CATEGORY REPETITION AND PROACTIVE INHIBITION IN SHORT-TERM MEMORY

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of the Ohio State University

by

Arnold Roy Collen, B.A., M.A.

The Ohio State University
1971

Approved by

Delos D. Wickens
Adviser
Department of Psychology

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ABSTRACT OF
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Professor Delos D. Wickens, Adviser

This study examined the effects of repeating a taxonomic category using the Wickens' modification of the Peterson-Peterson short-term memory technique. Word triads from seven taxonomic categories were presented in blocked fashion to human Ss for thirty-two trials. After each block of four trials of one category, the Ss in the control condition were shifted to a new category for the next four trials. In the experimental condition, other Ss received new word triads from the same category every other block.

The control Ss produced a "saw-tooth" function. PI build-up was evident within each block. When shifted to a new category, there was a release from PI. Category repetition effectively altered this function. Performance was markedly diminished on the repetition blocks. This dimunition in recall appeared to be constant across all of the repetition blocks and applied mainly to the initial trial of the block. The errors made by all Ss tended to be words belonging to the category being presented.

The findings of this study led to the conclusion that the repetition effect was due largely to undissipated interference generated within the repeated category. The interference was not accumulative and appeared to be restricted to the specific, repeated category.

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Hothersall, D., Johnson, D.A. and Collen, A. Fixed-ratio responding following septal lesions in the rat. Journal of Comparative and Physiological Psychology, 1970, 73, 470-476.

FIELDS OF STUDY

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INTRODUCTION

In 1959 Peterson and Peterson introduced a technique to examine the short-term retention of verbal material. The technique employed a rehearsal preventative task between the presentation and recall of the to-be-remembered items, and recall performance was measured over a predetermined number of trials.

Much evidence has accumulated which shows that the Peterson-Peterson technique produces a rapid drop in recall as a function of trials (Keppel and Underwood, 1962; Wickens, Born and Allen, 1963; Loess, 1964, 1967, 1968). This effect is most marked between the first and second trial. As the number of trials increases, performance approaches an asymptote which is usually reached by the fourth to fifth trial. In general, this asymptotic performance is maintained, although practice effects have been reported (Peterson and Peterson, 1959; Loess, 1964).

This impressive decrement is thought to reflect an interference process, whereby items from earlier trials proactively inhibit the recall of the most recently seen items. The level of recall can be shown to depend on the number of previous items or trials, the retention interval

(Keppel and Underwood, 1962) and the number of to-be-remembered units comprising each item (Murdock, 1961; Melton, 1963).

The build-up of proactive inhibition (PI) seems assured as long as the class of materials being shown to subjects (Ss) remains homogeneous. Once a change is made to a new class of materials performance improves. The recovery from PI can be just as dramatic as the build-up of PI. This important result was first found by Wickens, Born and Allen in 1963. In their study, three groups of Ss were shifted to numbers on Trial 5, 8 or 11 after four, seven or ten trials of consonant trigrams, respectively. Compared to the control Ss who were not exposed to a new class of stimuli, the experimental Ss showed almost complete recovery from PI. Other Ss shifted from numbers to trigrams produced the same result. Further research has revealed that the degree of recovery in large part depends upon the nature of the change in the stimulus. Semantic changes appear to be more important than physical or syntactic changes (Wickens, 1970). Such improvements in recall, frequently termed a recovery or release from PI, have been thought to reflect changes in stimulus encoding. When the S encodes the stimulus differently, it presumably frees that item from interference with earlier items. Thus, the position can be taken that interitem similarity leads to similar stimulus encodings which give rise to the PI, and a change from one stimulus class to another leads to dissimilar encodings which should limit the PI readily generated in the Peterson-Peterson situation.

The Wickens et al. (1963) finding has been interpreted as a release from, not a reduction in PI. Subsequent research by Loess has supported this interpretation. Loess (1968) selected word triads from four taxonomic categories (birds, countries, trees and presidents) and presented them to Ss in four conditions. Blocked conditions involved the presentation of two or four categories for twelve or six consecutive trials, respectively. Other Ss received triads from one category on the odd-numbered trials and triads from a second category on even-numbered trials. A fourth group of Ss was presented four categories in alternated fashion, one triad from each category every fourth trial. All Ss had a total of twenty-four trials. Looking at the percentage of words correctly recalled for the blocked presentations, a shift from one category to another produced a marked release from PI for the first triad of the new category. Presenting four categories alternatively retarded the build-up of PI. This gradual decline in recall over trials contrasted sharply with the rapid build-up for the condition in which only two categories were alternated.

In an earlier study, Loess (1967) showed how the rapid build-up of PI was retarded by the frequency of shifts to new taxonomic categories. Three conditions using word triads were compared in this study. Some Ss were shifted to a new category on every trial. Other Ss received blocks of three trials, so that they shifted on every fourth trial. A third group was given a word triad composed of different taxonomic categories on each trial. Eight categories were used and all Ss were given twenty-four trials. A rapid build-up of PI occurred in the mixed category condition, but little PI was evident when each trial was of a different category, despite the fact that Trials 9 to 16 and 17 to 24 were repetitions of the same eight categories used in Trials 1 to 8.

When presentations were blocked, performance did not remain at a high level found under the alternated condition. Rapid build-up of PI occurred within each block of three trials and was followed by release from PI for the first trial of each block. This shifting to a new category every fourth trial produced a "saw-tooth" function over twenty-four trials. The peaks of the function matched the level of recall found in Ss shifted to a new category on every trial, where the pits of the function reached the level of recall maintained by Ss receiving mixed category triads on every trial. In both the 1967 and 1968 study, release occurred in every case of a shift to a new taxonomic class under conditions of blocked presentation. Table 1 summarizes the outcomes of these two studies. While there was some tendency for the recall asymptote to drop as block

TABLE 1

Proportion of words correctly recalled under conditions of blocked and alternated presentation of taxonomic categories

Blocked presentation

Number of trials	Shift trial performance	Asymptote performance
3	.95*	.76*
6	.78**	.37**
12	.90**	.30**

Alternated presentation

Number of interpolated trials of another category	Single trial performance of repeated category
1	.32**
3	.50**
7	.92*

* Approximated from Loess (1967)
** Approximated from Loess (1968)

size increased, shift trial performance remained inconsis-
t
tent.

The implication from both Wickens *et al.* and Loess' research is that PI is due to item similarity. Loess has further concluded that PI is restricted to the particular class or taxonomic category of materials being presented. Therefore, whenever a change to a new class is made the PI generated by the old class should be ineffective in depressing the performance of the new class. Yet, will the old class effectively depress performance when the *S* is exposed at a later time to additional items from the old class? This question has not been explored in any depth and is the major subject of the present study.

Important to this study is the length of time between the *S*'s initial experience with a stimulus class and his later exposure to it. Loess' conditions described above shed some light on this issue. Alternating the presentations of two taxonomic categories for twenty-four trials produced a more rapid build-up of PI and a lower asymptote than alternating four taxonomic categories for the same number of trials. When seven interpolated trials separated the repetition of a category, there was little evidence of PI (Table 1). Hence, the greater was the number of interpolated trials, the higher was the recall of a triad from a previously presented category. This suggests that the PI which depressed the recall of items from a given category dissipated over time. In other words, the more trials that separated a repetition of a given category, the more time that was allowed for a reduction in the amount of interference.

More direct support for dissipation comes from studies that manipulate the intertrial interval (ITI), the time between the presentation of one item and the presentation of the next item. The major outcomes of these studies are presented in Figure 1. Under conditions of interitem similarity, PI is reduced with spaced, but not massed presentations. Using a fourteen second ITI for half their Ss and a twenty-five second ITI for the other half, Peterson and Gentile (1965) found higher recall of single nonsense syllables for the twenty-five than for the fourteen second ITI after a nine second retention interval. A ninety-one second rest period between the blocks of six trials further reduced PI. Loess and Waugh (1967) also used blocks of six trials, but their stimuli were word triads and each block involved ITI's of 23, 38, 53 and 83 seconds. Even though the greatest drop in recall occurred between the first and the second trial of each block, the asymptote was a direct function of the length of the ITI. In a second experiment with ITI's of 143, 203 and 323 seconds, PI was, in all cases not significantly different from the 83 second ITI of the

