THE EFFECTS OF PRONOUNCIABILITY, REHEARSAL, AND INTERFERENCE IN SHORT-TERM MEMORY WITH ACQUISITION CONTROLLED

By

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PREFACE

I would like to express my appreciation to a number of people who have helped make this study possible. A very large debt is owed to Dr. Robert F. Stanners who gave generously of his time and knowledge as thesis adviser. His capabilities as a teacher and scientist are held in the highest regard. Acknowledgment is also due the other members of my committee, Dr. Robert J. Weber and Dr. Thaddeus M. Cowan, for the encouragement and many helpful criticisms they provided. Finally, I would like to thank my wife Jo Ann and children Jeff and John for their patience and understanding throughout the duration of this study.

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CHAPTER I

INTRODUCTION

Although memory as a subject for investigation has had a relatively long and stable degree of popularity among experimental psychologists the specific study of retention over short time periods has just recently enjoyed a resurgence of interest. A study by Peterson and Peterson (1959) seems most responsible for the revitalized interest and many experiments on short-term memory. These investigators presented a single consonant trigram to their subjects for a brief study period and then asked the subject to recall that item after a specified number of seconds which were filled by an interference task. Despite the fact that each item was easily within the subject's immediate memory span the items were rapidly forgotten.

The present investigation is designed to shed further light on the processes of short-term memory.

Review of the Literature

With but few exceptions (Houston, 1965; Underwood and Richardson, 1956) most investigators of memory have not controlled for the level of acquisition in their studies. Waugh and Norman (1965) have recently implied a functional differentiation of acquisition and memory which may aid other investigators in determining the precise nature of each of these processes. They presented subjects with lists of 16 single digits in each of which the last digit had occurred at some point earlier in the sequence. On its second appearance this "probe-digit" was the cue for recall of the digit that had followed it initially. Digits were read at a constant rate of either one or four seconds and rehearsal was controlled by instructions to the subject to rehearse only the last digit heard and not any earlier ones. Waugh and Norman found that when rehearsal was not permitted, recall was independent of rate of presentation; that is, with no rehearsal, material was rapidly lost regardless of the rate at which it had been presented. This rapid rate of forgetting is in contrast to the results of the usual verbal learning experiment in which rehearsal is not controlled. The investigators state:

> It is almost as though rehearsal transferred a recently perceived verbal item from one memory store of very limited capacity to another more commodious store from which it can be retrieved at a much later time. (Waugh and Norman, 1965, p. 92.)

Terming the first store primary memory (PM) and the second store secondary memory (SM), Waugh and Norman hypothesize that rehearsal is necessary to retain items in PM and transfer them into the longer-lasting SM. Waugh and Norman provide some evidence for the two phases of memory by demonstrating how predictions from this interpretation would fit the results of selected free recall, paired-associate, and short-term memory studies. Norman (1966) utilized the probe-digit method and manipulated rate and type of presentation, length of list, type of item, and the method of testing for retention in an attempt to untangle the processes of memory and acquisition. His results suggested that memory was dependent only upon the number of items presented between the critical item and its test but acquisition was sensitive to the rate of presentation and length of the list. Another approach to these problems is to bring two different types of material to a common level of performance at a zero-second retention interval and to observe the performance under two different conditions (interference and delay followed by interference). Differential performance would indicate two different "states" of the material and thus different types of memory. The specific performance effects would provide information on the nature of these processes.

A distinction between acquisition and memory may aid in the understanding of other phenomena. One such related process is that of encoding. Presumably, before an item may be rehearsed it must be chunked (Miller, 1956), or encoded, into a form optimal for rehearsal (Aaronson, 1967). That this encoding may be sensitive to acoustic cues is suggested by various studies. Perhaps the acoustic confusions found by Conrad (1965) and Wicklegren (1965) were produced during the rehearsal of acoustically encoded items. Gorfein and Stone (1967) found that when syllables were presented for a duration corresponding to their individual pronounciation latencies rather than for the mean latency of all items, recall performance for the difficult-to-pronounce items was facilitated. It might be suggested that the standard time did not allow for sufficient encoding of the difficult-to-pronounce items. The very powerful effects of pronounciability in rote learning experiments (Underwood and Schulz, 1960) would also seem to suggest encoding along acoustic lines. Clearly, an attempt to uncover the relation between acquisition and encoding, acoustic or otherwise, does seem in order.

