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REPETITION AND ENCODING IN SHORT-TERM MEMORY

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
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by

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FIELDS OF STUDY

Major Field: Experimental Psychology. Professor Delos D. Wickens

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INTRODUCTION

The decay and interference dichotomy has often been used as an indicant to separate information in a short-term memory system from that in a long-term system. This dichotomy hypothesizes that the short-term mechanism is affected by decay and the long-term mechanism by interference. The appearance of the Peterson technique for investigating the short-term memory process in 1959 further enhanced this apparent separation. Sometimes referred to as the distractor technique (Murdock, 1966), the Peterson technique involves a procedure whereby a consonant trigram (CCC) is presented to a subject followed by a task which prevents rehearsal of this consonant trigram. Following the distractor task the S is asked for recall of the originally presented information. A series of such trials is presented and the probability of correct recall is then determined by the number, or percentage, of subjects correctly recalling the item for any particular trial. Since the Petersons found no progressive decrement across successive blocks of trials, they rejected interference theory in short-term memory in favor of a decay interpretation, thus substantiating the dichotomy.

A number of theorists have proposed that the short-term memory mechanism consists of a rapidly decaying memory trace which can be

kept active, and available for retrieval, only by continual rehearsal (Hebb 1949, Brown 1958, Broadbent 1958, Waugh and Norman 1965).

In particular Broadbent (1963) suggested that the decrement in retention, following presentation of a distractor task, is due solely to the factor of rehearsal prevention. An item of information can be held in short-term storage only as long as it can pass repeatedly through the same limited capacity channel through which it arrived. If this limited part of the system becomes unavailable through presentation of new interfering material, rehearsal or recirculation will be prevented and the earlier information will decay. Furthermore it is the amount of time during which the interfering activity occupies the limited capacity system that is of utmost import, rather than the similarity between original and interfering activities. This is in direct contrast with long-term memory research which has shown retention to be inversely related to the degree of similarity between the interfering activity and the to-be-recalled information (Melton and von Lackum, 1941).

This concept of different mechanisms of retention for short and long-term memory has been challenged by the major interference theorists. Keppel and Underwood (1962) indicated that certain aspects of the original procedure prevented the Peterson's from identifying proactive interference (PI) effects which may have been operating. Keppel and Underwood demonstrated that PI effects are maximized after only three to four presentation trials. Due to the fact that the Petersons had given their subjects ten practice trials the interference effect had not been detected,

since it was already at its maximum before data collection was initiated. PI effects after the first three to four trials cause performance to be stabilized at a 30-40% efficiency level. This steady state worked to mask the interference effects that had been operative, thus time appeared to be the only variable determining the amount of retention.

Now that interference could be demonstrated to be operating in short-term memory, theories emerged which considered short-term and long-term memory to be operating under essentially the same mechanisms. Hebb (1961) suggested that something more permanent than an activity trace resulted from a single presentation of the stimulus. Melton (1963), citing evidence from Keppel and Underwood (1962), plus experiments by Murdock (1961) and himself, proposed that the single mechanism responsible for performance decrement in both long-term and short-term memory was interference. This group of experiments had shown the decrement in retention to be a function of intra-item interference, i.e. the more to-be-recalled "bits" of information presented the less the retention. This proposal resulted in many studies concerned with investigating within a short-term memory framework the variables already known to affect retention in long-term memory.

Wickens, Born and Allen (1963) were first to demonstrate that retentive ability increased considerably when a shift from one class of material (CCC's) to another (NNN's) was introduced on successive trials within the Keppel-Underwood modified Peterson technique. Within the same class of material Wickens et. al. found,

as had Keppel and Underwood (1962), that interference developed rapidly over the initial three to four trials. With a shift in class material the initial item of the class was retained best with increasing interference demonstrated within that class over a series of four trials.

This study supported Melton's single mechanism theory since it demonstrated principles of interference that had previously been demonstrated in long-term memory studies. For example Underwood (1957) had shown that the greater the number of prior lists learned the greater the proactive interference. Melton and von Lockum (1943) had shown that retention was a negative function of the degree of interlist similarity. Wickens' experiment demonstrated that these variables, number of preceding items and similarity of items, were variables in short-term memory as well.

