Delay in short term memory as a result of extended periods of rehearsal prevention

by Gregory Lee Bashor

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OE SCIENCE in Psychology
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Abstract:
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In this study a non-interfering rehearsal prevention task (signal in white noise) was used to prevent twelve college students (5 male and 7 female) from rehearsing a five consonant quintigram which was recalled at 8, 40, 60, or 120 seconds. In contrast to the Shiffrin study, subjects in this study demonstrated a decrease in recall performance at extended (60 and 120 seconds) retention periods. The results of this study were interpreted as support for Reitman's (1974) study which proposed the possibility that the lack of forgetting in Reitman (1971) and Shiffrin (1973) was due to a ceiling effect. It concluded that the results provided support for a model of short term memory that includes decay as well as interference as mechanisms of forgetting.

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GREGORY LEE BASHOR

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Approved:

M. Paul Willis
Chairperson, Graduate Committee

Robert A. Marsh
Head, Major Department

Henry L Parsons
Graduate Dean

MONTANA STATE UNIVERSITY
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ABSTRACT

This paper is concerned with a replication and extension of the methods of Shiffrin (1973) which investigated the cause of short term memory forgetting. In the Shiffrin publication subjects were found to be able to retain a short term store memory trace for 40 seconds. Shiffrin concluded that when rehearsal was prevented, short term memory loss was the result of interference only.

In this study a non-interfering rehearsal prevention task (signal in white noise) was used to prevent twelve college students (5 male and 7 female) from rehearsing a five consonant quintigram which was recalled at 8, 40, 60, or 120 seconds. In contrast to the Shiffrin study, subjects in this study demonstrated a decrease in recall performance at extended (60 and 120 seconds) retention periods. The results of this study were interpreted as support for Reitman's (1974) study which proposed the possibility that the lack of forgetting in Reitman (1971) and Shiffrin (1973) was due to a ceiling effect. It concluded that the results provided support for a model of short term memory that includes decay as well as interference as mechanisms of forgetting.

INTRODUCTION

Investigators employing human information processing concepts generally accept a dual store memory model (e.g., Atkinson and Shiffrin, 1968; Waugh and Norman, 1965) distinguishing the short term store (STS) from the long term store (LTS). Classically, investigators have explored the role of rehearsal to maintain words in memory and the method of termination or loss of a "to be remembered" (TBR) item in STS.

A technique developed by Reitman (1971), based on an adaptation of the Peterson and Peterson (1959) paradigm, prevented rehearsal, while supposedly not introducing new inputs into the "limited capacity" (Miller, 1956) STS. This would enable the TBR item to remain in the STS without interference (loss or forgetting of the TBR item from the STS by new, incoming information). Assuming the interference displacement model is valid, there would be no loss of the TBR item, as would have occurred if a decay is a cause of forgetting in the STS. Forgetting by decay means the loss of the TBR item by simple passage of time assuming that the item is not rehearsed. Rehearsal in this case is the overt or covert verbal repeating of the TBR word or item to be retained in the STS. In Reitman's study, the subjects were able to maintain and recall three words perfectly for a period of 15 sec. of rehearsal prevention (signal detection). This study gave strong support to an interference model of forgetting.

Atkinson and Shiffrin (1971) and Shiffrin (1973) replicated Reitman's (1971) study extending the rehearsal prevention period to 40 sec., and found no forgetting. These studies also gave no support to a decay model of forgetting.

Reitman (1974) recently proposed a model of the STS that included both decay and interference, in combination, as a possible reason for forgetting. In this study, a technique was discussed that extracted the percentages of the decay and interference (56%) responsible for forgetting.

This paper will investigate a decay-interference model of forgetting in light of the findings of Reitman (1974), using the investigative techniques devised by Shiffrin (1973). The most important change in the Shiffrin technique will be an examination of the results and implications of an extension of the 40 sec. rehearsal prevention period and, therefore, an extended recall period.

Reitman (1974) investigated the possibility that the recall task was too easy and forgetting was not detected, i.e., a ceiling effect. She also investigated the possibility of surreptitious rehearsal in her earlier study (Reitman, 1971) and by implication, questioned Shiffrin's (1973) study. Reitman's (1974) results indicated the possibility of a ceiling effect in both Reitman's (1971) and Shiffrin's (1973) studies. A ceiling effect would allow subjects to respond with a high number of recall items, at 0, 15, or 40 sec., but the difficulty of recall would increase with the passage of time.

The possibility of a degree-of-difficulty-of-recall through time may be tested in an extension of the 40 sec. rehearsal prevention task and, in turn, explore the possibility of a ceiling effect in earlier studies.

If a ceiling effect was present in the Reitman (1971) and Shiffrin (1973) studies, a longer period of STS recall delay may allow for the possibility of the degree of difficulty to show. A degree of difficulty, or inability to recall items through time, could be interpreted as a decay process.