Once acquisition is controlled, another interesting question arises, namely, are there any other variables which may affect memory?

The results of many investigations of which Peterson and Peterson, 1959, and Murdock, 1961, are examples which tend to indicate that rehearsal and interference may be very important in a short-term memory task. Hellyer (1962) has demonstrated that retention loss is inversely related to rehearsal time. Positive effects of pronouncing have been noted in an incidental learning task (Mechanic, 1962, 1964, 1966) and in discrimination learning (Carmean and Weir, 1967). Waugh and Norman (1965) and Norman (1966) contend that rehearsal is needed to retain items in primary memory and transfer them to secondary memory. Sperling (1966) noted the importance of a rehearsal component for a model of short-term memory and included such a component based upon acoustic cues in his model. He proposed that acoustic confusions are produced during rehearsal. The amount of time that rehearsal is prevented before recall also has been repeatedly demonstrated to be related to the decrement in recall (Neimark, Greenhouse, Law, and Weinheimer, 1965) although the precise cause of this loss is not fully understood (Adams, 1967). A direct attack upon the relationship between acquisition, rehearsal, and rehearsal-prevention (interference) seems warranted.

Statement of the Problem

The intent of this study was two-fold: (1) to provide indications of where pr. has its effects in verbal learning, i.e., is it important in acquisition or memory, or in both; and (2) to determine the function of rehearsal in the retention of verbal items and any additional variables which may interact with rehearsal when the level of acquisition is controlled. Main effects in the analysis were not considered of primary interest because all, with the exception of rehearsal, had been rather thoroughly investigated. However, some of the interactions were felt to be potentially extremely informative, e.g., would rehearsal have a stabilizing effect on memory over intervals suggesting that rehearsal might provide the encoding for the long term memory store? Would there be a differential effect of pr. over rehearsal levels suggesting that rehearsal may be sensitive to acoustic cues. And would there be differential degrees of forgetting for items varying in pr. when acquisition was controlled?

CHAPTER II

METHOD

Subjects

The subjects were 144 students taken from introductory psychology classes at Oklahoma State University.

Materials

Three-letter units of varying difficulty of pronounciability were used because of their obvious acoustic properties. Items were drawn from a pool of 293 3-letter units scaled for pronounciability (pr.) by Underwood and Schulz (1960). They were rank-ordered according to pr. value and the median item discarded leaving 119 high pr. (easy to pronounce) items and 119 low pr. (difficult to pronounce) items. The last two items for each of these groups were also discarded. Thirty-nine slides, each containing three 3-letter units assembled in a left to right fashion with one space between units, were prepared from each set. The restrictions used in forming the slides were that no letter appeared more than once in the same position on any slide and that the average pr. values for the 39 slides of either group be minimized. Ten slides were selected from each group which were representative of the range of mean pr. values within the group. These 20 slides were set aside for use in the determination of the exposure times for the retention tests. Five further slides were discarded from each group bringing the number of slides per group to 24, a convenient value for counterbalancing purposes. The range of average pr. values in the high pr. group was 2.46 - 2.93; the corresponding range for the low pr. group was 6.06 - 6.46. All such slides which appeared in the experiment are presented in Appendix A.

Twenty-four additional slides each with a randomly selected 3-digit number were also prepared.

Experimental Design

The design had two between-Ss factors, one at two levels (high or low pr.) and one at three levels (amount of rehearsal--0, 5, or 10 sec.), and one within-Ss factor (amount of interference--0, 5, or 10 sec.). Seventy-two subjects were assigned to each level of pr. and each of these groups was divided into the three levels of rehearsal containing twenty-four subjects each.

Procedure

All slides were back-projected onto a 12" by 12" plexi-glass screen to a height of 1½" by dual Kodak Carousel projectors. The S was seated 36 inches in front of the screen. A Lafayette 8-bank timer (Model 1431A) was used to program the projectors.

In the initial portion of the experimental session (pretesting) the exposure time to be used on the subsequent retention trials was determined for each S. The materials were the 10 slides previously selected as being representative of the particular pr. group. A red pilot lamp mounted below the screen was used to signal the beginning of recall and came on with the offset of each slide. The screen was illuminated both preceding and following the presentation of a slide. The S was instructed to write his recall on a scoring sheet with spaces corresponding to the spatial arrangement of the slide. The intertrial interval was 30 sec. which has previously been found to reduce proactive inhibition (Loess and Waugh, 1967). All Ss were given 10 trials regardless of how quickly the exposure time corresponding to the criterion value (6-8 letters correct) was established. The exposure time resulting in the criterion was used in the second portion of the experiment. Assignment of a subject to a level of pr. was done on an alternating basis and assignment to one of the three conditions within each level was done on a cyclical basis in the order of appearance at the laboratory.