The above technique has been used most recently as a method to study encoding classifications employed by subjects. Some theories have described the short-term mechanism as being composed of a limited number of slots (Waugh and Norman, 1965) into which information can be placed. This memory system can hold and reproduce a limited amount of information which Miller (1956) described as being approximately seven plus or minus two "chunks" of information. This information is available to interfere with all the other information currently in storage that has been encoded as being of the same class as the incoming information. If the new information is encoded in a manner similar to that already present then, at recall, all the similarly encoded information will interfere with its

retrieval. If it is encoded differently, then at the time of retrieval, it is readily accessible. Melton (1963) and Broadbent (1963) have described this process of encoding, storing, and retrieving as a "flow" of information. Melton (1963) stated that an information trace undergoes three stages of transformation beginning with the trace being formed at the time of its initial presentation. Next it is stored (according to the present author's assumptions) depending upon how it was subjectively encoded by the subject, as being from the same information class as the preceeding information or different from it. Lastly the trace is utilized or recalled, and this depends on how it was stored. If it has been subjectively encoded as being different from preceeding information there will be no interference from those items at the time of recall. If it has been encoded similarly, there will be interference at recall. This can be demonstrated, using the Peterson technique, by a substantial increase in performance for that item at recall. If the item has been encoded differentially and stored differentially, then recall will be facilitated since no other potentially interfering items have been encoded as being similar to this item.

Wickens has used this assumption as a means of determining what response classes subjects can use as functional encoding instruments. This can be done without requiring the subjects to cognitively or introspectively identify the classes. In an experiment by Wickens, Clark, Hill and Wittlinger (in press) two different grammatical classes were employed: verbs and adjectives.

Here release from interference was observed when the to-be-recalled information was changed from one class of words to the other. Thus the authors concluded that grammatical class is not utilized by subjects to differentially encode items held in short-term memory. Later Wickens and Clark (1967) were able to demonstrate, using this PI shift technique, that subjects could use opposite dimensions of the Osgood Semantic Differential Scale to encode information. Shifting from one extreme of the Potency, Activity or Evaluative Scale, to the other extreme of that same scale resulted in a substantial release of the interference and a resultant increase in performance. Loess (1967) has also demonstrated this same build-up and release of PI when shifting from one classification of words (e.g. birds) to another (e.g. trees).

Conrad (1964) and Wicklegren (1965) have advanced the theory that all interference effects in short-term memory are primarily due to acoustic similarity, at least as far as the recall of a series of unrelated letters are concerned. By analyzing the intrusion errors for subjects in the recall of strings of letters, they found interference to come from within sets of similarly sounding letters. Conrad determined three such sets of acoustical sound-alikes which produced interference at the time of recall. These sets are composed of the letter groupings BCPTV, FSX, and MN. The interitem interference generated in this experiment lasted for only a few seconds after presentation. It would appear therefore that a generalization of this to the Peterson paradigm would be unjustified since a complete trial consists of at least twenty to

thirty seconds between item presentations. This should be more than sufficient time for the acoustic interference to have decayed.

Conrad's theory, however, also proposes that a combination of both decay and interference contributes to any decrement in retention. His assumption is that a trace decays with time, but, while it is still active, it is available to act as an interferer. In this respect we could speak of interference decaying with time.

Posner's (1967) "acid bath" theory takes a somewhat different view of the same interacting process. He proposes that it is the similarly stored items themselves that determine the rate of decay for any particular item. In Melton's model we could say that Conrad's interference takes place at the time of the trace utilization or retrieval, while Posner's takes place during trace storage.

A recent experiment by Wickens and Simpson (1968) has demonstrated the inadequacies of Conrad's acoustic interference model in explaining the release phenomenon in the modified Peterson short-term memory technique. However his concept of the decay of interfering traces has received some support in a study by Nield (unpublished). Nield found that the longer the interval between successive trials the greater the probability of recall. This was observed despite the fact that the critical item was from the same information class as the preceeding items. Furthermore tasks, employing colornaming or recall of NNN's, could be presented during this time interval and performance on the subsequent CCC still proved to be a function of the elapsed time. Any information that did not provide further interference acted similarly to a rest interval and the interference

effects dissipated. New information could thus be thought of as acting as a buffer to protect further interference from forming within the original class and allowing that already formed to dissipate.