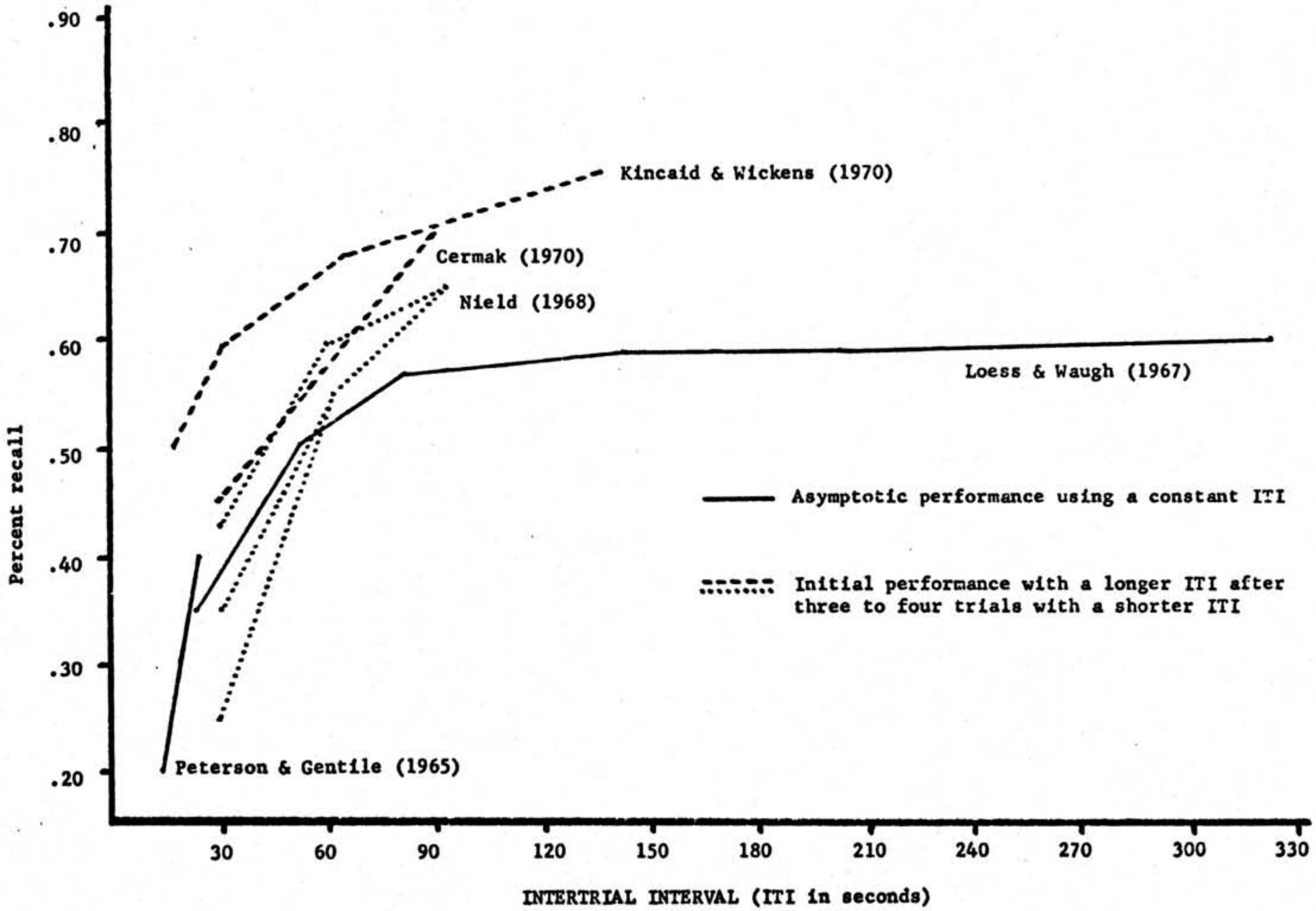

Figure 1. The short-term retention of items as a function of the intertrial interval.

first experiment. The level of recall in these studies ranged from 20 to 40 percent for 14 to 23 second ITI and 55 to 65 percent for a 83 to 323 second ITI.

Just as a shift in class membership brings a change in performance, so does a sudden shift from a shorter to a longer ITI. For example, after four trials of consonant trigrams with a thirty second ITI, a ninety second ITI was introduced before Trial 5 (Cermak, 1970). This shift increased recall on the fifth trial to a level comparable to the performance of Ss who received the long ITI for all five trials. Other Ss who were shifted from the long to the short ITI just before Trial 5 showed a marked drop in recall to the performance level of Ss who received the short ITI for all five trials. Kincaid and Wickens (1970) have extended Cermak's findings to longer ITI's. Using consonant trigrams and Stroop color naming as a distractor task, Ss continued to color name for 0, 15, 45 or 120 seconds between Trials 3 and 4. A direct relationship was found between Trial 4 performance and the extended ITI, even though Trial 4 performance was never as high as Trial 1. This agreed with Loess and Waugh (1967) who also found incomplete dissipation even at their longest ITI (Figure 1). As in the case of interpolated trials of other categories (Loess, 1967, 1968), the increased recall which accompanies a shift to a longer ITI (Cermak, 1970; Kincaid and Wickens,

1970) suggests dissipation of, rather than release from PI.

This reduction in PI is not altered by the activity which occupies the Ss attention during the ITI. Nield (1968) has shown that as the ITI lengthened, recall of consonant trigrams improved at the same rate regardless of whether the Ss learned three digit numbers, named colors or simply rested during the ITI. In this study, as in all others employing the Peterson-Peterson technique, it is assumed that the interpolated activity was interpreted by the S as distinct from the class of materials under investigation and was therefore, not the major source of interference in this situation.

Given the build-up of PI under blocked presentation of a stimulus class, the implication is that two underlying processes bring about improvements in performance. (1) Changing the stimulus class results in a release from PI. (2) A lengthened ITI, be it filled or unfilled, results in dissipation of PI. Current evidence suggests that both the build-up of and release from PI are probably responsible for the "saw-tooth" function (Loess, 1967). If PI is class bound as Loess contends, then the process of build-up and dissipation for a given taxonomic category should be relatively independent of other categories presented either before or after that category. Furthermore, release from PI should depend chiefly on the degree of stimulus change from trial to trial.

The purpose of this study was to examine the effects of category repetition under conditions of blocked presentation. A block was defined as four consecutive trials with words from one taxonomic category, where one word triad was presented on each trial. All _S_s were given eight blocks in succession. In the repetition (experimental) condition, Ss worked with the same category in four of the eight blocks. One block of a not-to-be-repeated category separated each block of the repeated category. Altogether, there were three category repetitions. Because this study was not concerned with the repetition of specific items, new words always occurred in each block of the repeated category. In the nonrepetition (control) condition, other _S_s received no category repetitions, but every block was with a new category.

If PI is restricted to taxonomic category and an interpolated block of another category provides a condition for dissipation, then any changes in performance when an earlier category is repeated should depend on the interference still present within the repeated category. It was hypothesized that there would be a greater decrease in recall performance on blocks in which a category was repeated. Also of interest were differences between _S_s in the nonrepetition condition who were expected to produce the "saw-tooth" function and Ss in the repetition condition who were expected to deviate from this function.

METHOD

Subjects.- Two hundred and eighty-eight college students enrolled in introductory psychology at Ohio State University served as the Ss. Seventy-six percent of the students were from the first introductory course and participated in this experiment as part of a course requirement. The other twenty-four percent of the students came from a subsequent course on a volunteer basis. All Ss were randomly assigned to either the experimental or control condition in their order of appearance.

Stimuli.- The stimuli were common nouns from eight taxonomic categories: A four-footed animal, a chemical element, a country, a kind of cloth, a musical instrument, an occupation, a part of a building, or a vegetable. These categories were taken from the Battig and Montague (1969) norms and were selected for their low degree of associative overlap. Their associative overlap was determined from pilot data collected by Wickens and Morisano (1970; unpublished study), who asked Ss to sort forty-seven of the fifty-six categories from the Battig-Montague norms into as many piles as they wanted. The frequency with which any two categories were sorted into the same pile could range from zero to seventy-five. The frequency count was taken as a rough approximation of the degree of associative overlap. Table 2 shows the sorting frequencies between the eight categories used in this study. In general, the degree of associative overlap between all the categories was very low.

The frequency of occurrence in the English language (Thorndike and Lorge, 1944), the number of letters and the number of syllables were determined for each word taken from the Battig-Montague norms. From each word list, word triads were formed to represent each category. An effort was made to equate the categories with respect to word frequency, word length and number of syllables. The Thorndike-Lorge frequency distribution of the words representing each category is shown in Table 3. Within each word triad two additional requirements were imposed: No two words could begin with the same letter of the alphabet, or be easily construed as synonyms or homonyms of one another.

Because of their abundance, word triads from animals, countries and occupations were chosen for the to-be-repeated categories. These word triads, sixteen in total, were further broken down into four groups of four. Again, an effort was made to make each group equivalent to other such groups. The category showing the most associative overlap, a part of a building, was used for four practice trials for all Ss. Word triads from the remaining categories served

TABLE 2

The frequency with which the taxonomic categories were sorted into the same pile

From Wickens and Morisano (1970, unpublished study)

	Taxonomic category	1	2	3	4	5	6	7
1	Four-footed animal							
2	Chemical element	2						
3	Country	3	0					
4	Kind of cloth	0	5	0				
5	Musical instrument	1	4	0	6			
6	Occupation	1	1	3	4	3		
7	Part of a building	0	2	10	8	6	2	
8	Vegetable	6	1	1	1	1	0	0

TABLE 3

The percentage of words from each category representing high, medium and low frequency of occurrence in the English language

Taxonomic category	Frequency*			Total words
	high	medium	low	
Four-footed animal	19	19	63	48
Chemical element	17	25	58	12
Country	15	21	65	48
Kind of cloth	17	17	66	12
Musical instrument	17	25	58	12
Occupation	19	19	62	48
Part of a building	17	25	58	12
Vegetable	17	17	66	12

* Thorndike-Lorge (1944) frequency counts:

high = a count of 50 or more times per million (A or AA)

medium = a count of 20 to 49 times per million

low = a count of 1 to 19 times per million the purpose of the not-to-be-repeated categories in the control condition and the interpolated blocks in the repetition condition.