To test for a ceiling effect, Reitman (1974) increased the number of TBR items in a filled recall delay. Reitman (1971) used three words during a retention interval of 15 sec.; Shiffrin (1973) used five consonants in the form of a nonsense word and a retention interval of 40 sec.; Reitman (1974) increased the STS load to five English four-letter nouns of one syllable each. These nouns appeared simultaneously previous to a short period of 15 sec. of filled (nonverbal rehearsal prevention) delay. Increasing the number of TBR items may possibly be a form of interference. Reitman (1974) increased the load on the STS to the point that the subjects were unable to recall 100% of the TBR items, even when rehearsal was allowed. The inability of Reitman's subjects to recall 100% of the TBR items could suggest forgetting caused by an interference mechanism. An introduction of more material than can be handled in a limited capacity system would cause greater interference of previous items and increase the probability of STS forgetting.

By maintaining a STS load that can definitely be handled by the STS, such as the five consonants in Shiffrin's study, the probability of interference can be greatly reduced. Yet, it would be possible to extrapolate evidence of a ceiling effect, through the difficulty of recall possibility.

Reitman (1974) and others (e.g., Belleza and Walker, 1974; Götz and Jacoby, 1974; Kroll and Kellicut, 1972; Modigliani and Seamon, 1974; Watkins, Watkins, Craik and Mazuryk, 1973) have recently questioned the accepted definition of rehearsal's function in memory. This in turn generates questions about the effectiveness of the rehearsal prevention task as described in Reitman (1971) and Shiffrin's (1973) studies.

Studies by Atkinson and Shiffrin (1968; 1971) and Rondus and Atkinson (1970) have demonstrated that rehearsal not only serves to maintain information in STS, but also determines the amount of information that is transferred to LTS. In other words, the longer the rehearsal process is allowed, the stronger the LTS trace becomes. Other studies (Jacoby, 1973; Jacoby and Bartz, 1972; Craik and Lockhart, 1972; Meunier, Ritz and Meunier, 1972) propose that rehearsal functions to maintain items in STS only.

Götz et al. (1974) contend that for immediate recall, or recall after a non-interfering delay, the rehearsal strategy keeps the TBR item in STS without the need for involved encoding processes, or a transfer to LTS.

Watkins and Watkins (1974) submit that a transfer to LTS is accomplished by a different type of rehearsal, other than a maintenance type rehearsal. Götz et al. point out that overt, or forced, rehearsal allows only the study of the subject's vocalization of TBR items. The rehearsal strategy may be quite different, and covert, or surreptitious rehearsal may occur.

If rehearsal is of a covert or surreptitious type, it is possible that the rehearsal prevention task devised by Reitman (1971), which prevents overt rehearsal responses, was not effective. Reitman (1974) believed that this was possibly true and developed seven different measures of rehearsal detection. This procedure detected surreptitious rehearsal during the rehearsal prevention periods more effectively than the two measures of detection used in previous studies. Reitman's seven measures analysis intimated that subjects in earlier studies (e.g., Atkinson and Shiffrin, 1971; Reitman, 1971; and Shiffrin, 1973) may have been rehearsing during the rehearsal prevention periods; rehearsal was less pronounced, but nevertheless present.

It could be argued that if rehearsal did take place, as Reitman's results indicated, this rehearsal was detrimental to STS recall rather than advantageous. Götz et al. (1974) suggest that the STS trace would suffer from attempts to organize the TBR words for LTS recall. In an unfilled delay period, rehearsal and encoding are allowed to take place. Upon recall the STS response would not have the advantages of immediate recall; the recall would be based on more permanent LTS attributes. Short lived STS attributes, such as illuminative or acoustic traces, would be lost. Götz et al. predicted that STS recall could be enhanced by increasing the duration of a filled delay. This delay would include interfering items.

In expanding the suggestions of Götz et al. (1974), a presumably non-interfering delay (signal detection) has the same influence on STS recall as immediate recall. This assumption is based on the results of Reitman (1971) and Shiffrin (1973). In these studies the subjects, after a non-interfering delay, showed near perfect recall. In other studies (Peterson et al., 1959; and Shiffrin, 1973), immediate recall has also resulted in near perfect responses. In conjunction with the conclusions of Götz et al. (1974), the surreptitious rehearsal during the non-interfering delay, and the subsequent LTS processing would account for the almost perfect recall of previous studies, i.e., Reitman, 1971 and Shiffrin, 1973. It may then be assumed that the rehearsal prevention methods of Reitman (1971) and Shiffrin (1973) are equal to the task they were meant for. Consequently, these methods were used in the present study.

