE OF FIRST VS. SECOND LIST LEARNING TO CRITERION

Source	DF	MS	F
Between Ss	107		
Age levels (A)	2	9.45	
Error (b)	105	5.44	
Within Ss	108		
List (L)	1	15.04	7.23*
A x L	2	1.51	
Error (w)	105	2.08	
Total	215		

* $p < .01$

TABLE IIa

ANALYSIS OF VARIANCE OF CRITICAL LIST LEARNING

Source	df	ms	F
Conditions (C)	2	8.33	2.25
Age Levels (A)	2	15.37	4.14‡
A x L	4	1.70	.46
Within	99	3.71	
Total	107		

‡ $p < .025$

TABLE IIIa

ANALYSIS OF VARIANCE OF RECALL UNDER MFR I, LIST ORDER AND AGE LEVEL

Source	df	ms
Between Ss	35	
Age	2	1.63
Error (b)	33	1.28
Within Ss	36	
Lists	1	.01
Age x Lists	2	.18
Error (w)	33	1.22
Total	71	

TABLE IVa

ANALYSIS OF VARIANCE OF RECALL UNDER MFR I, LIST ORDER x AGE LEVEL (Correct Identifications)

Source	df	ms
Between Ss	35	
Age Levels (A)	2	.93
Error (b)	33	1.96
Within Ss	36	
1st vs 2nd (L)	1	.00
A x L	2	.58
Error (w)	33	1.19
Total	71	

TABLE Va

ANALYSIS OF VARIANCE OF MODIFIED
FREE RECALL, CONDITION II
(Correct Identifications)

Source	df	ms	F
Between Ss	23		
Age	2	3.94	2.18
Error (b)	21	1.81	
Within Ss	24		
Lists 1 and 2	1	1.02	
A x L	2	.39	
Error (w)	21	1.51	
Total	47		

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