The actual words used in this study can be found in Table 4. Three categories were represented by four blocks of four triads and the other five categories by one block of four triads.

Design.- Two treatment conditions were compared in this study. Control Ss were presented eight blocks in succession. Each block dealt with a different taxonomic category. At no time were the Ss in this condition exposed to one category for more than one block. On the other hand, experimental Ss were exposed to the same category on Blocks 2, 4, 6 and 8. Each repetition block always consisted of new word triads from the category given in Block 2. One block of a not-to-be-repeated category separated each block of the repeated category. Table 5 summarizes the design. Each letter in the table represents four trials on the same taxonomic category. Altogether, each S received eight blocks or thirty-two triads for a total experience of thirty-two trials with the Peterson-Peterson technique.

Making comparisons between the two conditions at each point of a category repetition requires that the repeated category be presented on every trial in the control condition in which it occurs in the experimental condition.

TABLE 4

The word triads used in this study

Category	Block	Word triads
Four-footed animal	1	dog,camel,antelope;tiger,buffalo,otter; mouse,raccoon,seal;elephant,gopher,lynx.
	2	hyena,opossum,cat;deer,coyote,walrus; squirrel,elk,leopard;beaver,llama,monkey.
	3	porcupine,horse,jaguar;wolf,gazelle,boar; rabbit,zebra,sloth;sheep,gorilla,hamster.
	4	lion,kangaroo,muskrat;cow,giraffe,alligator; donkey,bear,moose;goat,skunk,panther.
Chemical element	1	silver,tungsten,copper;hydrogen,cobalt,lead; mercury,argon,helium;bromine,sulfur,zinc.
Country	1	france,honduras,sudan;russia,iceland,morocco; panama,england,sweden;holland,australia,laos.
	2	spain,libya,uruguay;lebanon,china,malaya; canada,poland,brazil;italy,korea,belgium.
	3	portugal,cuba,japan;india,paraguay,denmark; greece,america,iran;austria,chile,egypt.
	4	britain,peru,norway;mexico,ireland,albania; scotland,israel,burma;germany,syria,finland.
Kind of cloth	1	gaberdine,cotton,denim;flannel,corduroy,silk; linen,mohair,tweed;satin,velvet,worsted.
Musical instrument	1	horn,saxophone,guitar;bell,flute,piano; organ,trumpet,violin;drum,accordion,oboe.
Occupation	1	plumber,accountant,surveyor;sailor,fireman, editor;architect,mortician,cashier;shoemaker, botanist,nurse.
	2	clerk,bartender,surgeon;author,machinist,coroner; policeman,banker,chemist;merchant,laborer,artist.
	3	manager,auditor,painter;contractor,judge,barber; jeweler,blacksmith,minister;actor,physicist, janitor.
	4	mechanic,carpenter,butler;pilot,bookmaker, dentist;lawyer,scientist,waiter;writer,salesman, engineer.
Part of a building	1	window,balcony,girder;door,pillar,closet; ceiling,rafter,patio;banister,skylight,furnace.
Vegetable	1	asparagus,corn,spinach;potato,broccoli,turnip; radish,parsley,bean;onion,cucumber,lettuce.

Table 5. The two treatments used in this study.

Block	1	2	3	4	5	6	7	8
Treatment								
Experimental	E	A	B	A	C	A	D	A
Control	E	E	B	A	C	F	D	G

Table 6. Counterbalanced design for the repetition of three different categories.

Block	1	2	3	4	5	6	7	8
Treatment								
	E	A	B	A	C	A	D	A
Experimental	E	F	B	F	C	F	D	F
	E	G	B	G	C	G	D	G
	E	H	B	F	C	G	D	A
Control	E	H	B	G	C	A	D	F
	E	H	B	A	C	F	D	G

To maintain the integrity of the control condition, four control Ss would be needed for every experimental S. This obstacle was overcome by using three different categories for repetition (A, F and G in Table 5) and a fourth category (H in Table 5) to parallel the experimental Ss initial experience with the to-be-repeated category. The categories within the two conditions were counterbalanced (Table 6). This expanded design allowed for (1) an even distribution of Ss between the two conditions, and (2) the potentiality for extending the results to taxonomic categories in general. Thus, three different groups of Ss comprised each treatment condition.

Further counterbalancing within each S group was done in order to minimize potential order effects that might arise from presenting the stimuli to all Ss in the same sequence. With the exceptions of Blocks 1 and 2 (Table 6), all categories occurred equally often in each appropriate position: B, C and D in Blocks 3, 5 and 7; A, F and G in Blocks 4, 6 and 8 in the control condition, and in Blocks 2, 4, 6 and 8 in the experimental condition. Potential within-block order effects were also counterbalanced. For every block position, there were four within-block positional changes. Ninety-six Ss were required to complete the counterbalanced design. The entire design was replicated three times to give a total of 288 Ss. The block position of categories B, C and D was rotated for each replication of the design.

Apparatus.- The experiment took place in a small, sound-proofed room. Over the S's left shoulder, 35 millimeter slides were shown by means of a Kodak 800 Carousel projector. The slides were exposed for a predetermined time interval by means of a Gerbrands tape-timer. The S sat in a comfortable chair five feet in front of a screen.

Procedure.- When the S and experimenter had taken their places, in the chair and behind the S, respectively, the following instructions were read aloud to the S:

> The purpose of this experiment is to study your ability to remember words and to perform a counting task at a fairly fast and constant rate.
>
> First, you will see an asterisk projected on the screen in front of you. The asterisk is your ready signal. Two seconds later you will see three words. You are to read the words out loud as quickly as you can, for you will see them for only two seconds.
>
> After the words a three digit number will appear. As soon as you see the number, say it out loud, then begin counting backward from the number by threes. For example, if the number was 999, you would first say 999, then 996, 993, 990, 987, and so on until a question mark appears.
>
> When you see the question mark, try to tell me the three words that were presented before the number. Give them in order if you can and out loud so that I can hear them clearly. You will have sixteen seconds to recall the three words. Then the question mark will be replaced by the asterisk, your signal that another three words are about to be presented.
>
> Therefore, what you are to do is this: First, pronounce the three words as fast as you can, then pronounce the three digit number which follows them. Third, count backward from the number by threes at the pace of the click, and finally,

> recall the three words in order if you can.
> The basic procedure will be repeated a total of thirty-two times. You should try to do as well as you can on both the words and the numbers, and keep your eyes on the screen in front of you throughout the experiment.
> Can you very briefly repeat to me what you are to do, so that I understand that the experiment is clear to you?

The sequence of events comprising each trial is summarized in Table 7. The retention interval was filled by asking the S to count backward from a three digit number by threes to the one second beat of a metronome. Each number was drawn from a table of random numbers and remained on the screen throughout the retention interval. This counting activity was assumed to have the function of preventing active rehearsal of the triad. The asterisk served as a ready signal and the question mark, as a signal for recall.

This modified version of the original Peterson-Peterson technique was continued for a total of thirty-two trials. After the last trial, the S was asked the following questions:

1. "Did the words on different trials fall into groups or categories?" If the S said "yes" he was then asked, "Can you name them?"

2. "Words from one group were presented for four consecutive trials, then words from another group were presented for the next four trials, and so on in this fashion through the experiment. Once a group had been presented, did it reoccur at a later time in the experiment?" If the S said "yes" he was then asked, "Can you name the group or groups?"

The specific order of the stimuli each S received was predetermined before the experiment and prearranged in the Carousel. The first four trials enabled the S to become familiar with both the retention and rehearsal preventative tasks.

TABLE 7

Events and their duration that comprised one trial

Event	Duration (seconds)
Asterisk	2
Word triad	2
Retention interval	10
Question mark	16
Total time per trial	30

RESULTS

The performance of each *S* on each trial was determined by giving one point for each word correctly recalled plus an additional point if all three words were recalled in their original order. The mean performance of the control *S*s over trials was plotted (Figure 2). This condition produced the expected "saw-tooth" function. There was a marked drop from the first to the fourth trial of all blocks, $F(3,429) = 201.03$ ($p < .001$). The average within-block performance changed from 70.8 to 43.6 percent. A significant Blocks X Trials (within-blocks) interaction, $F(21,3003) = 2.61$ ($p < .001$), indicated that the degree of change varied from block to block. A supplementary analysis of variance (ANOVA) on just the *peaks* (arrows in Figure 2) of the curves showed that the performance on the initial trial of each block was nearly the same, $F(7,1001) = 0.70$, but on the final trial of each block, the *pits* of the curves, performance significantly differed, $F(7,1001) = 5.39$ ($p < .001$). The *pits* rose from 35.6 percent in Block 1 to 50.9 percent in Block 8. A Newman-Kuels test for the differences between all pairs of means (Winer, 1962) further revealed that the *pits* of Blocks 1 and 5 were significantly lower than Blocks 4, 7 and 8 ($p < .01$). Blocks 2, 3 and 6 were common to both groups.