If the quantity of rehearsals is not a factor in recall of STS items, the rehearsals observed by Reitman (1974) would not be responsible for the high retention of TBR items in STS, but point to a STS-LTS transfer or consolidation. The consolidation would give results that could be equally interpreted as retrieval from the STS or as retrieval from LTS. Shiffrin (1973) submitted that the STS-LTS transfer occurs either during or shortly after presentation of the TBR item. If rehearsal is present, as suggested by Reitman (1974), recall after presentation would be from the LTS. This would account for the high recall in both Reitman's (1971) and Shiffrin's (1973) studies. An extension of the recall period would detect the rehearsal by the probability that a STS-LTS transfer had taken place and would be the result of a permanent LTS trace. As in previous studies (Reitman, 1971; Shiffrin, 1973), an extension would test periods longer than 40 sec. of rehearsal prevention and subsequent recall. If rehearsal is prevented, or rather a STS-LTS transfer is prevented, and a decay mechanism (as suggested by Reitman, 1974) was in effect, there would be a decrease in recall at some point in time. If a transfer has taken place, between STS and LTS, a LTS free-recall post test, as suggested by Meunier, et al. (1972), would demonstrate the amount of LTS-STS transfer that has taken place.

The intent of this paper was to investigate the possibility of decay as well as interference displacement in combination as a mechanism of STS forgetting. It is hypothesized that an extension of the STS rehearsal prevention period past 40 sec., up to and including 120 sec., will demonstrate the strength of the decay mechanism in conjunction with the interference mechanism. What has been termed "decay" may actually be intra-unit interference (e.g. Bennett, 1974). As such, the term decay will be interchangeable with intra-unit interference as an explanation for forgetting. The possibility of a ceiling effect as discussed by Reitman (1974) will also be investigated. The issue of a ceiling effect will be investigated without the added interference of an overloaded STS. The bulk of the experiment will be a replication-extension of Shiffrin's (1973) experiment. It will include an examination of the results of quintigram (five consonants in a nonsense word) recall at 8, 40, 60, and 120 sec. of rehearsal prevention, i.e., a non-interference signal detection task.

METHOD

Subjects

Twelve volunteer students (five male and seven female) were drawn from a Montana State University introductory psychology class. The Ss received extra class credit and were paid in accordance with their performance. The Ss took part in four to five sessions lasting approximately one hour each. Sessions were scheduled at the Ss convenience.

Apparatus

Visual material was presented with the use of a Ralph Gerbrands tachistoscope model number T-26-C. Audio material was produced by a General Radio white noise generator model number 138. Pure tones (signals) were produced by a Hewlett-Packard tone generator model number 200-AD. Audio input was presented to S in stereo earphones that were worn throughout the experiment. The S's memory task responses were recorded, by the S, with pencil and prepared paper. E recorded S's signal detection performance as indicated by Hunter Klockounter model number 120-A.

Procedure

A single trial was presented in the following manner: First, white noise was introduced into the earphones, which acted as a cue for the S to look into the tachistoscope. Then there was a 2 sec. pause before a five consonant nonsense word (a quintigram) was illuminated in the tachistoscope for 3 sec. At the termination of the quintigram presentation, the signal detection task began. At the end of the signal detection the white noise ceased in the earphones. The S would write down the quintigram, and within a 10-15 sec. delay indicated his readiness to continue. Finally, the white noise would resume in the earphones, indicating the start of the next trial.

Memory Task

All quintigrams were a random choice of five different consonants from the following set of 11: F, G, H, J, K, M, P, Q, V, X, and Z. During an experimental session the S was seated facing the face-plate of a tachistoscope, and wearing earphones. The tachistoscope hood and earphones served to eliminate most external audio-visual stimuli. The S was cued that the first quintigram, of a block of four, was to be presented when the white noise began. The white noise also cued S to place his face against the hood of the tachistoscope, where he remained throughout a session, except to write the quintigram at the end of a signal detection period. The tachistoscope's sequential function was: (a) a constant intensity background illumination; followed by (b) the quintigram presentation for 3 sec., with no change in intensity of illumination; followed by, (c) background illumination throughout the signal detection period; followed by, (d) the respond cue (termination of white noise in the earphones) for the S to write the quintigram. The experimental room was maintained with minimal external noise levels and constant illumination consistent with tachistoscope illumination levels.

Signal Detection Task

S wore earphones that were emitting a constant white noise before, during, and after the quintigram presentation. After the quintigram presentation, a two sec. delay occurred before the beginning of the signal detection task. A pure tone (signal) was introduced within the white noise at random intervals. The Ss were instructed to press a response key whenever a signal was detected. Comfortable earphone volume levels were established and probability of correct signal detection was adjusted to about .80 for each S, during numerous practice sessions and pilot studies. There was a 2 sec. delay period after each signal, during which no other signal occurred. This 2 sec. delay period allowed time for S's key-press response and was determined to be detected as such by S during the course of the study. With the event of the two sec. delay period, ..."the next signal was exponentially distributed with a mean of 3 sec. Thus, signals occurred about every 5 sec. on the average." (Shiffrin, 1973, p. 42) The task concluded with the termination of the white noise which cued the S to respond with the quintigram.