A different type of information classification has been present in the writings regarding the incremental (Postman 1962, Underwood and Keppel 1962) versus the all-or-none (Rock 1957, Estes 1960) controversy. Regarding the probability that a particular response will be made, the incremental view has held that it depends on the number of repetitions necessary to place associative strength above threshold, with each trial adding to that strength. The all-or-none view holds however that a repetition merely increases the probability that a particular item will be sampled. If it is sampled it is added to the response class of learned vs. unlearned items.

Peterson (1959) found that if the subject repeated the to-be-recalled information once, twice or three times immediately upon its presentation that recall was an increasing function of the number of repetitions. This may be interpreted therefore as being either a function of the incremental strengthening of each repetition or a function of the information being encoded differentially from the preceding information, thus more likely to be retained as a function of its uniqueness. This encoding of an item as a repeat would cause it to be differentially encoded and thus free from the interference generated by the non-repeated items, from the same class, which preceded it. Hypothetically then it could

be asked whether repetition acts to strengthen a memory trace incrementally or causes that trace to become distinctive and form a new class, those of repeated versus non-repeated items.

The purpose of the present study is to determine the answer to this question of whether improvement on a repeated item in a short-term memory task is due to factors caused by incremental or differentially encoded effects. Four experiments have been designed, first to determine the effects of repetition itself, and then to converge upon the factor or factors responsible for this effect. The first three experiments were designed to determine if an effect is present at all and, if so, how strong such an effect can be. The fourth experiment employed the findings of Field as cited above. Using this technique it was felt that if a repeated item is encoded differentially, as a new class, then proactive interference should dissipate over time, as it would with any new non-interfering class of differentially encoded material. If interference does not decay, if performance on the next new item is not facilitated, then repeated items are not encoded differentially. Improvement then must be due to some other factor such as that proposed by an incremental interpretation.

EXPERIMENT I

METHOD

Subjects.- The Ss were 192 introductory psychology students at The Ohio State University who chose to participate in the experiment as partial fulfillment of a course requirement. The Ss were randomly assigned to one of the four groups in order of their appearance.

Design.- The experiment was designed in such a way that a block of four stimuli could be completely repeated at least once in order to determine the effects of continued repetition. Allowing a single letter to denote a block of four trials the experiment could be summarized succinctly as:

Group - 1 A A A

Group - 2 B A A

Group - 3 A B A

Control C B A

The stimulus information consisted of consonant (CCC) trigrams whose association value was 29 to 33% according to Witmer (1929). Allowing a single letter now to stand for one of these consonant

trigrams (e.g. CCC_A=A): a complete trial by trial, rather than block by block, analysis was designed as follows:

<u>Trial</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	<u>11</u>	<u>12</u>
Group - 1	A	B	C	D	A	B	C	D	A	B	C	D
Group - 2	E	F	G	H	A	B	C	D	A	B	C	D
Group - 3	A	B	C	D	E	F	G	H	A	B	C	D
Control	I	J	K	L	E	F	G	H	A	B	C	D

The distractor task consisted of a counting backward procedure. The subject was required to track the beat of a metronome (one beat per second) by pronouncing a number each time three below the last pronounced number. This counting began with a number shown on a projection screen.

Neither the consonant trigrams nor the three digit numbers contained identical items appearing in the same position as any other in the list. Also no item was repeated within a CCC or MNM trigram. An attempt was made to equate the number of times a single consonant or number was employed. A counterbalancing procedure insured that each trigram and number appeared equally often at each trial position.

Apparatus.- The subject was seated in an isolated sound-proof chamber. A screen was placed before him on which the material could be projected by means of a series of external mirrors. A Kodak Carousel 800 projector was timed by means of a tape timer which

programmed the series of events presented to the subject. The only other apparatus employed were a metronome set to beat at one second intervals, an Ampex stereo tape recorder which delivered the instructions to the subjects, and four cards taped to the room's door to acquaint the subject with the various types of material.