Shifting to a new taxonomic category produced just as marked an improvement in performance as the initial decrement, $\underline{F}(1,143) = 549.06$ ($\underline{p} < .001$). On the average, recall jumped from 42.5 to 70.7 percent. This ANOVA, comparing the seven category shifts, yielded a significant Shifts X Trials interaction, $\underline{F}(6,858) = 3.24$ ($\underline{p} < .001$). This meant that all pit-to-peak changes were not equivalent. The magnitudes of change arranged from highest to lowest were: Shift number $1 \cong 5 > 3 > 4 \cong 6 \cong 7 > 2$.

A "saw-tooth" function of a different character was generated when Ss received three repetitions of a taxonomic category (Figure 3). Decrements in performance occurred within the blocks, $\underline{F}(3,429) = 159.27$ ($\underline{p} < .001$). The average within-block change was from 67.3 percent on Trial 1 to 44.6 percent on Trial 4. A supplementary ANOVA on the pits of the curves showed that the performance on the final trial of each block varied significantly, $\underline{F}(7,1001) = 2.89$ ($\underline{p} < .01$). Like the control condition, there was a slight increase in performance over the experiment, even though only the pit trial performance of Blocks 1 and 8 differed significantly ($\underline{p} < .01$, Newman-Kuels test). The Blocks X Trials (within-blocks) interaction, $\underline{F}(21,3003) = 3.72$ ($\underline{p} < .001$), pointed out significant variation of the trial-to-trial changes between the eight blocks. Unlike the control

Ss, the peaks of the curves did differ from one another, $F(7,1001) = 15.22$ ($p < .001$). A Newman-Kuels test on these differences revealed that the initial trial (arrow in Figure 3) of Blocks 4 and 6 varied significantly from Blocks 1, 2, 3, 5 and 7. Block 8 was common to both groups in initial trial performance. Blocks 4, 6 and 8 were on the repeated category, where Blocks 1, 3, 5 and 7 involved the nonrepeated categories. Block 2 was the first exposure to the to-be-repeated category.

The pit-to-peak changes from one category to another were not as marked as for control Ss. Nevertheless, they were highly significant, $F(1,143) = 354.55$ ($p < .001$). Figure 3 suggested that Shift numbers 3, 5 and 7 varied greatly from Shifts 1, 2, 4 and 6. The former group involved a change to the repeated category, and the later group were shifts to a not-to-be-repeated category. The ANOVA on the seven category shifts produced a significant Shifts X Trials interaction, $F(6,858) = 12.70$ ($p < .001$). An examination of the magnitude of change for each shift indicated that Shifts 1, 2, 4 and 6 were about three times greater than Shifts 3, 5 and 7. These changes ordered from the greatest to smallest were: Shift number $4 > 1 \cong 2 > 6 > 5 \cong 7 \cong 3$.

When the "saw-tooth" function of the control Ss is superimposed upon that of the experimental Ss, they do not coincide (Figure 4). An ANOVA comparing both functions showed a Treatments X Trials (within-blocks) interaction, *F*(3,429) = 3.29 ($p < .05$). An additional ANOVA was performed on Blocks 4, 6 and 8 to clarify the principle differences between the two functions. Both the Treatments main effect and the Treatments X Trials (within-blocks) interaction were significant, *F*(1,858) = 45.57 ($p < .001$) and *F*(3,429) = 8.19 ($p < .001$), respectively. This indicated a differential degree of change between the two treatment conditions over trials within the three blocks. Both curves appeared to approach the same asymptote, but the control *S*s started at a higher level of performance than the experimental *S*s. The stability of this finding was strengthened by the insignificant Treatments X Blocks X Trials (within-blocks) interaction, *F*(6,858) = 1.41. In other words, these trial-to-trial differences were similar within all three of the repetition blocks.

In general, the *pits* of the two functions were similar, but all of the *peaks* were not. This was supported by the Treatments X *Pit* Trials interaction, *F*(7,1001) = 1.50, and the Treatments X *Peak* Trials interaction, *F*(7,1001) = 10.02 ($p < .001$). A Newman-Kuels test on the *peak* means of both conditions showed that the *peaks* of the repetition blocks in the experimental condition, Trials 13, 21 and 29, were significantly lower than the other *peaks* of the two func-

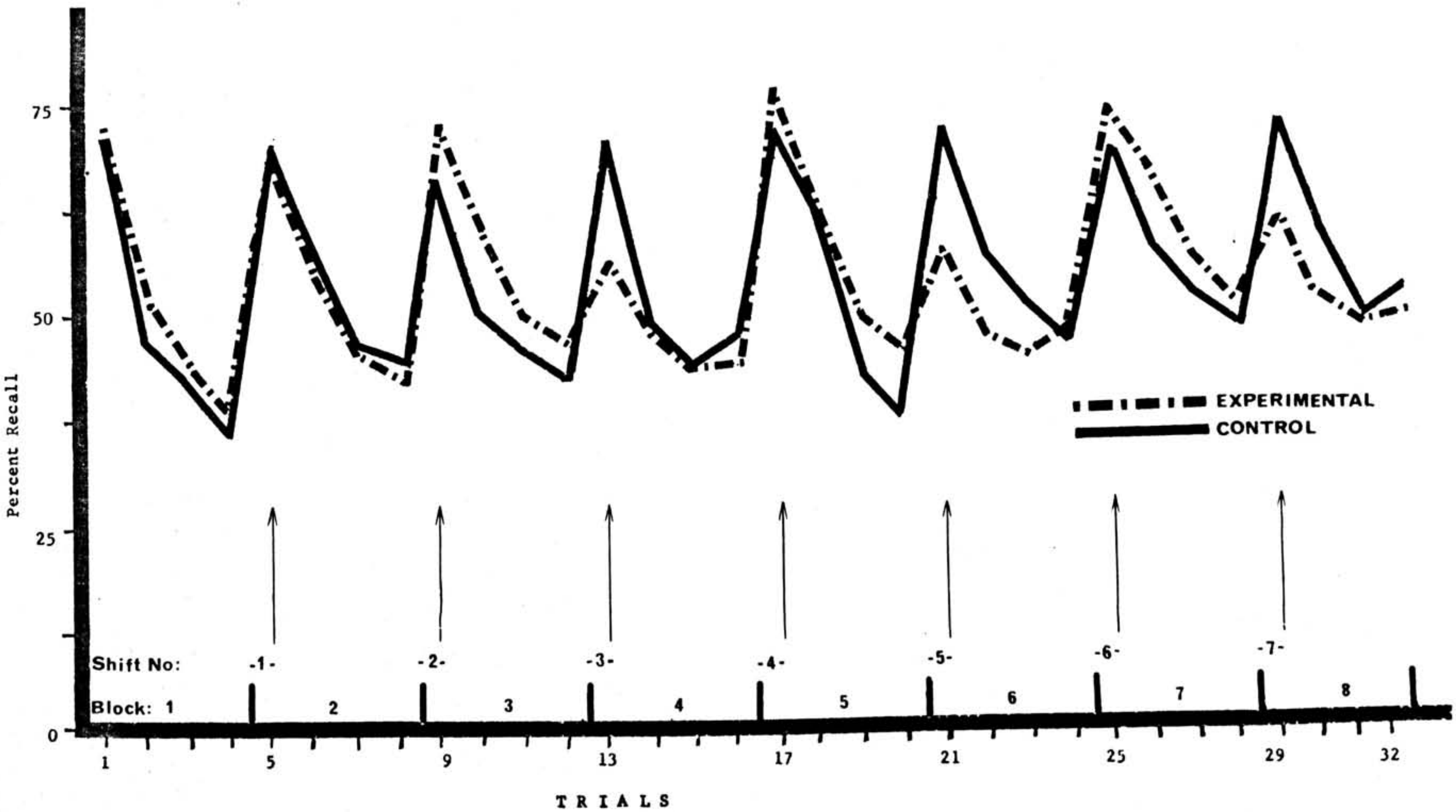

Figure 4. Mean performance of the two treatment conditions over the 32 trials.

tions ($p < .01$). In other words, in every case of a repetition of a taxonomic category, the mean performance on the initial trial of the repeated block was lower than the control condition.