In the second phase of the session (testing) each slide was followed by a rehearsal period of 0, 5, or 10 sec. depending upon the condition to which the subject had been assigned. During the rehearsal period the screen was blank. The S was uninstructed regarding the rehearsal period. This period was followed in turn by either 0, 5, or 10 sec. of a Peterson and Peterson (1959) type of interference task. During the interference period the S was instructed to say aloud a 3-digit number which was presented on the screen for a 1-sec. interval and then to count backwards by threes in time with a white pilot lamp which flashed at a 0.75-sec. rate. The onset of the red lamp occurred with the offset of the white lamp and signalled the beginning of the recall period. Counterbalancing consisted of each slide occurring equally often in each of the 24 serial positions, in each rehearsal period, and at each level of interference. Six different orders of interference (counting) levels were used.

CHAPTER III

RESULTS

The stimulus presentation time allowed each subject is presented as Appendix B. An analysis-of-variance on the mean time for each condition (Table I) demonstrates that acquisition times are significantly different only over levels of pr. ($p < .001$). In order to determine if there were any significant performance differences between groups at a 0-sec. level of rehearsal period an analysis-of-variance was carried out on the mean performance of the last three pretesting trials for each subject. This analysis is presented as Table II. No significant effects were found in the analysis indicating that all groups of subjects had been brought to an equal level of performance. The .05 level was adapted as the minimal level for an effect to be considered significant in all statistical analyses.

The main analysis (Table III) was an analysis-of-variance performed on the mean number of correct responses for each subject at each condition. A correct response was defined as the correct letter in the proper position. The main effects for rehearsal and counting were both significant ($p < .001$); as indicated in Figure 1, mean performance improved with rehearsal and decreased with counting. All simple interactions were also significant ($p < .001$).

Tests, reported in Table IV, were made on the main effects of rehearsal and counting by the Neuman-Kuels procedure (Winer, 1962).

TABLE I

ANALYSIS-OF-VARIANCE ON STIMULUS PRESENTATION TIMES

Source	df	SS	MS	F
Total	143	1038.10		
Pronounciability (P)	1	925.63	925.63	1142.75 ($p < .001$)
Rehearsal (R)	2	0.74	0.37	0.46
PxR	2	0.44	0.22	0.27
Error	138	111.29	0.81	

TABLE II

ANALYSIS-OF-VARIANCE OF PERFORMANCE ON LAST THREE PRETESTING TRIALS

Source	df	SS	MS	F
Total	143	83.74		
Pronounciability (P)	1	0.01	0.01	0.02
Rehearsal (R)	2	1.56	0.78	1.32
PxR	2	0.33	0.17	0.28
Error	138	81.84	0.59	

TABLE III

MAIN ANALYSIS-OF-VARIANCE

Source	df	SS	MS	F	
Total	431	1519.0			
Between Ss	143	577.81			
P	1	7.34	7.34	3.205	
R	2	188.60	94.30	41.18	(p <.001)
PxR	2	65.66	32.83	14.34	(p <.001)
Error (between)	138	316.21	2.29		
Within Ss	288	941.19			
Counting	2	691.75	345.88	488.52	(p <.001)
RC	4	42.70	10.68	15.08	(p <.001)
PC	2	5.37	2.69	3.79	(p <.001)
PRC	4	5.96	1.49	2.11	
Error (within)	276	195.41	.71		