Procedure.- After the subjects had settled into the chair the following tape recorded instructions were presented to him:

This is an experiment in which we are studying your ability to perceive letters, and to perform a counting task at a fairly fast and constant rate. During the entire experiment you should keep your eyes on the screen in front of you because all materials will be presented there.

On the door to your right you see some sample slides. You may refer to these as you listen to the rest of your instructions. First, you will see an asterisk projected on the screen in front of you. This is your ready signal. Immediately following it you will see three letters printed in a row as shown in the sample. You are to read these letters out loud as quickly as you can. After you have pronounced the three letters they will be replaced by a number as shown in the sample. Your task at this point is to count backward by threes beginning with the number on the screen. You are to do this in time with a metronome which will beat at a one second rate. You will continue to count backward by threes until you see a question mark projected on the screen. When you see the question mark you are to try to recall the three letters out loud so that I can hear you. After the question mark disappears, there will be a short rest interval before the next ready signal is given. Then another set of letters will be presented and the procedure will continue the same as before. You should try to do as well as possible on both tasks.

The subject was then asked to repeat the instructions briefly to determine understanding of the procedure. Any misunderstandings were immediately corrected and repeated. Then the subject was instructed to count backward from a three digit number provided verbally by

the experimenter in order to familiarize him with the task and the rate of the metronome. Finally the door was closed and the procedure begun. The timing and sequence of events was initiated by the tape timer and followed the time intervals for one trial as listed below:

Asterisk-----two seconds

Trigram Presentation--one and one-half seconds

Retention Interval----fifteen seconds

Recall Interval-----ten seconds

Rest Interval-----sex seconds

A correct recall was scored only if all consonants were reproduced in the order originally presented. Intrusions and inversions were recorded as the S responded.

RESULTS

The results for the three experimental groups and the control group are depicted in figure 1. In the following statistical report for this experiment and the experiments to follow, all within-group comparisons are analyzed using a chi square for correlated proportions (Ferguson, 1959). The between-group analysis use a chi square technique for independant proportions (Ferguson, 1959).

The three most critical trials are trial five for the experimental-1 group and trial nine for both the experimental-2 and experimental-3 groups. On the fifth trial the experimental-1 group (77% correct) differed significantly from the control group (33%) at the $p < .001$ level with $\chi^2 = 15.28$, $df = 1$. The experimental-2 group was significant at $p < .05$, $\chi^2 = 5.08$, $df = 1$, for trial nine performance (67% vs. 42%). On the same trial the experimental-3 group was significantly superior to the control at the $p < .01$ level, $\chi^2 = 7.15$, $df = 1$ (71% vs. 42%). All points on the figure, after the particular critical trial for groups 1 and 2, were significantly above the control at least at the $p < .01$ level except trial seven for experimental-1 and trial twelve for experimental-2. No trials for experimental-3 were significantly better than the control other than the first repetition, the critical trial. The acceptance of a $p < .10$ significance level would include all points after critical trials except trial seven for experimental-1.

Within-groups analysis revealed that all groups demonstrated a significant decrement in performance over the first four trials at least at the $p < .001$ level. For experimental-1 there was a significant improvement from trials four (35% correct) to five (77% correct), $p < .001$, $\chi^2 = 15.38$, $df = 1$. Thereafter only trial seven (46%) was significantly different from any of the others and this trial differed from all the other at least at $p < .05$. For experimental-2 the repetition on trial nine improved performance from trial eight (38% to 67%) at the $p < .01$ level, $\chi^2 = 8.05$, $df = 1$. No points thereafter differed significantly from one another. For experimental-3, trial nine also was significantly better than trial ten (35% vs. 71%) at the $p < .01$ level. Trial nine and twelve (71% vs. 50%) differed at the $p < .01$ level, $\chi^2 = 5.00$, $df = 1$. Trials ten and eleven did not differ significantly from either nine or twelve.

Figure 1--Percentage of correct responses for all groups in exp-I.