The comparison of all pit-to-peak changes in the two S groups did not differ for Treatments, $F(1,858) = 2.55$, however the Treatments X Trials interaction, $F(1,143) = 11.35$ ($p < .001$), indicated that the control Ss showed a greater overall improvement in performance than the experimental Ss. The differential degree of recovery was not the same for all shifts. There was also a substantial Treatments X Shifts X Trials interaction, $F(6,858) = 9.86$ ($p < .001$). Shifts 3, 5 and 7 reached the .01 level of significance and Shift number 4, the .05 level (Table 8). The former group involved a shift to a repeated category. The insignificant shifts were to a not-to-be-repeated category. Shift number 4 was the only exception. Thus, only shifts to a repeated category produced large treatment differences in the degree of recovery.

The percent recovery in Table 8 was calculated as the ratio of experimental to control mean performance form Trial 4 of one block to Trial 1 of the next block. These percentages indicated the direction of recovery of the experimental condition with respect to the control condition. When experimental Ss were shifted to a not-to-be-repeated

TABLE 8

The F ratios and percent recovery for changes in performance when shifting from one category to another for the two treatment conditions

Shift number	Trials	Treatments X Trials Interaction	Percent recovery
1	4 to 5	0.86	89.71
2	8 to 9	3.72	136.09
3	12 to 13	21.17***	50.86
4	16 to 17	4.54*	135.92
5	20 to 21	27.69***	32.67
6	24 to 25	0.48	112.06
7	28 to 29	8.67**	45.71

* $p < .05$
** $p < .01$
*** $p < .001$

category, recovery was superior to the control group (Shift numbers 2, 4 and 6), yet when shifted to a previously used category, it was clearly inferior to the controls (Shift numbers 3, 5 and 7). The smallest change in both conditions when shifting to a not-to-be-repeated category was two times greater than the largest change chen shifting to a previously repeated category.

Differences between the two conditions also appeared in block-by-block mean comparisons. Figure 5 shows the mean performance over each block for the two S groups. The main effect of Blocks in the control condition was highly significant $F(7,14) = 6.99$ (p .001). The mean block performance tended to increase from 49.0 percent in Block 1 to 57.0 percent in Block 8. In contrast to the control Ss, large differences appeared among the block means in the experimental condition, $F(7,14) = 21.44$ ($p <$ .001). A Newman-Kuels test on the mean block differences supported the graphic separations in Figure 5. Blocks 3, 5 and 7 differed from 4, 6 and 8. Common to both groups were Blocks 1 and 2. Finally, the nonrepetition and repetition blocks were significantly above and below the control condition, respectively. In the first case, the $F(1,429) = 36.22$ ($p < .001$) and in the second case, the $F(1,429) = 47.94$ ($p < .001$).

In order to ensure that order effects were not affecting

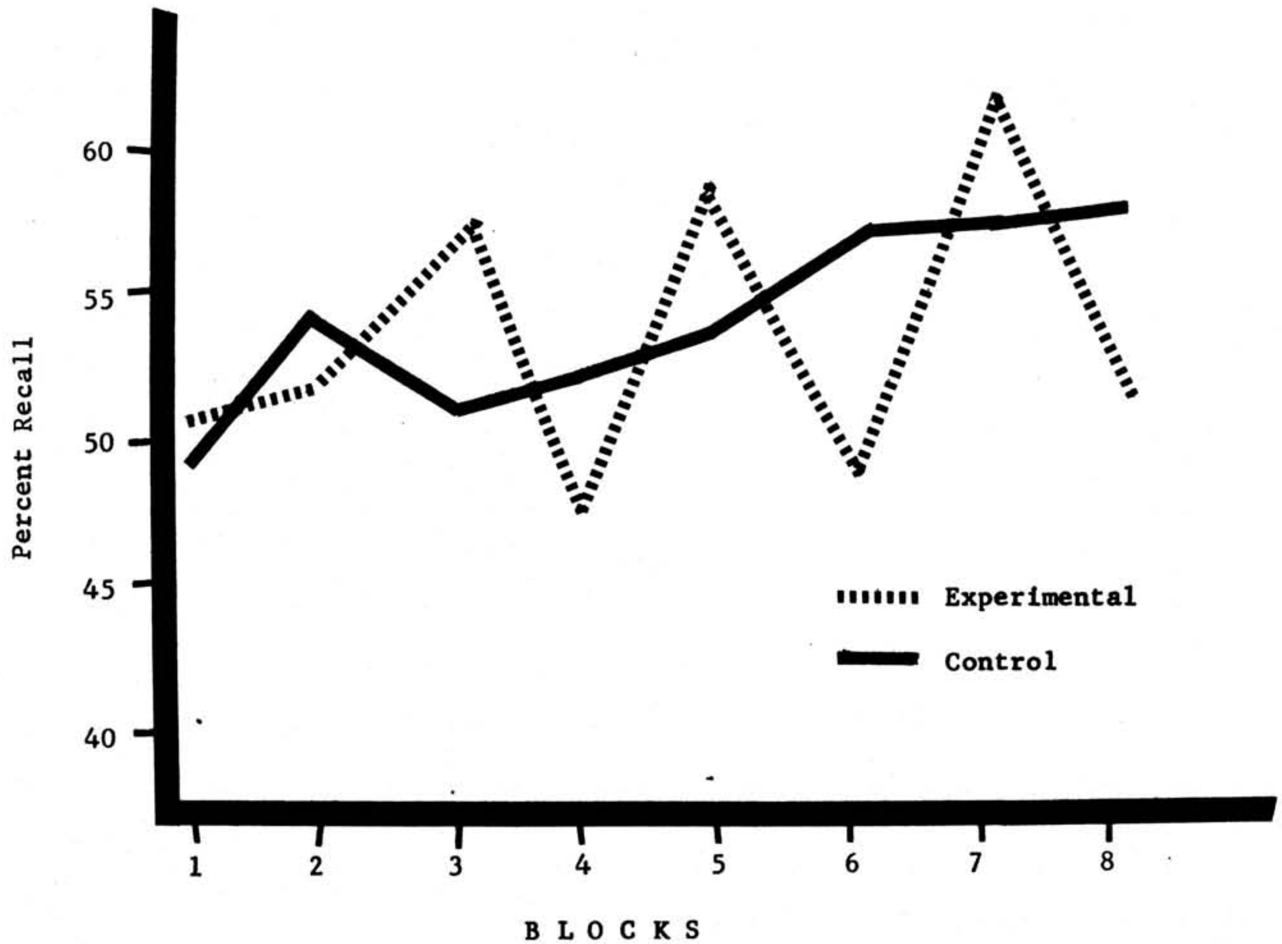

Figure 5. Mean performance of the two treatment conditions over the eight blocks.

the findings, a general ANOVA of the entire design was completed. The three replications of the design differed, *F*(2,1116) = 40.67 (*p* < .001). The difference was produced either by the superior overall performance of *S*s participating in the latter third of the experiment or by an advantageous nonrepetition block arrangement (kinds of cloth, chemical elements, vegetables). Some categories appeared easier than others, *F*(2,1116) = 39.05 (*p* < .001). The recall of animals, for example, was higher than countries and occupations which did not differ from one another. Finally, between blocks counterbalancing did reach significance, *F*(3,1116) = 10.10 (*p* < .001), and within block changes were marginally significant, *F*(3,1116) = 3.29 (*p* < .05). Despite the stimulus selection and counterbalancing, the experiment was not entirely successful in eliminating order and position effects.

An analysis of errors made by *S*s over the thirty-two trials is presented in Table 9. By far, the largest type of error was an omission. On the average, a *S* made 33.7 omissions in the experiment. Omissions were not as frequent in one treatment condition as in the other. Each of the S's total number of omissions on the repetition blocks (4, 6 and 8) and the interpolated blocks (3, 5 and 7) was determined. An ANOVA on these sums showed that more omissions occurred in the experimental than in the control

TABLE 9

The probability and frequency of intrusions and omissions for the two treatment conditions

INTRUSIONS:	Source	Condition		
		Experimental	Control	Both
Within a block	Previous trial	.56	.58	.58
	Two trials previous	.10	.13	.11
	Three trials previous	.03	.04	.03
	Total	.69	.75	.72
Between blocks	Preveous repeated category	.13	—	.06
	Previous nonrepeated category	.02	.02	.02
	Total	.14	.02	.08
Importations	Same category	.13	.20	.17
	Different category	.03	.03	.03
	Total	.17	.23	.20
ERRORS:	Omissions	.81	.80	.80
	Intrusions	.19	.20	.20
	Total	.50	.50	1.00

condition, $F(1,143) = 8.26$ ($p < .01$), and in the repetition blocks than in the interpolated blocks, $F(1,143) = 49.61$ ($p < .001$). The latter difference held for both treatment conditions, accounting for the insignificant Treatments X Blocks interaction, $F(1,143) = 0.31$.