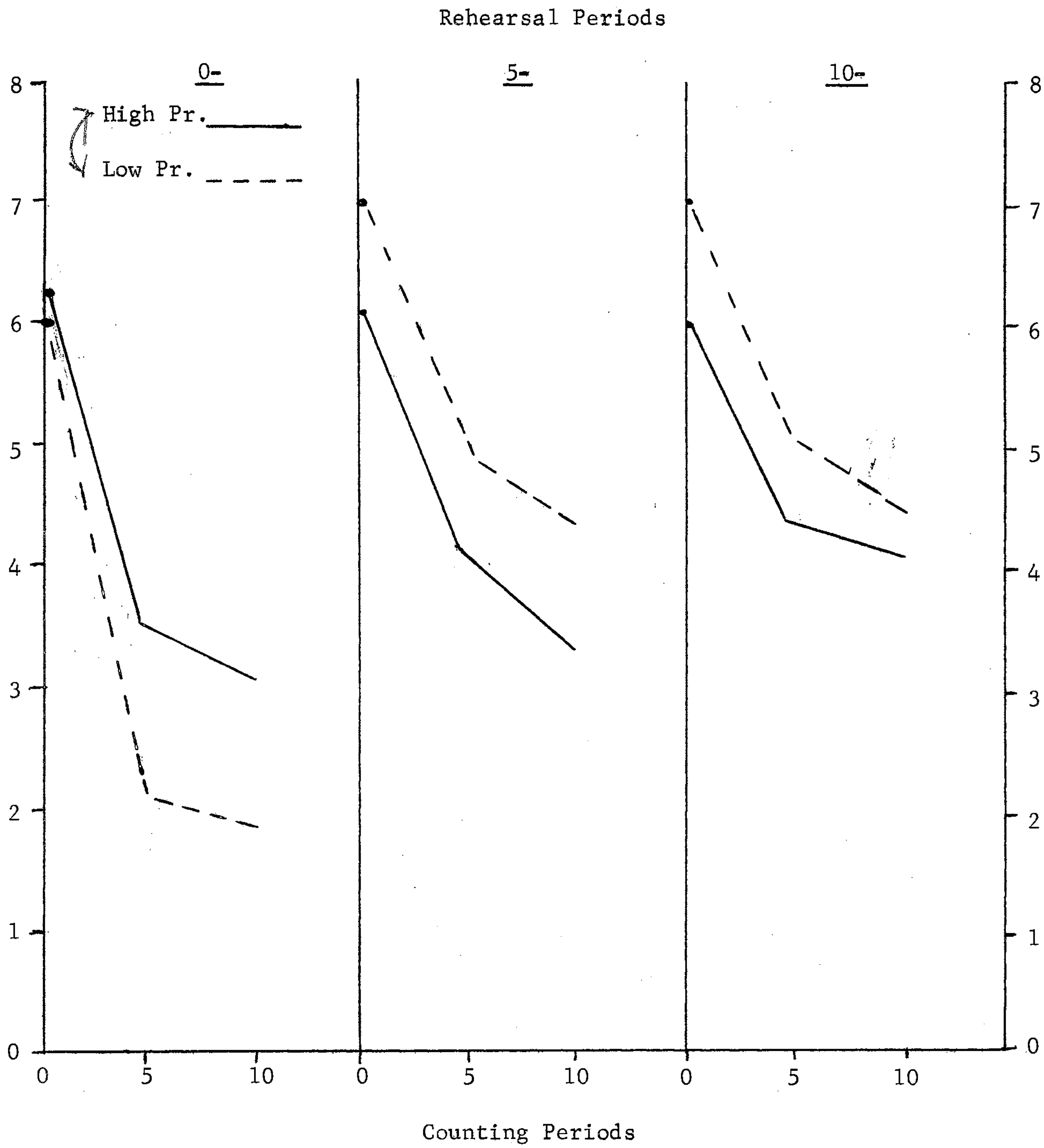

Figure 1. Retention Curves for each Level of Pronounciability at each Rehearsal Period

TABLE IV

TESTS ON REHEARSAL AND COUNTING MAIN EFFECTS
USING NEUMAN-KUELS PROCEDURE

	Rehearsal Levels		
	0	5	10
Totals	536.78	716.32	755.24
536.78		9.88*	12.02*
716.32			2.14
755.24			

	Counting Levels		
	0	5	10
Totals	924.23	575.52	508.59
924.23		34.49*	41.01*
575.52			6.62*
508.59			

* Significant difference at $p < .001$

The 5- and 10-sec. levels of rehearsal were not different but both were significantly different from the 0-sec. condition ($p < .001$). All comparisons on levels of counting were significantly different ($p < .001$).

In order to gain purchase on the pr. by rehearsal interaction two separate analyses-of-variance were performed on the data considering rehearsal at 0- and 5-sec. in the first analysis and at 5- and 10-sec. in the second (Table V). The pr. by rehearsal interaction is significant only in the first analysis ($p < .001$) indicating that rehearsal has differential effects over pr. levels when rehearsal is considered at short intervals. The significant three-factor interaction in the first analysis ($p < .001$) indicates a differential flattening of the two retention curves over 0- and 5-sec. of rehearsal; that is, the curve for high pr. materials becomes flatter after 5-sec. of rehearsal than does the low pr. curve. These curves are presented in Figure 1.