Instructions, Incentives, and Feedback

Emphasis was placed on the need for good signal detection performance. The Ss were instructed to recall the quintigram but not to let it interfere with the prime objective of the signal detection task. It was suggested that the S do not repeat the letter to himself, as it would be detrimental to the signal detection performance. The S's payment was contingent upon the signal detection performance, but no monetary or verbal reward was received for quintigram recall performance. The Ss received one cent for each correct signal (a response key press within 1.5 sec. of the signal presentation) and would lose one cent for each false alarm (a response not within a 1.5 sec. period). At the end of each hourly session, the Ss were advised of their signal detection performance in terms of approximately how well they were doing. Poor performances were pointed out and the S was encouraged to do better next session. The Ss were questioned after each session and extensively questioned after the study, when monetary payment was made. At a later date, post tests were made of the S's long term recall of the quintigrams.

Each S went through four to five sessions of approximately 25 quintigrams each and subsequent signal detection tasks (8 sec., 40 sec., 60 sec., or 120 sec.). One of each signal detection period was thrown out due to recording errors, resulting in 24 trials per category, across each of the twelve subjects.

RESULTS

Results were computed with the statistical methods employed by Shiffrin (1973). Significance tests were performed using the methods developed by Scheffé (1959).

Table 1 (page 18) and Table 2 (page 19) summarize the data for signal detection and quintigram letter recall across Ss and sessions. Table 2 is a partial report of Shiffrin's work (Shiffrin, 1973, Table 1), and is included for comparison purposes only. Table 1 and Table 2 are presented in the same form to facilitate comparison. The initial description of Table 1 also describes the pertinent aspects of Table 2. The conditions of this study (Table 1) are designated by 8 sec., 40 sec., 60 sec., and 120 sec. These conditions represent the time intervals of the signal detection periods, and therefore, the intervals between quintigram presentation and quintigram recall. These conditions are analogous to the SD-8 and SD-40, which are also the time intervals of signal detection in sec. (8 sec. and 40 sec.), Table 2.

Columns 2-4 summarize the results of the signal detection performance. Column 2 gives the probability of a correct signal detection, P(C). Column 3 shows the probability of a false alarm, P(FA), based on the assumption that the S had as many intervals without signals as the S had with signals. This is an arbitrary assumption based on estimates of the actual signal detection performance.

Column 4 presents a pseudo-d' (Shiffrin, 1974) measure computed from the numbers in Column 2 and 3. The pseudo-d' measure is not an absolute measure, but shows possible response tendencies in the different conditions and any trends therein. A higher d' denotes a better signal detection performance. Throughout Table 1 (page 18), Column 4, the signal detection performance remained stable which gives assurance that the Ss were attuned to the signal detection performance rather than quintigram rehearsal.

Column 5-9 represents the probability (i.e., P(C) for letter i in input position i) that any letter of the TBR quintigram will be recalled correctly in position i, for i = 1-5. Column 10 gives the averages of the numbers in Columns 5-9, i.e., the average probability of recall of a quintigram letter regardless of input position.

Column 11-10 represents the probability that exactly j letters are recalled in their correct position, for j = 0-5. In order to obtain these probabilities each letter in S's response quintigram was compared with each letter in the TBR quintigram. If a correct letter was not found in any position the probability was scored in column 11. If one correct response letter in the response quintigram was found in the TBR quintigram, the result was reported in column 12. This process occurred for all letters of the response quintigram across subjects. In summary, the response event that occurred with lowest probability was that of column 11, i.e., zero letters recalled correctly. The most prevalent response was that of column 16, i.e., all five letters recalled correctly. The general tendency as depicted in column 16 is that recall probability decreases with the passage of time: 8 sec. = .94; 40 sec. = .85; 60 sec. = .80; and 120 sec. = .76 (for P(C), Table 1, page 18) and 8 sec. = .84; 40 sec. = .63; 60 sec. = .56; and 120 sec. = .50 (for P(j), Table 1).