The second most common error was an intrusion. Even though the total number of intrusions in each column of Table 9 was used as the base for calculating the within block, between block and importation probabilities, the magnitude of any intrusion probability is some proportion of 0.20 which represents the proportion of intrusions errors of all kinds made by Ss. The highest source of an intrusion error was a word from the previous trial within the block. Extra-experimental errors (importations) tended to be restricted to the taxonomic category being presented and were slightly more frequent in the control than in the experimental condition. Repeating a category did have an effect as seen in the probability of an intrusion from a previously presented category. Yet, this was a small effect in comparison to the within-block intrusion probability. As with omissions, intrusions were summed for the repetition and interpolated blocks in each treatment condition. An ANOVA produced insignificant main effects for Treatments, $F(1,143) = 0.28$, and for Blocks, $F(1,143) = 0.50$. The Treatments X Blocks interaction was significant, $F(1,143) =$

4.30 ($p < .05$); the frequency of intrusions in the interpolated blocks of the experimental condition was higher than in the control condition.

A tally of responses to the two questions asked Ss (Table 10) showed that approximately ninety-nine percent of the Ss were aware by the end of the experiment that the words fell into several taxonomic categories (Question 1). Eighty-one percent of the experimental Ss became aware of the category repetition (Question 2).

TABLE 10

The frequency and percentage of yes-no responses to two post-experimental questions

Question	Response	Condition	
		Control	Experimental
1*	Yes	99.3	98.6
	No	0.7	1.4
2**	Yes	10.4	81.3
	No	89.6	18.7

* "Did the words on different trials fall into groups or categories?"

** "Words from one group were presented for four consecutive trials, then words from another group were presented for the next four trials, and so on in this fashion through the experiment. Once a group had been presented, did it reoccur at a later time in the experiment?"

DISCUSSION

The major outcome of this study was the poorer retention of new word triads belonging to a previously presented category. Both the first trial and mean block performance of each repetition block in the experimental condition was below that of the controls. Significant Treatments X Trials (within-blocks) interactions in the repetition blocks pointed to differing rates of within-block build-up of PI. Furthermore, Treatments X Trials interactions in recovery occurred only when shifting to a previously repeated category. Outside of these major differences, the peaks, pits and within-block changes of the two functions were alike.

There was a slight tendency for the pits and mean block performance to rise and the within-block decrements to decrease over the experiment. These general improvements with trials strongly suggested a practice effect similar to those reported by earlier investigators using the Peterson-Peterson technique (Peterson and Peterson, 1959; Loess, 1964). The peaks of the two functions showed no such effect.

With respect to interpretations of this study, there are three alternatives which might account for the effect of category repetition under blocked presentation: (1) Stimulus change, (2) dissipation of PI, and (3) accumulation of PI.

With respect to the first interpretation, dissimilar stimulus encodings produced in a shift from one stimulus class to another should bring nearly complete recovery in both treatment conditions. That is, encoding new stimuli differently on the next trial will be more important than having these stimuli belong to the same taxonomic category used some time earlier in the experiment. The first position states, in effect, that the two treatment conditions will fail to vary significantly simply because the critical variable is the effect of class change.

The second position assumes an interpolated block of four trials should allow for the dissipation of PI from the to-be-repeated category. When the S is returned to the category in question, his performance should be inferior to the controls, if the dissipation of PI for the repeated category is incomplete. Previous research has found that a 120 second ITI is enough time for about seventy-five percent recovery from the build-up of PI (Loess and Waugh, 1967; Kincaid and Wickens, 1970). Shifting to a previously repeated category, therefore, should expose the S to undissipated PI. With the fixed ITI consisting of an interpolated block of a not-to-be-repeated category between the category repetitions, this alternative predicts poorer performance of the experimental Ss. Furthermore, the S's performance should remain unchanged across all repetition blocks. This is because the interference should be restricted to the repeated category and the ITI should exert a predictable effect on the amount of dissipation that takes place from one category repetition to the next.

The final position predicts a gradual decline in performance over the repetition blocks, despite any effect attributable to release from and dissipation of PI. This interpretation states that PI should not be restricted to any one category, but should gradually accumulate over blocks. Progressive decrements should be obtained in both treatment conditions.

The major findings of this study discredited the first view that stimulus change is the single most important variable. Recovery for the experimental Ss on the initial trial of the repetition blocks was less than half that of the control Ss. The percent recovery on Shifts 3, 5 and 7 was 50.9, 32.7 and 45.7, respectively. If stimulus change effected both conditions to an equal degree, then the percent recovery would have been close to 100.0. In addition, the Newman-Kuels test on all the peaks of both functions showed a decrement in performance only for the experimental Ss on the initial trials of Blocks 4, 6 and 8.

The second position predicts a reproducible effect of category repetition. In the experimental condition, the peaks of the repetition blocks were similar. This was also the case for the pits of these blocks. The insignificant Treatments X Blocks X Trials (within-blocks) interaction indicated that the difference from the control condition remained relatively invariant for Blocks 4, 6 and 8. Further, the mean block performance did not significantly differ for these blocks and was consistly below the controls. The only evidence opposing the second interpretation was the recovery data. The percent recovery for Shifts 3, 5 and 7 was not equal (50.9, 32.7 and 45.7). Trial 4 and Trial 20 performance in the control condition were significantly below all pits of both treatment conditions. This possible chance deviation may have caused Shift number 5 to be markedly below Shifts 3 and 7. Except for these differences in recovery, all of the findings of this study supported the interpretation that shifting to a previously presented category 120 seconds later exposed the experimental Ss to undissipated PI. Under these conditions, the undissipated PI was enough to markedly diminish the extent of release from PI that would have occurred had the shift been to a new category. The stability and reproducibility of this effect suggested that interfreence was category specific and the ITI was an important variable when a category repetition was involved.

Like the first interpretation, evidence supporting the third view is untenable. This position predicts a progressive drop in performance over category repetitions. Shifting to a old category for the third time produced greater recovery than for the second time (Shift number 7 versus 5). PI build-up proceeded at a significantly slower rate within the repetition blocks of the experimental condition, and the _pits_ did not drop below those in the control condition. Furthermore, no additional drops in _peak_ trial performance were noticeable after the first block repetition. In other words, category repetition did not progressively increase the degree of PI build-up for the experimental _S_s, but only pushed performance toward the same asymptote in each repetition block. Mean block performance, _pits_ and within-block changes had a tendency to move over blocks in the direction opposite to the predictions of this position. Finally, there were not any progressive decrements found in the control condition. It was therefore concluded that PI did not accumulate over the repetition blocks. If an accumulation was occurring, then measurable, progressive decreases within the repetition blocks as well as in the control condition should have been found. The lack of evidence to support this view reinforces the interpretation that PI is class-specific.

Both S groups produced "saw-tooth" functions. The control condition replicated Loess' (1968) 4S condition. In the Loess study there was much variablility. The peaks of the curve ranged from 72 to 91 percent recall, and the pits, from 22 to 40 percent. In the present study, the function was more stable. The peaks (70-75 percent) and the pits (35-40 percent) fell well within the limits of Loess' function. The difference between the two experiments was that Loess' 4S condition involved six trials per block, where the conditions of this study used four trials per block. In the "saw-tooth" function generated by the experimental Ss, the invariance of the repetition blocks could be related to the number of interpolated trials. Under alternated presentation, more interpolated trials heightened the recall of a repeated category (Loess, 1967, 1968). Although dissipation and class bound character of PI may account for the findings of the present study, experiments that systematically vary block size are needed to see more precisely whether the invariance of the repeated blocks is a function of the time between category repetitions.

With respect to errors made by the Ss, the majority of them were omissions and previous item intrusions. Transpositions were not scored in this study. The probability of an intrusion in this study, 0.20, was close to

0.18 obtained by Loess (1968). The largest source of intrusions was the previous item within the block (0.72). Loess (1968) found previous item intrusion probability equalled 0.64. Finally, the extent of extra-experimental errors was similar in both studies, here 0.08 and Loess (1968) 0.10.

The frequency and nature of the errors tended to support the second interpretation. Although both conditions contributed an equal proportion of omissions and intrusions, most of the importations and previous item intrusions were words belonging to the stimulus class being presented.

CONCLUSION

The purpose of this study was to examine the effects of repeating a taxonomic category on the build-up, release and dissipation of PI. Blocked presentation of the categories replicated the "saw-tooth" function first demonstrated by Loess in 1967. Category repetition effectively altered this function. The performance of the experimental *S*s was markedly diminished on the repetition blocks. This dimunition appeared to be constant across all of the repetition blocks and applied mainly to the initial trial of the block.

The implication from this study is that when a shift is made from the interpolated block back to a previously presented category, the PI already present curtails the usual degree of release from PI. If interference is accumulative because other categories contribute to the dampening, then a progressive fall in recovery should occur when a category is repeated every other block. Drops in the *pits* should also accompany these changes in recovery. Instead, recovery did not differ from category repetition to repetition and the *pits* rose over trials. Finally, the errors from a given category tended to appear only when the *S* was presented with words from that category.

The findings of this study lead to the conclusion that the repetition effect was due only to interference generated within the repeated category. PI appeared to be restricted the specific, repeated category.