Additional information concerning the significant rehearsal by counting interaction in Table III is presented as Figure 2. By collapsing over levels of pr. it becomes apparent that the curves at 5- and 10-sec. of rehearsal are more similar to one another than to the 0-sec. curve. Statistical confirmation of this relationship is provided by Table V. With rehearsal at the 0- and 5-sec. levels of significant rehearsal by counting interaction is found ($p < .001$) but with rehearsal considered at the 5- and 10-sec. levels no such interaction appears. Table VI demonstrates, however, that the effects of rehearsal on the retention curves are similar for both levels of pr. when rehearsal is considered at all three levels. In this table a significant rehearsal by counting interaction was found for both high pr. items ($p < .001$) and

TABLE V

ANALYSIS-OF-VARIANCE ON DATA AT 0-5 SECONDS
AND 5-10-SECONDS REHEARSAL

		0-5 sec. Rehearsal			5-10 sec. Rehearsal		
Source	df	SS	MS	F	SS	MS	F
Total	287	1078.83			769.53		
Between Ss	95	375.14			264.15		
P	1	0.15	0.15	0.07	46.98	46.98	20.53 ($p < .001$)
R	1	111.93	111.93	49.75 ($p < .001$)	5.26	5.26	2.30
PxR	1	56.53	56.53	25.12 ($p < .001$)	1.00	1.10	0.40
Error (Between)	92	207.23	2.25		210.91	2.29	
Within Ss	192	703.69			505.12		
C	2	578.36	289.18	573.70 ($p < .001$)	321.94	160.97	167.68 ($p < .001$)
PxC	2	4.28	2.14	4.17 ($p < .025$)	0.73	0.37	0.39
RxC	2	22.75	11.38	22.18 ($p < .001$)	2.31	1.16	1.21
PxRxC	2	3.75	1.88	3.65 ($p < .05$)	2.81	1.14	1.47
Error (Between)	184	94.55	0.51		177.33	0.96	