DISCUSSION

All three experimental groups demonstrated that a repetition of an item produces a dramatic increase in performance compared to a non-repeated item of the same encoding class. Furthermore the improvement in performance was the same regardless of whether the repeated item had been initially presented in the beginning of the list or in the middle. Also it did not matter whether a short or a long period of time had elapsed since the initial presentation. The experimental-1 group repeated item number one four trials later; experimental-3 repeated this same item eight trials later and experimental-2 repeated a later item (item five) four trials later. Experimental-1 also repeated its item a second time on trial nine. The fact that it is a repeated item appears to increase performance regardless of its apparent initial strength or the time allowed for this strength to decay.

It was originally felt that if an item were repeated it would be differentially encoded and then, if followed by other repeated items, proactive interference would build-up within the class of repeats. For experimental-1 this appears to be justified at least for trials five to seven. For experimental-3 there is also a significant drop from the first repeated (trial nine) to the last (trial twelve). Experimental-2 appears to be in the correct direction but was not significantly so. This can be interpreted as being a build-up of PI within this new class of material consisting of

repeated items from the original class. Perhaps it could have been more dramatic if the blocks of repetitions had been eight to ten items in length so that the effects could have stabilized.

The odd case for the experimental-1 group on the eighth trial can be partially explained through the invocation of an RI hypothesis. In the Nield experiment, cited previously, an MMFR test given following the conclusion of the experiment indicated a strong recency effect despite the performance effect favoring the initial items. Later items tended to interfere with the recall of preceeding items though this is generally not measured in an experiment of this nature. These RI effects are undoubtedly occurring in the present experiment. The items for which both RI and PI effects were present may not be as strongly retained and not recognized upon representation. Thus the low performance on item seven due to it not having been recognized as a repeat. Trial eight was item four repeated, and this item, due to the change of class following its initial appearance, had been protected from any possible RI. Thus on trial eight it was recognized as having been previously presented, and it was encoded as a repeat.

In order to validate the assumption that performance is enhanced by repetition regardless of where an item was initially presented in the list, a second experiment was designed. It was also decided to explore whether a repeated item would merely be released from PI or whether its appearance would act to dissipate the PI. If the PI dissipated with the introduction of a repeated item, then a new item following the repetition should be recalled quite easily even

if it is a member of the same class as the items presented previously.

To test these hypotheses the following experiment was performed.

EXPERIMENT II

METHOD

Subjects.- The Ss were 100 introductory psychology students at The Ohio State University who chose to participate in the experiment as partial fulfillment of a course requirement. The Ss were randomly assigned to one of the four groups in the order of their appearance.

Design.- The experiment was designed such that the critical item occurred on either the first, second, or third trial initially. It was then represented twice again at four trial intervals. Allowing a single letter to stand for a consonant trigram (e.g. CCC_A=A) the complete design was as follows:

<u>Trial</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	<u>11</u>	<u>12</u>	<u>13</u>	<u>14</u>
Group-1	A	B	C	D	A	F	G	H	A	J	K	L	M	N
Group-2	A	B	C	D	E	B	G	H	I	B	K	L	M	N
Group-3	A	B	C	D	E	F	C	H	I	J	C	L	M	N
Control	A	B	C	D	E	F	G	H	I	J	K	L	M	N

Apparatus and Procedure.- The apparatus and procedure were precisely the same as in the previous experiment with the exception

of two additional CCCs which were of the same Witmer association value as before. Instructions, task and procedure for data collection remained the same.

RESULTS

The results can be seen in figures 2 (for all groups), 3, (Group-1 and control, 4 (Group-2 and control), and 5 (Group-3 and control). Again Fergusons tests for independant proportions and correlated proportions were used depending on the analysis desired. The results can be summarized succinctly since all trials on which a repeated item occured were significantly above the control group at least above the $p < .05$ level of significance.

Trials five and nine for experimental-1 were significantly above the control group. Trials six and ten for experimental-2, and seven and eleven for experimental-3 also were above this group. The percentage correct for the experimental groups varied between 71% to 93%, while the control was established between 25%--43%. There were no significant differences between performance on any repeat trials between groups. The within group analysis for PI build-up from trial one to four was significant at least above the $p < .001$ level.

Figure 2--Percentage of correct responses for all groups in exp-II.

Figure 3--Percentage of correct responses for exp-1 vs. Control in exp-II.