Figure 1 graphically illustrates Table 1 and Table 2, column 10, P(C) and column 16, P(j). Figure 1 - Table 1 illustrates the probability of recall from 8 sec. to 120 sec. for P(C) and P(j). Figure 1 - Table 2 illustrates the results from Shiffrin's (1973, pg. 42) study. Table 2 includes the P(C) and P(j) for signal detection for 1 sec., 8 sec., and 40 sec., (SD-1, SD-8, and SD-40). Also included are the P(C) and P(j) for signal detection plus arithmetic (SD-1+A, SD-8+A, and SD-40+A). Figure 1 - Table 1, P(C) and P(j) present a gently sloping decrease in quintigram recall performance with the passage of time. These lines approximate the signal detection plus arithmetic task SD-1+A, SD-8+A, and SD-40+A) results of Shiffrin, 1973. It must be noted that any direct comparison of the results of Shiffrin (1973) and the results of this study are impossible. Any comparisons can only be speculative.

Table 3 (page 21) is a variance table of the probability of a correct recall in input position _i_, for _i_ = 1-5. The dependent variable (D.V.) in this case was P(C), the relative frequency of a correct recall in 24 trials. This is a rBC mixed model unreplicated analysis of variance. The letter "r" represents individual's (Ss). The letter "B" represents the variable of the main effect, the probability of the input position i of the letters in the TBR quintigram. This is a classification variable and was found to be significant, $F(4,32) = 9.28$, $p<.001$. The letter "C" represents the time interval in seconds (8, 40, 60, and 120 sec.), "BxC" $F(3,24)=15.94$, $p<.001$. The "BxC" interaction was significant, $F(12,96)=3.06$, $p<.001$. This significant interaction is important when considering the significant main effects: input position (B) and the interval in sec. (C) individually. For this reason Table 5 (page 23) "Multiple Comparison for P(C) Averages (overall input positions)" is included. This table compares the interval effect of the mean times, intervals in sec. (B, Table 3, page 21). Significant differences were found between 8 sec. and 60 sec. intervals ($F=34.13$, $p<.01$) and the 8 sec. and 120 sec., intervals ($F=27.93$, $p<.01$). No significant differences were found in the other time intervals. The degrees of freedom were individualized, rather than overall error rates, which allows for a very conservative error rate.

Table 4 (page 22) gives the variance for P(j), the probability that exactly j numbers of letters will be recalled in their correct position, for j = 0-5 positions. This is a rBC mixed model, unreplicated analysis of variance. The number of letters recalled in their correct position ("B" main effect) was significant, $F(5,40)=151.29$,

$p<.001$. The "C" main effect was not found to be significant. Here, as in Table 3, (page 21) the "BxC" interaction was found to be significant $F(15,120)=8.92$, $p<.001$ and a multiple comparison, (Table 6, page 24, $P(j)$ - probability that all letters are recalled in their correct positions), was performed. Significant differences were found at 8 sec. vs. 40 sec. ($F=35.32$, $p<.01$); 8 sec. vs. 60 sec. ($F=31.71$, $p<.01$); and 8 sec. vs. 120 sec. ($F=39.44$, $p<.01$). Significance was not found in other time intervals.

The LTS post-tests provided no evidence that STS-LTS transfer had taken place for any of the 96 quintigrams across subjects and sessions.

Table 1

Results of Signal Detection and Quintigram Recall Across Ss and Sessions

Condition	Signal Detection Performance			P (C) for letter in Input positions <u>i</u>						Probability that exactly <u>j</u> letters are recalled correctly					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	P(C)	P(FA)	d'	1	2	3	4	5	Ave.	0	1	2	3	4	5
Control	.81	.26	1.52	-	-	-	-	-	-	-	-	-	-	-	-
8 sec.	.84	.20	1.83	.97	.92	.93	.92	.96	.94	.00	.01	.02	.06	.07	.84
40 sec.	.84	.22	1.76	.91	.86	.80	.83	.88	.85	.01	.04	.05	.13	.15	.63
60 sec.	.87	.29	1.68	.88	.82	.72	.80	.79	.80	.02	.03	.09	.17	.12	.56
120 sec.	.86	.22	1.77	.82	.67	.76	.78	.76	.76	.04	.07	.09	.18	.14	.50

Table 2

Shiffrin (1973) - Results for Experiment I Across Ss and Sessions

Condition	Signal Detection Performance			P(C) for letter in Input positions *i*						Probability that exactly *j* letters are recalled correctly					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	P(C)	P(FA)	d'	1	2	3	4	5	Ave.	0	1	2	3	4	5
Control	.79	.15	1.84	-	-	-	-	-	-	-	-	-	-	-	-
SD-8	.82	.25	1.59	.99	.99	.98	.95	.96	.97	.00	.01	.01	.03	.04	.92
SD-40	.77	.18	1.66	.99	.97	.97	.95	.97	.97	.00	.01	.01	.03	.03	.92
SD-8 +A	.81	.26	1.52	.75	.69	.66	.63	.64	.67	.13	.12	.08	.09	.10	.49
SD-40 +A	.78	.16	1.76	.72	.71	.68	.68	.68	.69	.12	.08	.09	.09	.10	.51