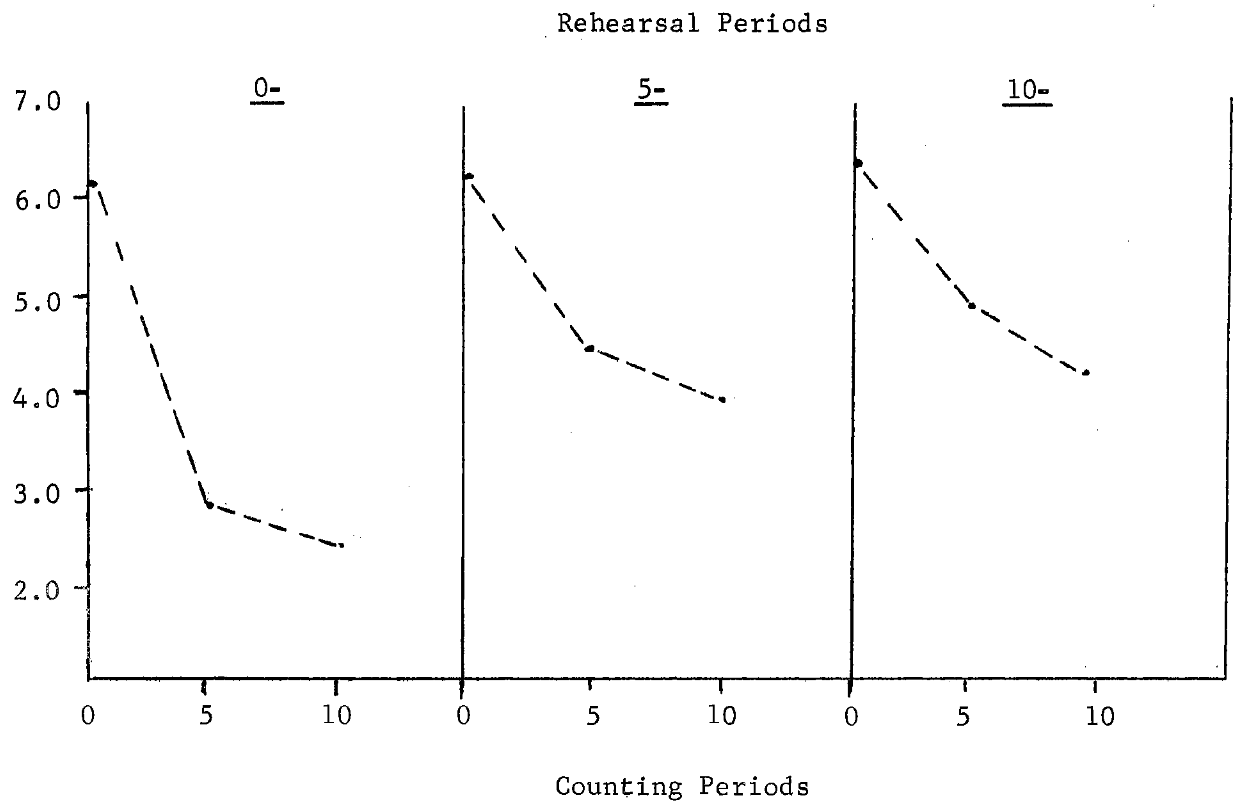

Figure 2. Retention Curves Collapsed over Pronounciability Levels.

TABLE VI

ANALYSIS-OF-VARIANCE OF REHEARSAL AND COUNTING
AT EACH LEVEL OF PRONOUNCIABILITY

Source	df	SS	MS	F
Hi Pr.				
Total	215	891.91		
Between Ss	71	384.94		
R	2	283.72	141.66	64.66 (p <.001)
Error (between)	69	151.22	2.19	
Within Ss	144	506.97		
C	2	407.08	203.54	424.04 (p <.001)
RxC	4	34.01	8.53	17.77 (p <.001)
Error (within)	138	65.88	0.48	
Lo Pr.				
Total	215	644.43		
Between Ss	71	185.53		
R	2	20.55	10.28	4.30 (p <.025)
Error (between)	69	164.98	2.39	
Within Ss	144	458.90		
C	2	290.05	145.03	129.49 (p <.001)
RxC	4	14.24	3.56	3.17 (p <.025)
Error (within)	138	154.61	1.12	

low pr. items ($\underline{p} < .025$). Other significant effects in these tables would be predicted from preceeding analyses.

Reference to Figure 1 helps clarify the significant pr. by counting interaction in the main analysis. Seemingly, there is a differential rate of decline for the two pr. curves only at the 0-sec. rehearsal level. An analysis-of-variance performed at each level of rehearsal (Table VII) provides statistical evidence for this observation as the pr. by counting interaction is significant only at the 0-sec. rehearsal level ($\underline{p} < .001$).

TABLE VII

ANALYSIS-OF-VARIANCE ON PRONOUNCIABILITY AND COUNTING AT EACH LEVEL OF REHEARSAL

		0 Rehearsal			5 Rehearsal			10 Rehearsal		
Source	df	SS	MS	F	SS	MS	F	SS	MS	F
Total	143	590.07			376.84			387.45		
Between *Ss*	47	130.32			132.90			126.00		
P	1	25.02	25.02	10.73 ($p < .001$)	30.86	30.86	13.90 ($p < .001$)	17.13	17.13	7.23 ($p < .001$)
Error (between)	46	105.30	2.29		102.04	2.22		108.87	2.37	
Within *Ss*	96	459.75			243.94			261.45		
C	2	409.94	204.97	455.49 ($p < .001$)	190.57	95.29	168.65 ($p < .001$)	133.94	66.92	48.88 ($p < .001$)
PC	2	8.05	4.03	8.96 ($p < .001$)	1.39	.69	1.23	1.89	.95	.690
Error (within)	92	41.76	.45		51.98	.56		125.62	1.37	

CHAPTER IV

DISCUSSION

Pronounciability was an important factor in the stimulus presentation times required to bring all Ss to a similar level of acquisition. Ss viewing high pr. materials required much less time to reach this level than did Ss viewing low pr. items.