Figure 4--Percentage of correct responses for exp-2 vs. Control in exp-II.

Figure 5--Percentage of correct responses for exp-3 vs. Control in exp-II.

DISCUSSION

This experiment has demonstrated that the "release" of interference when an item is represented does not carry over to the next item if it is a member of the same class. This indicates first that the increase in performance for the repeated item is best phrased as release from, but not of, interference. Furthermore performance on this repeated item is the same regardless of its initial retrievability. Apparently enough of a memory trace has been formed at the initial presentation to enable an item to be recognized as having previously appeared. Thus although it is not strong enough to escape interference it is formed nonetheless and, when the same item appears later, is available for comparison despite its initial strength. The items from any of the first three positions, which display a decreasing trace availability, are retrieved equally well upon being represented. In an encoding framework this is easily explainable, as any item despite its initial strength can still be recognized as having appeared previously. Therefore it can be differentially encoded as being a repeated item and hence different from the items preceeding it. There are evidently levels of encoding used by subjects depending upon the stimulus materials, time available for encoding and the retention task for which the subject prepares.

In the case of a repetition a subject makes use of these various levels of encoding. In order to retain the item when it was initially presented the subject must encode it on such a level that it can be

differentiated from similar items in storage at recall. This level is above the sophistication necessary merely to recognize the information at some later time. These levels seem to require more time depending upon the previous amount in store and the testing situation. In a situation such as the present this obviously becomes increasingly difficult. Recognition of an item as having previously appeared is a lower level of encoding however and could be readily achieved in the time available. Thus any item has been encoded at a level which makes it available for recognition, but not necessarily for complete retrieval.

An incremental hypothesis cannot be rejected here because there may be a ceiling effect produced by the fact that recall is nearly perfect. Also, as stated above, the recognition trace formed during initial presentation could be assumed to be equivalent. At recall it is still equally as strong as any of the others, but there are merely more present to interfere with recall. Therefore there actually was no differential strength of trace formation and one would assume that a repeat of an item would facilitate, or add to, performance in an equivalent manner.

The problem concerning the time that had elapsed between the initial presentation and its reintroduction was not actually tested, thus another experiment was designed. From Experiments I and II there is evidence that a separation of either four or eight trials produced no difference in performance on the recall of the repetition (Groups-1 and 3 from Experiment I and all groups in the present experiment). It was decided to test the other extreme by repeating

an item on two successive trials to see if performance would be better than an interval of four trials. For this purpose, the following experiment was performed.

EXPERIMENT III

METHOD

Subjects.- The Ss were 50 male and female students at Ohio Wesleyan University. Some volunteered to participate in order to achieve extra class credit; others merely volunteered. The Ss were randomly assigned in order of their appearance to one of two groups.

Design.- The experiment was designed in order that an item appearing on trial four would be repeated on the following trial. The control group had a different item on trial four, but the same on trial five. The design was as follows:

<u>Trial</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>
Experimental	A	B	C	D	D	E	F
Control	A	B	C	G	D	E	F

Apparatus and Procedure.- The procedure was the same as in the previous two experiments: the apparatus being somewhat modified. The experimenter sat behind the S in the same room and the instructions were read to the S. All other apparatus and method of data recording were the same.

RESULTS

The within-groups analysis again demonstrated a significant drop in recall from trials one to four at least at the $p < .05$ level. The effects of repeating an item on a succeeding trial was significant at the $p < .01$ level (85% vs. 48%), $\chi^2 = 7.69$, $df = 1$. The following trial (six) was not significantly above the control group. These results are presented in figure 6.

Figure 6--Percentage of correct responses for all groups in exp-III

DISCUSSION

As indicated previously this experiment, in conjunction with the first two, demonstrated, at least for the range of from one to eight trials, that it does not matter how recently an item has been presented for its performance upon being repeated to be maximal. This maximum appears to approach a level somewhere between 85-95% correct responses. The recall effects on the subsequent trial however are in no way enhanced or facilitated. The repeated item does not release interference from the experimental situation, in fact it is still fully available on the subsequent trial. A repeated item, or any differentially encoded item, is merely free itself from the present interference.