This study supports Loess' belief that PI is class bound: When a shift is made to a new class, PI of the old class is ineffective in altering the S's performance on the new class. However, once the S returns to the old class, undissipated PI will again become an influencial factor in his level of recall.

APPENDIX A

Analyses of Variance on the Control Condition

TABLE 11

Analysis of variance on all trials of the control condition

Source	SS	df	MS	F
Subjects	889.62	143	6.22	5.28***
Blocks	50.99	7	7.29	6.99***
Trials (within-blocks)	828.60	3	276.20	201.03***
Subjects X Blocks	1042.76	1001	1.04	0.88
Subjects X Trials	589.41	429	1.37	1.17*
Blocks X Trials	64.59	21	3.08	2.61***
Residual	3537.23	3003	1.18	
Total	7003.20	4607		

* $p < .05$
*** $p < .001$

TABLE 12

Analyses of variance on the peaks and pits of the "saw-tooth" function of the control condition

Source	SS	df	MS	F
Peaks:				
Subjects	365.08	143	2.55	2.47***
Trials (peaks)	5.08	7	0.73	0.70
Residual	1033.05	1001	1.03	
Total	1403.21	1151		
Pits:				
Subjects	427.94	143	2.99	2.54***
Trials (pits)	44.42	7	6.35	5.39***
Residual	1177.47	1001	1.18	
Total	1649.83	1151		

*** $p < .001$

TABLE 13

Analysis of variance on all pit-to-peak changes in the control condition

Source	SS	df	MS	F
Subjects	559.44	143	3.91	3.84***
Shifts	15.73	6	2.62	2.29*
Trials	638.83	1	638.83	549.06***
Subjects X Shifts	980.41	858	1.14	1.12*
Subjects X Trials	166.38	143	1.16	1.14*
Shifts X Trials	19.78	6	3.30	3.24**
Residual	873.31	858	1.02	
Total	3253.88	2015		

* $p < .05$
** $p < .01$
*** $p < .001$

APPENDIX B

Analyses of Variance on the Experimental Condition

TABLE 14

Analysis of variance on all trials of the experimental condition

Source	SS	df	MS	F
Subjects	1244.88	143	8.71	7.16***
Blocks	153.74	7	21.96	21.44***
Trials (within-blocks)	572.38	3	190.79	159.27***
Subjects X Blocks	1025.18	1001	1.02	0.84
Subjects X Trials	513.91	429	1.20	0.99
Blocks X Trials	95.01	21	4.52	3.72***
Residual	3650.88	3003	1.22	
Total	7255.96	4607		

*** $p < .001$

TABLE 15

Analyses of variance on the _peaks_ and _pits_ of the "saw-tooth" function of the experimental condition

Source	SS	df	MS	F
Peaks:				
Subjects	468.71	143	3.28	3.15***
Trials (peaks)	111.39	7	15.91	15.22***
Residual	1046.60	1001	1.05	
Total	1626.70	1151		
Pits:				
Subjects	402.36	143	2.81	2.30***
Trials (pits)	24.80	7	3.54	2.89**
Residual	1225.29	1001	1.22	
Total	1652.46	1151		

** $p < .01$
*** $p < .001$

TABLE 16

Analysis of variance on all pit-to-peak changes in the experimental condition

Source	SS	df	MS	F
Subjects	616.43	143	4.31	3.99***
Shifts	42.71	6	7.12	6.13***
Trials	405.26	1	405.26	354.55***
Subjects X Shifts	996.15	858	1.16	1.08
Subjects X Trials	163.45	143	1.14	1.06
Shifts X Trials	82.22	6	13.70	12.70***
Residual	925.83	858	1.08	
Total	3232.05	2015		

*** $p < .001$

APPENDIX C

Analyses of Variance Comparing Both Treatment Conditions

TABLE 17

Analysis of variance on all trials of both treatment conditions

Source	SS	df	MS	F
Treatments	0.43	1	0.43	0.38
Subjects	1285.75	143	8.99	8.01***
Blocks	106.91	7	15.27	14.07***
Trials (within-blocks)	1388.45	3	462.82	355.54***
Treatments X Subjects	848.75	143	5.94	5.29***
Treatments X Blocks	97.83	7	13.98	14.26***
Treatments X Trials	12.52	3	4.17	3.29*
Subjects X Blocks	1086.82	1001	1.09	0.97
Subjects X Trials	558.45	429	1.30	1.16
Blocks X Trials	118.59	21	5.65	4.45***
Treatments X Subjects X Blocks	981.12	1001	0.98	0.87
Treatments X Subjects X Trials	544.87	429	1.27	1.13
Treatments X Blocks X Trials	41.01	21	1.95	1.74*
Subjects X Blocks X Trials	3813.88	3003	1.27	1.13*
Residual	3370.33	3003	1.12	
Total	14255.69	9215		

* $p < .05$
*** $p < .001$

TABLE 18

Analysis of variance on Blocks 4, 6, and 8 of both treatment conditions

Source	SS	df	MS	F
Treatments	51.52	1	51.52	45.57***
Subjects	608.11	143	4.25	3.76***
Blocks	18.47	2	9.24	9.09***
Trials (within-blocks)	312.63	3	104.21	83.39***
Treatments X Subjects	445.56	143	3.12	2.76***
Treatments X Blocks	2.68	2	1.34	1.71
Treatments X Trials	34.45	3	11.48	8.19***
Subjects X Blocks	290.61	286	1.02	0.90
Subjects X Trials	536.12	429	1.25	1.11
Blocks X Trials	5.29	6	0.88	0.71
Treatments X Subjects X Blocks	224.74	286	0.79	0.70
Treatments X Subjects X Trials	601.14	429	1.40	1.24**
Treatments X Blocks X Trials	9.56	6	1.59	1.41
Subjects X Blocks X Trials	1065.96	858	1.24	1.10*
Residual	969.98	858	1.13	
Total	5176.81	3455		

* $p < .05$
** $p < .01$
*** $p < .001$

TABLE 19

Analyses of variance on the peaks and pits of both treatment conditions

Source	SS	df	MS	F
Peaks:				
Treatments	10.97	1	10.97	11.03***
Subjects	470.32	143	3.29	3.31***
Trials (peaks)	46.70	7	6.67	6.16***
Treatments X Subjects	363.47	143	2.54	2.55***
Treatments X Trials	69.78	7	9.97	10.02***
Subjects X Trials	1083.62	1001	1.08	1.09*
Residual	995.89	1001	0.99	
Total	3040.73	2303		
Pits:				
Treatments	1.00	1	1.00	0.85
Subjects	510.68	143	3.57	3.02***
Trials (pits)	56.84	7	8.12	6.66***
Treatments X Subjects	319.63	143	2.24	1.89***
Treatments X Trials	12.38	7	1.77	1.50
Subjects X Trials	1220.03	1001	1.22	1.03
Residual	1182.77	1001	1.18	
Total	3303.33	2303		

* $p < .05$
*** $p < .001$

TABLE 20

Analysis of variance on all pit-to-peak changes for both treatment conditions

Source	SS	df	MS	F
Treatments	2.63	1	2.63	2.55
Subjects	690.67	143	4.83	4.68***
Shifts	42.55	6	7.09	6.00***
Trials	1030.76	1	1030.76	911.94***
Treatments X Subjects	485.19	143	3.39	3.28***
Treatments X Shifts	15.90	6	2.65	2.36*
Treatments X Trials	13.35	1	13.35	11.35***
Subjects X Shifts	1013.53	858	1.18	1.14*
Subjects X Trials	161.63	143	1.13	1.09
Shifts X Trials	40.84	6	6.81	6.41***
Treatments X Subjects X Shifts	963.03	858	1.12	1.09
Treatments X Subjects X Trials	168.19	143	1.18	1.14
Treatments X Shifts X Trials	61.14	6	10.19	9.86***
Subjects X Shifts X Trials	910.51	858	1.06	1.03
Residual	886.30	858	1.03	
Total	6486.21	4031		

* $p < .05$
*** $p < .001$

TABLE 21

Analyses of variance comparing each pit-to-peak change of both treatment conditions

Source	SS	df	MS	F
Shift number 1:				
Treatments	0.00	1	0.00	0.00
Subjects	230.46	143	1.61	1.82***
Trials	260.01	1	260.01	253.38***
Treatments X Subjects	191.75	143	1.34	1.51*
Treatments X Trials	0.77	1	0.77	0.86
Subjects X Trials	146.74	143	1.03	1.16
Residual	126.94	143	0.89	
Total	956.66	575		
Shift number 2:				
Treatments	0.56	1	0.56	0.52
Subjects	250.97	143	1.76	1.63**
Trials	171.17	1	171.17	163.37***
Treatments X Subjects	205.44	143	1.44	1.33
Treatments X Trials	4.00	1	4.00	3.72
Subjects X Trials	149.83	143	1.05	0.97
Residual	153.94	143	1.08	
Total	935.91	575		

TABLE 21 (continued)