Once Ss had been brought to equal levels of initial performance all succeeding changes in performance were uncontaminated by the acquisition process, i.e., all following performance differences were indications of retentive processes. With 0-sec. of rehearsal the two retention curves diverge across counting intervals, but when 5- and 10-sec. of rehearsal are allowed, not only is this divergence inhibited but, the position of the curves, relative to one another, is reversed (Figure 1). The low pr. items were more resistant to forgetting at a 0-sec. rehearsal period than were the high pr. items. When rehearsal was allowed this relationship was reversed. One possible explanation for these results is provided by the findings of other experiments. Sperling (1966) and Waugh and Norman (1965) have proposed a two-stage conception of memory. These writers suggest that items are transferred from a short, fragile store to a longer more stable memory store by rehearsal. Laughery and Pincus (1968) have suggested that the facilitative effect of pronounciability in short-term memory is due to the greater efficiency of rehearsal with high pr. items, i.e., the higher the pronounciability of a item, the faster it can be pronounced, and the more rehearsal time per unit. Some support for this proposed relationship is provided by Gorfein and Stone (1967) and Newman and Williams (1967). The inference of Underwood and Schulz (1960), that the degree of pronounciability reflects the degree of integration of an item, implies that the relationship between rehearsal efficiency and pronounciability is found because high pr. items may be treated as single units rather than as three separate letters during rehearsal. Presumably, in the present study, low pr. Ss were able to rehearse when they were in sensory contact with the material due to their long presentation times. This rehearsal allowed transfer of some items into the more stable store and produced the unique relationship between the curves at 0-sec. rehearsal (Figure 1). When high pr. Ss were allowed rehearsal the retention curves were inverted because of the greater efficiency of rehearsal for the more integrated items, i.e., they were able to deposit more total letters into the second store during the rehearsal interval. An examination of recall performance for high pr. Ss at 0- and 5-sec. rehearsal with no counting gives additional support to this conception. Test by means of the Neuman-Kuels procedure (Winer, 1962, Chapter 3) indicates that recall after 5 sec. of rehearsal is significantly better than recall immediately following sensory contact ($q_{(1,67)} = 3.34$, $p < .05$). Again, it may be suggested that this "inverse forgetting" (Crawford, Hunt, and Peak, 1965) was produced by rehearsal which made the items less susceptible to forgetting during the recall process.

CHAPTER V

SUMMARY AND CONCLUSIONS

In the present experiment the performance effects of three variables--the rated degree of pronounciability (pr.) of the materials, the amount of rehearsal allowed, and the duration of a rehearsal-preventing activity (counting)--were evaluated in an attempt to better understand the processes of short-term memory. The rehearsal-preventing activity always took place after the S was out of sensory contact with the material. Recall performance improved with rehearsal but decreased with counting. Rehearsal raised the overall level of retention for high pr. material and flattened the retention curves for both types of material. When no rehearsal was allowed following sensory contact with the material the retention curve for high pr. items was lower than that for low pr. items. A conceptualization of memory was offered to account for the results. Briefly, it was hypothesized that memory consists of at least two stages, a short, fragile storage and a longer lasting and more stable storage. Rehearsal was proposed as the mechanism which "transports" items from the first to the second storage. Because rehearsal efficiency varies directly with pr. it was postulated that high pr. units may be put into the second storage more efficiently than low pr. items.

This conceptualization of memory helps to explain the very powerful effects of pr. in rote memory experiments (Underwood and Schulz, 1960).

Because high pr. materials benefit much more from equal amounts of rehearsal than do low pr. units one would expect them to be learned faster. In the present experiment Ss were able to enhance retention by rehearsing both while in sensory contact with the materials and after the items had been removed from this contact. That is, low pr. Ss were able to "transfer" some items into a stable storage during sensory contact, but once items were removed rehearsal efficiency was greatest for high pr. items.

Several studies are suggested by the results of this experiment. Differential effects of rehearsal over pr. levels were found when 5 sec. of rehearsal were allowed as compared to 0 sec. of rehearsal. An experiment allowing periods of rehearsal less than 5 sec. would be useful in clarifying the relationship between rehearsal and pr. For example, it may be found that only 3 sec. of rehearsal are needed to invert the relative position of the retention curves for differing pr. items as in Figure 1.

A study in which rehearsal is manipulated both before and after counting might give further indications of the role of rehearsal in retention and of the memory stores. Specifically, a study of this general design would provide indications of the duration of the item's "trace" in the first storage and of whether items already in a stable storage might also be rehearsed.