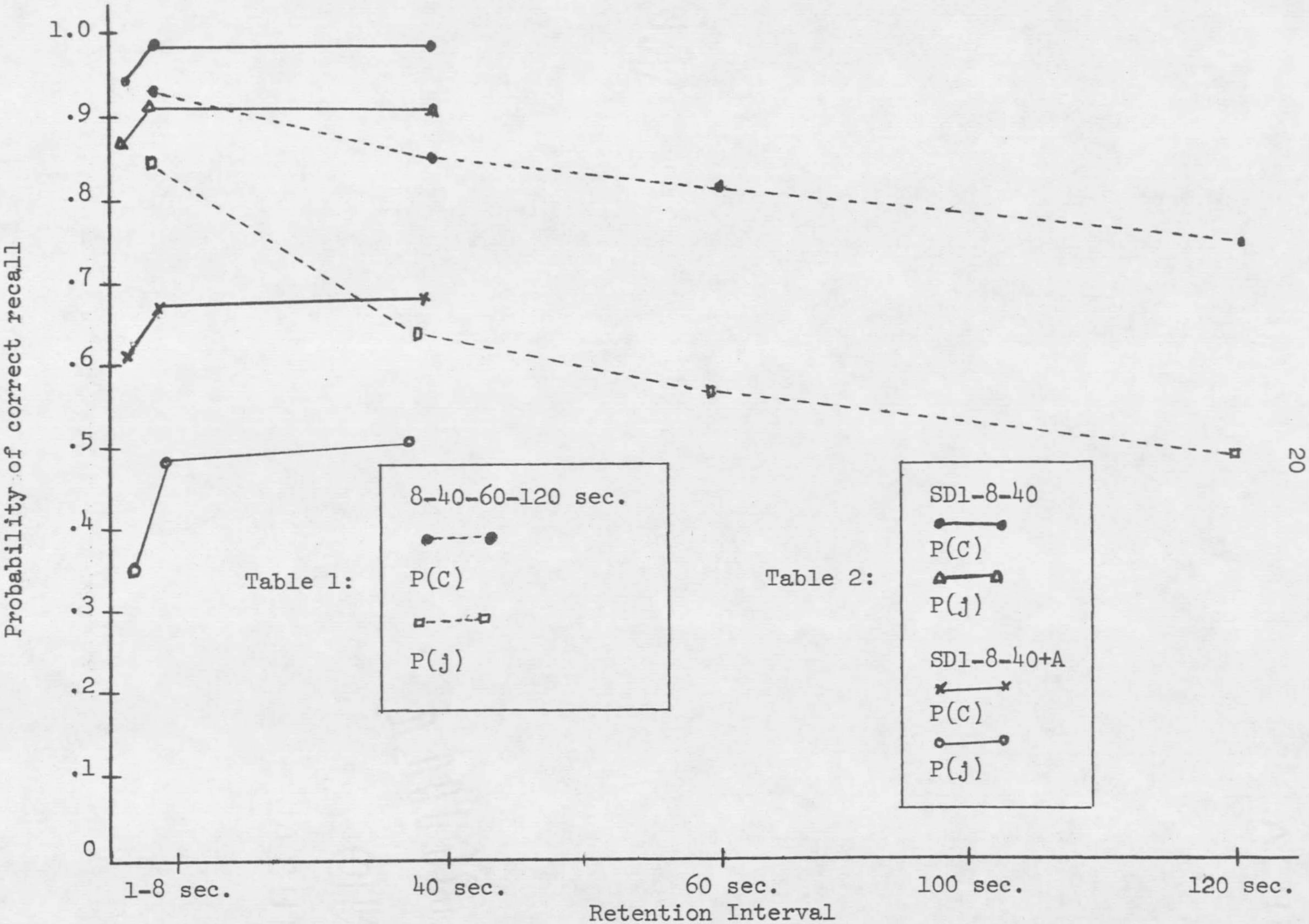

Figure 1. Quintigram recall results from Tables 1 & 2 (Col. 10 & 16)

Table 3

P(C) (rBC Mixed Model - Unreplicated) Variance Table

Source	SS	df	MS	F
r (individuals)	.42952	8	.05369	-----
B (input position)	.23992	4	.05998	9.28 **
C (interval in secs.)	.72434	3	.24145	15.94 **
r x B	.20678	32	.00646	-----
r x C	.36348	24	.01515	-----
B x C	.10807	12	.00901	3.06 *
r x B x C	.28245	96	.00294	-----
TOTAL	2.35456	179		