Source	SS	df	MS	F
Shift number 3:				
Treatments	7.56	1	7.56	7.10**
Subjects	281.31	143	1.97	1.85***
Trials	93.44	1	93.44	95.07***
Treatments X Subjects	179.44	143	1.25	1.18
Treatments X Trials	22.56	1	22.56	21.17***
Subjects X Trials	140.56	143	0.98	0.92
Residual	152.38	143	1.07	
Total	877.25	575		
Shift number 4:				
Treatments	0.14	1	0.14	0.14
Subjects	220.96	143	1.55	1.55**
Trials	194.83	1	194.83	156.59***
Treatments X Subjects	191.61	143	1.34	1.35*
Treatments X Trials	4.52	1	4.52	4.54*
Subjects X Trials	177.92	143	1.24	1.25
Residual	142.16	143	0.99	
Total	932.13	575		

TABLE 21 (continued)

Source	SS	df	MS	F
Shift number 5:				
Treatments	3.67	1	3.67	3.17
Subjects	233.16	143	1.63	1.41*
Trials	124.69	1	124.69	130.81***
Treatments X Subjects	234.33	143	1.64	1.41*
Treatments X Trials	32.11	1	32.11	27.69***
Subjects X Trials	136.31	143	0.95	0.82
Residual	165.83	143	1.16	
Total	930.11	575		
Shift number 6:				
Treatments	1.89	1	1.89	1.80
Subjects	215.21	143	1.50	1.43*
Trials	155.21	1	155.21	155.70***
Treatments X Subjects	201.86	143	1.41	1.34
Treatments X Trials	0.50	1	0.50	0.48
Subjects X Trials	142.54	143	1.00	0.95
Residual	150.17	143	1.05	
Total	867.38	575		

TABLE 21 (continued)

Source	SS	df	MS	F
Shift number 7:				
Treatments	4.69	1	4.69	4.06*
Subjects	272.14	143	1.90	1.65**
Trials	72.25	1	72.25	57.96***
Treatments X Subjects	243.81	143	1.70	1.47*
Treatments X Trials	10.03	1	10.03	8.67**
Subjects X Trials	178.25	143	1.25	1.08
Residual	165.42	143	1.16	
Total	946.59	575		

* $p < .05$
** $p < .01$
*** $p < .001$

TABLE 22

Analyses of variance on the mean block performance of both treatment conditions

Source	SS	df	MS	F
Blocks 1, 3, 5 and 7 only:				
Treatments	157.53	1	157.53	36.22***
Subjects	2679.90	143	18.74	4.31***
Blocks	291.29	3	97.10	20.15***
Treatments X Subjects	1891.23	143	13.23	3.04***
Treatments X Blocks	15.16	3	5.05	1.16
Subjects X Blocks	2067.46	429	4.82	1.11
Residual	1865.82	429	4.35	
Total	8968.39	1151		
Blocks 2, 4, 6 and 8 only:				
Treatments	180.50	1	180.50	47.94***
Subjects	2807.72	143	19.63	5.21***
Blocks	86.77	3	28.92	6.52***
Treatments X Subjects	2018.50	143	14.12	3.75***
Treatments X Blocks	33.47	3	11.16	2.96*
Subjects X Blocks	1903.73	429	4.44	1.18*
Residual	1615.38	429	3.77	
Total	8646.06	1151		

* $p < .05$
*** $p < .001$

APPENDIX D

TABLE 23

Analysis of variance on the counterbalancing

Source	SS	df	MS	F
Treatments (TMTS)	0.43	1	0.43	0.40
Replications (Subjects) (REPL)	87.22	2	43.61	40.67***
Within-block Order (WBO)	10.59	3	3.53	3.29*
Between-block Order (BBO)	32.50	3	10.83	10.10***
Category (CAT)	28.38	2	14.19	13.23***
Trials (TRLS)	1613.95	31	52.06	28.77***
TMTS X REPL	3.81	2	1.90	1.78
TMTS X WBO	20.97	3	6.99	6.52***
TMTS X BBO	1.70	3	0.57	0.53
TMTS X CAT	73.59	2	36.80	34.31***
TMTS X TRLS	151.36	31	4.88	3.71***
REPL X WBO	41.79	6	6.97	6.50***
REPL X BBO	66.43	6	11.07	10.32***
REPL X CAT	31.93	4	7.98	7.44***
REPL X TRLS	112.20	62	1.81	1.69***
WBO X BBO	68.07	9	7.56	7.05***
WBO X CAT	33.51	6	5.58	5.21***
WBO X TRLS	283.88	93	3.05	1.32
BBO X CAT	38.03	6	6.34	5.91***
BBO X TRLS	103.47	93	1.11	1.09
CAT X TRLS	110.52	62	1.78	1.71**
TMTS X REPL X WBO	13.72	6	2.29	2.13*
TMTS X REPL X BBO	15.89	6	2.65	2.47*
TMTS X REPL X CAT	20.02	4	5.00	4.67***
TMTS X REPL X TRLS	81.55	62	1.32	1.31

TABLE 23 (continued)

Source	SS	df	MS	F
TMTS X BBO X CAT	81.10	6	13.52	12.60***
TMTS X BBO X TRLS	89.12	93	0.96	0.87
TMTS X CAT X TRLS	94.08	62	1.52	2.02***
REPL X WBO X BBO	215.24	18	11.96	11.15***
REPL X WBO X CAT	93.69	12	7.81	7.28***
REPL X WBO X TRLS	428.83	186	2.31	2.15***
REPL X BBO X CAT	62.61	12	5.22	4.87***
REPL X BBO X TRLS	189.78	186	1.02	0.95
REPL X CAT X TRLS	128.67	124	1.04	0.97
WBO X BBO X CAT	163.48	18	9.08	8.47***
WBO X BBO X TRLS	350.16	279	1.26	1.22
WBO X CAT X TRLS	237.06	186	1.27	1.10
BBO X CAT X TRLS	194.45	186	1.05	1.00
TMTS X REPL X WBO X BBO	104.36	18	5.80	5.41***
TMTS X REPL X WBO X CAT	67.53	12	5.63	5.25**
TMTS X REPL X WBO X TRLS	203.78	186	1.10	1.02
TMTS X REPL X BBO X CAT	51.93	12	4.33	4.04***
TMTS X REPL X BBO X TRLS	204.19	186	1.10	1.02
TMTS X REPL X CAT X TRLS	93.20	124	0.75	0.70
TMTS X WBO X BBO X CAT	44.14	18	2.45	2.29**
TMTS X WBO X BBO X TRLS	354.88	279	1.27	1.10
TMTS X WBO X CAT X TRLS	163.15	186	0.88	0.79
TMTS X BBO X CAT X TRLS	206.58	186	1.11	1.16
REPL X WBO X BBO X CAT	312.29	36	8.67	8.09***
REPL X WBO X BBO X TRLS	572.40	558	1.03	0.96
REPL X WBO X CAT X TRLS	432.26	372	1.16	1.08
REPL X BBO X CAT X TRLS	394.09	372	1.06	0.99
WBO X BBO X CAT X TRLS	663.79	558	1.19	1.06
TMTS X REPL X WBO X BBO X CAT	222.42	36	6.17	5.76**

TABLE 23 (continued)

Source	SS	df	MS	F
TMTS X REPL X WBO X BBO X TRLS	646.61	558	1.16	1.08
TMTS X REPL X WBO X CAT X TRLS	411.31	372	1.11	1.08
TMTS X REPL X BBO X CAT X TRLS	356.33	372	0.96	0.89
TMTS X WBO X BBO X CAT X TRLS	664.29	558	1.19	1.11*
REPL X WBO X BBO X CAT X TRLS	1257.60	1116	1.13	1.05
Residual	1196.75	1116	1.07	
Total	14255.69	9215		

* $p < .05$
** $p < .01$
*** $p < .001$

APPENDIX E

Analysis of Variance on Errors

TABLE 24

Analysis of variance on omissions comparing the repetition and nonrepetition blocks

Source	SS	df	MS	F
Subjects	6084.49	143	42.55	5.44***
Treatments	64.67	1	64.67	8.26**
Blocks	388.39	1	388.39	28.94***
Subjects X Treatments	5013.09	143	35.06	4.48***
Subjects X Blocks	1919.37	143	13.42	1.71***
Treatments X Blocks	2.40	1	2.40	0.31
Residual	1119.46	143	7.83	
Total	14591.86	575		

** $p < .01$
*** $p < .001$

TABLE 25

Analysis of variance on intrusions comparing the repetition and nonrepetition blocks

Source	SS	df	MS	F
Subjects	1531.99	143	10.71	3.01***
Treatments	1.00	1	1.00	0.28
Blocks	1.78	1	1.78	0.48
Subjects X Treatments	1400.00	143	9.79	2.75***
Subjects X Blocks	526.22	143	3.68	1.03
Treatments X Blocks	15.34	1	15.34	4.30*
Residual	509.60	143	3.56	
Total	3985.93	575		

* $p < .05$
*** $p < .001$

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