These three experiments have served to demonstrate the effects of repetition and its similarity, in a short-term memory situation, to the introduction of a new class of material. However the question as to whether repetition does indeed form a new class of differentially encoded material or whether performance is maximized by an incremental effect has not been answered. It was an attempt to converge on this question that formed the rationale behind the next experiment.

EXPERIMENT IV

METHOD

Subjects.- The Ss were 450 introductory psychology students at The Ohio State University who chose to participate in the experiment as partial fulfillment of a course requirement. The Ss were randomly assigned to one of nine groups in order of their appearance.

Design.- Three experimental groups were employed in order that an item could be repeated either once, twice or three times successively. This procedure resulted in either 35, 70 or 105 seconds between presentations of non-repeated information. To determine if the repeated item would act as a new class, three groups were also designed in which either one, two or three NNNs separated the two non-repeated CCCs. A control group had one, two or three non-repeated CCCs between the critical test items. The entire design can be illustrated as outlined below ($CCC_A=A$, $CCC_B=B$, etc.):

<u>Trial</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>
Experimental--1 (Repetition)	A	B	C	D	A	E		
2	A	B	C	D	A	A	E	
3	A	B	C	D	A	A	A	E
Control-----1 (Numbers)	A	B	C	D	NNN ₁	E		
2	A	B	C	D	NNN ₁	NNN ₂	E	
3	A	B	C	D	NNN ₁	NNN ₂	NNN ₃	E
Control-----1 (Consonants)	A	B	C	D	F	E		
2	A	B	C	D	F	G	E	
3	A	B	C	D	F	G	H	E

The distractor task employed in this experiment was a color naming procedure. Due to the presence of the to-be-recalled NNNs in three of the above groups, a counting task could not be used. Four slides containing three rows of three colors each were projected on the screen, and the subject was instructed to call out the colors on the screen as quickly as possible. Each slide was present for three and three-fourths seconds apiece, thus the retention interval remained the same as in the other experiments.

Apparatus and Procedure.-- The apparatus and procedure were essentially the same as the other experiments performed at The Ohio State University with the exception of the inclusion of the color slides. The metronome was eliminated as the color naming task was

self-paced rather than timed. The instructions were altered to explain that either letters or numbers could appear as the to-be-recalled information, and the color naming instructions replaced those of counting backward. Before initiating data collection the Ss were given three practice color slides to familiarize them with the task before the actual experiment began. Two classes of repeated items were employed: one-half of the Ss received either XTN or SBM as the repeated item and one-half received either RHJ or WLQ. This was necessary in order to determine if acoustic interference was operative in this design. XTN and SBM both contain one item from each of Conrad's three classes. RHJ and WLQ contain items that partake of none of these classes. It was hypothesized that if XTN and SBM resulted in a greater maintainence of interference than did RHJ and WLQ, then interference was acoustic. This acoustic interference would be maintained by the presentation of acoustically interfering items, even if it were the same item on each trial.

RESULTS

Figures 7, 8 and 9 show the results obtained for the 35 second, 70 second, and 105 second groups. This interval refers to the amount of time the intervening activity took between the presentation of the last new information and the critical test item. In all three figures performance was significantly lower on trial four than trial one for all groups at the $p < .001$ level. Also in all graphs the intervening activity, the performance on repeated items or numbers, was significantly greater than the control group at least at the $p < .02$ level for all trials of this activity. PI occurred within the class of numbers on both graphs in figure 8 and 9 at least at the $p < .01$ level. Also the increment for each successive repetition was significant, but this was due purely to the fact that there were no reversals in any instance.

Figure 10 is the critical graph for this study since it is a representation of performance on the first item presented following the intervening activity. The 1, 2 and 3 on this graph indicate the number of items intervening between the last new item (on trial four) and this, the critical, item (trials 6, 7 or 8). One intervening item trial takes 35 seconds, therefore two indicates 70 seconds and three, 105 seconds, since trial four. There was no significant difference between groups after one intervening item. After two presentations, the number's group performance on the CCC following the two number presentations was significantly better

$\chi^2=4.84$, $p<.01$, than the control (62% vs. 38%). It was not however significantly better than the repetitions group (62% vs. 46%), $\chi^2=1.97$, $p<.20$. The repetition group was also no better than the control. After three intervening items the numbers group was significantly above the control (76% vs. 40%), $\chi^2=11.86$, $p<.001$ and the repetitions (76% vs. 44%), $\chi^2=9.38$, $p<.01$. Again the repetitions were not significantly above the control.