*p = .001
**p < .001

D.V. = P(C) - relative frequency correct in 24 trials

Table 4

P(j); Exactly j Letters Correct (rBC Mixed Model - Unreplicated)
Variance Table

Source	SS	df	MS	F
r (individuals)	.000000426	8	.000000053	-----
B (No. of Letters)	8.752707912	5	1.750541582	151.29 *
C (interval in secs.)	.000000236	3	.000000079	1.36
r x B	.462836630	40	.011570916	-----
r x C	.000001389	24	.000000058	-----
B x C	.594497181	15	.039633145	8.92 *
r x B x C	.532914444	120	.004440954	-----
TOTAL	10.34295822	215		

*p < .001

D.V. - P(j=0,1,...s) i.e., relative frequency of exactly j letters correct in 24 trials

Table 5

Multiple Comparisons for P(C) Avg. (over all input positions)

Interval:	8 sec.	40 sec.	60 sec.	120 sec.
$\bar{X}$:	.92	.84	.79	.74

Comparison	F	P
8" vs. 40"	11.94	>.05
8" vs. 60"	34.13*	<.01
8" vs. 120"	27.93*	<.01
40" vs. 60"	5.14	>.05
40" vs. 120"	8.47	>.05
60" vs. 120"	4.71	>.05

p = .05: Scheffe $F_s = (a-1)F_{.05}\ (a-1,\ df_{rC})$

$= (4-1)F_{.05}\ (3,8)$; individualized, rather than overall, error df

$= 3(4.07)$ (conservative EW error rate)

$= \underline{12.21}$

p <.01: Scheffe $F_s = (a-1)F_{.01}\ (a-1,\ df_{rC})$

$= 3(7.59)$

$= \underline{22.77}$

Table 6

Multiple Comparisons for P(j=5); all 5 positions correct

Interval:	8 sec.	40 sec.	60 sec.	120 sec.
$\bar{X}$:	.79	.62	.54	.48

Comparison	F	P
8" vs. 40"	35.32*	<.01
8" vs. 60"	31.71*	<.01
8" vs. 120"	39.44*	<.01
40" vs. 60"	6.58	>.05
40" vs. 120"	8.52	>.05
60" vs. 120"	1.63	>.05

$p = .05$: Scheffe $F_s = (a-1)F_{.05}\,(a-1, df_{rBC})$; individualized, rather than overall, error df

$= (4-1)F_{.05}\,(3,8)$ (conservative EW error rate)

$= 3\,(4.07)$

$= \underline{12.21}$

$p < .01$: Scheffe $F_s = (a-1)F_{.01}\,(a-1,\ df_{rBC})$

$= 3\,(7.59)$

$= \underline{22.77}$

DISCUSSION

The results of this study are consistent with a model of STS forgetting which includes decay and interference in combination, as mechanisms of STS forgetting. These results do not necessarily conflict with the results of Reitman (1971) or Shiffrin (1973), whose studies call for interference as the only mechanism of STS forgetting. The difference in interpretation very possibly could be the product of a ceiling effect, as suggested by Reitman (1974). By extending the Shiffrin (1973) study, the possibility of a ceiling effect was examined. The influence of the ceiling effect was tested without overloading the limited store STS system, as was a possibility in the Reitman (1974) study. Reitman (1974) interpreted her results as pointing to the presence of a ceiling effect in the Reitman (1971) and Shiffrin (1973) reports. However, evidence suggests the possibility that the number of TBR items used by Reitman (1974), in an effort to investigate the ceiling effect, overloaded the STS system. In conjunction with this investigation, Reitman (1974) postulated a "degree of difficulty" hypothesis, which could be interpreted as a decay mechanism of forgetting.

Shiffrin (1973) also suggested the probability that decay during the signal detection task would appear if the number of TBR items were increased beyond five. Shiffrin (1973) further stated that a choice between two models of STS forgetting must be explored: (1) that any trace, no matter how complex, will not decay once established due to mutual interference of its parts over time, or (2) that such decay will occur for sufficiently complex material.

Posner and Rossman (1965) and Glanzer, Gianutsos, and Dubin (1969) also found that information load (the number of words or letters) was a critical factor in removing items from STS. More recent evidence comes from the work of Baddely, Thomson, and Buchanan (1975), who explored the hypothesis that STS memory is not constant but varies with the length of the TBR items. They found that: (1) memory span is inversely related to word length across a wide range of material, and (2) when the number of phonemes are held constant, words of shorter temporal duration are better recalled than words of long duration.

For the above reasons, the TBR items used in this study remained a five consonant quintigram as used by Shiffrin (1973). The results of this study support Reitman's (1974) assumption that a ceiling effect was present in the data of Reitman (1971) and Shiffrin (1973).