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APPENDIX A

APPENDIX A

HIGH PR PRE-TEST SLIDES

Slide	Mean Pr	Slide	Mean Pr
MOP PIM CES	2.67	MEL ING JUS	2.53
ZED FUS MAN	2.53	KIX WAM PLO	2.82
HER BOT CHI	2.67	TIS VAN HAZ	2.67
WIF VAD PUS	2.76	SLO ZIN ROC	2.67
TUD DAP SOG	2.91	FEM HOB ENT	2.71

HIGH PR TEST SLIDES

FEN NOP MAK	2.69	COM URN TIV	2.71
MOG CUB JAD	2.71	CED HAT JOR	2.80
BUT ZAM WIS	2.66	MUL ART ROZ	2.60
DAL ITS ROX	2.91	ROP LAR KIM	2.64
CHA FIB SUK	2.70	ITE VOL CAT	2.66
EST BOY PIX	2.62	JUM DIR ELK	2.91
BAL HUM WHA	2.46	VOM SUL RAT	2.68
VAS WHO COU	2.77	VIT STI LOX	2.84
REL SUB DOK	2.59	FOC ISH GEL	2.84
FON HOB MEF	2.79	BLI FET PAR	2.50
SOM LED VIL	2.46	YIN REC STY	2.93
BON FRO HEG	2.60	ZON VIZ SUD	2.72

APPENDIX A
(Continued)

LOW PR PRE-TEST SLIDES

Slide	Mean Pr	Slide	Mean Pr
YOX VUF JPV	6.13	ROQ DYI ZJM	6.23
KNO RCE ZOQ	6.31	SOU TRC KBR	6.32
YAL WIH VGJ	6.11	BLE XAT ZQP	6.29
KIV ELK CQU	6.23	WUX ZOW YLV	6.27
YUK ZOJ IDW	6.26	WHE XET HFG	6.24

LOW PR TEST SLIDES

Slide	Mean Pr	Slide	Mean Pr
POH MPO DFL	6.10	QUE COH GVS	6.06
FAI CFL XPO	6.34	YIR WSE CKB	6.66
JOK WUQ MPT	6.43	LIR RCH MBE	6.37
JUX QOH NCE	6.46	UND QAZ WXY	6.14
ULD RAJ HTF	6.22	TID YUW MKB	6.31
ATI NIQ KBV	6.03	OMP UNH WFI	6.34
ZAV YOQ NDR	6.26	QAD GIH NDF	6.12
CAK MPA GHT	6.36	GUD CYR XIK	6.06
ZOX EIG TJU	6.12	BLE ABL XFH	6.17
IFO TUW EQR	6.16	OUS XOM VXK	6.08
DIH TLX XPL	6.42	GOI YUQ LZW	6.35
SCI XOL FJQ	6.11	BUV LTY NDE	6.34

APPENDIX B

APPENDIX B

PRE-TESTING TIMES

	High Pr			Low Pr		
	0 Reh.	5 Reh.	10 Reh.	0 Reh.	5 Reh.	10 Reh.
	.43	.43	.53	5.80	4.76	4.45
	.37	.31	.21	6.51	5.08	6.73
	.58	.23	.90	4.76	4.97	4.01
	.83	.63	.74	6.00	7.30	5.28
	.48	.31	.39	5.28	6.00	5.48
	.43	.93	.63	4.45	5.28	6.34
	.26	.49	.74	6.73	4.23	9.33
	.31	.53	.80	6.62	3.90	6.34
	.37	.34	.41	5.48	3.48	6.34
	.75	.75	.65	4.90	5.78	6.28
	.46	.65	.42	5.44	4.02	6.28
	.61	.33	.65	6.28	4.02	3.13
	.65	.56	.42	5.44	5.78	6.28
	.75	.29	.93	8.05	6.65	4.55
	.33	.42	.46	4.55	3.13	7.22
	.56	.29	.42	5.44	7.22	3.13
	.56	.75	.52	4.02	7.55	5.44
	.46	.33	.75	5.44	5.44	5.78
	.75	.42	.56	4.02	7.22	7.22
	.46	.46	.52	4.90	6.28	5.78
	.65	.46	.65	6.28	7.22	4.55
	.56	.70	.46	3.66	7.22	6.28
	.56	.75	.87	4.55	6.65	6.28
	.75	.65	.65	6.28	6.28	5.44
Totals	12.92	12.01	14.28	130.88	135.46	137.94
$\bar{x}$	.54	.50	.59	5.45	5.64	5.74
$\bar{X}$		.54			5.61	

VITA

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Master of Science

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