This rise in the number group with increasing presentations, a between Ss analysis, was significant from one presentation to three (40% vs. 76%), $\chi^2=11.86$, $p<.001$ and from one to two (40% vs. 64%), $\chi^2=4.00$, $p<.05$. The increment from two to three or 70 seconds to 105 was not significant and all increments within the repetitions class were not significant.

The final figure (11) represents the division of the effects on the critical item after having had repetition on either the acoustically interfering (VTM or SBM) items or the non-acoustically interfering items (RBJ or VLO). There were no significant differences achieved by this division.

Figure 7--Percentage of correct responses after 35 secs. of intervening activity.

Figure 8--Percentage of correct responses after 70secs. of intervening activity

Figure 9--Percentage of correct responses after 105 secs. of intervening activity

Figure 10--Percentage of correct responses after varying numbers of intervening items.

Figure 11--Percentage of correct responses for similar and dissimilar repetitions.

DISCUSSION

The results of this experiment substantiate the preceeding ones in demonstrating that the performance effects produced by repetition of a previously introduced item are similar to those produced by switching class of items. However it has shown that although the effects appear to be similar, since performance is facilitated to approximately the same degree, the explanation for these effects must necessarily differ.

The Nield study was replicated by the NNN groups in this experiment. The results demonstrated that the longer the time between presentations, with no new intra-class interference presented, the greater the performance on the critical item. This result can be interpreted to mean that, since differentially encoded classes allow preceeding interference to dissipate, anything which allows dissipation to occur is differentially encoded. No amount of repetition, at least up to three, allows interference to decay. Therefore it was not differentially encoded. The only interpretation left is that repetitions do not facilitate recall due to differential encoding, but to some incremental strengthening effect. Furthermore it is not an acoustical effect since items from Conrad's classes acted substantially the same as items excluded from his classification schema. It is purely the effect of class interference. This interference is not reduced when the repeated item is from the same class as the preceeding information, thus it does not form

a new class simply because it is a repeated item. The interference originally generated within that class does not dissipate, is not maintained by acoustical similarity, therefore must be attributed to the fact that the original encoding class is still being utilized by the subject.

GENERAL CONCLUSIONS

The effects of repeating a previously presented item in a short-term memory task are to facilitate performance on that repeated item. That this is a release "from" interference and not "of" interference is demonstrated by the subsequent introduction of a novel item from the same information class as that directly preceeding the repeated item. Regardless of the number of intervening repetitions since the presentation of the last item, performance on the critical item is no more facilitated than in a group where interference has been maintained by items from the same information class.

Apparent evidence that this increase in performance, when an item is repeated, is due to differential encoding comes from the fact that the repeated item can be presented initially at any position in the list. If it is first presented in the first position then its strength, indicated by its performance at recall, is stronger than items from other positions. This can be determined by scanning any of the PI curves. Yet performance on the repetition trial is the same regardless of initial position or distance of separation between the initial and the repeat trials.

However this may be due either to ceiling effects or to the assumption that recall performance is not a true indicant of

trace strength. All items may have initially been equally as strong at the time of presentation. Repetition therefore adds incrementally to these already equivalent traces, causing performance at the recall of the repeated to item to be maximized. The class of repetitions does not act, as do other differentially encoded classes, to isolate previous interference and to allow its dissipation. It can only be concluded that it has not formed a subjectively different class. Rather it has been encoded as being from the same information class (as in fact it is) as the preceeding items. Interference is maintained the same as it would if new items from that class had been employed.

Repetition acts to facilitate recall by adding to an already existent trace. The subject need only have encoded the original stimulus to the extent that he can recognize that it has already been presented. Upon representation the item gains enough incrementally to allow its strength to now be above threshold at recall. This interpretation lends further evidence to the necessity to speak of levels of encoding in memory and to the line of research which seeks to trace these hierarchical variables.

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