The results demonstrate that, in conjunction with the ceiling effect, an increasing difficulty of recall (Reitman, 1974) was brought out as a result of the STS recall time extension. Recall performance did decrease with the passage of time, but the decrease occurred as a consequence of time passage rather than with an increase in the number of TBR items. This would lead to the conclusion that the ceiling effect was present in the previous studies of Reitman (1971) and Shiffrin (1973) but that the recall periods were too brief to reveal the effect.

As to the question of signal detection as an effective rehearsal preventor, it was shown that rehearsal was either not present or had little effect on the Ss STS recall ability. If rehearsal had been an important factor, STS recall performance should have remained at the high levels at the longer recall periods (60 sec. and 120 sec.) that existed in the first few seconds (8 sec.). This was definitely not the observed result.

Accepting the hypothesis that rehearsal facilitates transfer between the STS and the LTS, a LTS post test would have produced data pointing to this transfer. The results did not show this consequence, thus it can be concluded that rehearsal was either not present, or, if present, not effective.

Other types of rehearsal (i.e., maintenance type rehearsal, such as discussed by Jacoby et al., 1972) may also be disavowed as being a factor in this study, as the STS trace was not maintained at the very high levels demonstrated at shorter recall periods. Signal detection, as used in this study, seems to be an effective agent that either prevents rehearsal or reduces the rehearsal strategy to the point that the STS trace shows a significant decrease in recall performance.

In comparing the results of this study (Table 1, page 18) with those of Shiffrin (1973) (Table 2, page 19), it is noted that the quintigram P(C) and P(j), Table 1 values are not as high as the quintigram P(C) and P(j), Table 2 of Shiffrin's (1973) study. It is assumed that these discrepancies reflect the differences in equipment sophistication and small differences in methodology. These differences accommodate differences in the equipment available. It is believed that this study would have provided more positive results in relation to the hypothesis if the equipment and methodology differences had been corrected.

In summation, a model of STS forgetting proposed by this study would include a limited capacity system. The limit of the store is inversely related to STS recall item length. Items are believed to be lost through the passage of time when no new interfering items are introduced into the STS system. STS forgetting is due to both decay and interference. Forgetting is a function of: (1) similar interfering items; (2) increased number of phonemes; and (3) loss of items through the passage of time. Each of these causes of forgetting has precedent over the next, respectively, in accelerating STS forgetting.

Recent research (Bennett, 1975) was concerned with the fundamental forgetting process implied by (2) above, which questions whether the forgetting process is interference from internal competition or a simple process of decay. Further investigation may be able to determine if decay is responsible for STS forgetting in this study, or if the process of intra-unit interference is the agent of STS memory loss.

CONCLUSION

The extension of Shiffrin's (1973) study was helpful in exploring the STS forgetting process. The possibility of a ceiling effect, as first discussed by Reitman (1974), contributed to the fact that the Ss in the Reitman (1971) and the Shiffrin (1973) studies exhibited little or no forgetting for recall periods of up to 40 seconds. It seemed logical to question what would happen after 40 seconds.

Employing the methods devised by Shiffrin (1973), the recall period was extended to 120 seconds. Shiffrin's technique involved the use of a signal detection task to prevent rehearsal while no new material was introduced into the STS system.

It has been well established (e.g. Atkinson and Shiffrin, 1971; Reitman, 1971; and Shiffrin, 1973) that interference was an effective agent in producing forgetting from the STS. It has also been proposed (e.g. Adams, 1967; Brown, 1958; Keppel and Underwood, 1962; Murdock, 1961; Watkins et al., 1973) that decay was a factor in short term forgetting. Reitman (1974) states that forgetting should include both decay and interference as sources of recall item loss. Shiffrin (1973) found no evidence to support decay as a reason for forgetting.

By extending the recall periods with the aid of techniques incorporated by Shiffrin, this study supported Reitman's (1974) suggestion that a ceiling effect was present in the Shiffrin (1973) study. Shiffrin's (1973) own methods were used to show the presence of a ceiling effect, was responsible for the high probability of recall in earlier studies.

It was concluded in this study that the decline in recall performance, without the influence of the interjection of new items (interfering or displacing items) was the product of a decay mechanism. This conclusion lends support to Reitman's (1974) model of STS memory that includes the processes of decay as well as interference as causes of forgetting.

Suggestions for Further Research

Recent evidence (Bennett et al., 1975) suggests that the term "decay" is not correct. Forgetting is possibly a process of interference from internal competition. If this hypothesis is valid, there may not be simple loss of STS memory due to the passage of time, but a complicated intra-unit interference. The parameters of STS forgetting may be further defined by varying the STS load and increments of the recall periods.

Further research may benefit from a 7 different measures technique developed by Reitman (1974) which could help to determine the strengths and types of mechanisms that contribute to STS forgetting.

A combination of the above techniques may provide a valuable tool to help researchers investigate the mechanisms of STS forgetting.

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