A HABITUATION HYPOTHESIS OF THE BUILD-UP AND RELEASE OF PROACTIVE INHIBITION IN SHORT-TERM MEMORY

by

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ABSTRACT

Two experiments were performed in an investigation of the release of proactive inhibition observed in short-term memory. The Brown-Peterson short-term memory paradigm was employed for both experiments.

Experiment I involved a reduction in the physical size of the stimulus, on the shift trial, to investigate the abilities of this contextual category as a releaser. A release of proactive inhibition was obtained and was comparable in magnitude to releases obtained with content categories.

Experiment II employed a shift of numbers to letters, on the shift trial, in a content category release of proactive inhibition. In addition, the galvanic skin response was monitored throughout. A release of proactive inhibition was noted in the short-term memory. The magnitude of galvanic skin responses to the stimuli was positively correlated to the subsequent recall of the stimuli and shift trial galvanic skin responses were significantly larger in the shift group compared to the control group.

The results were interpreted as supportive of a habituation, perceptual alerting, arousal, or orienting response hypothesis. The relationship of the build-up and release of proactive inhibition in short-term memory to verbal learning in general was explored within the framework of the habituation hypothesis.

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CHAPTER I

INTRODUCTION

The variables which influence retention and forgetting in short-term memory (STM) are best approached within a historical framework. This chapter will begin with the methodology and theories employed in long-term memory (LTM) studies. The two main theories, interference and decay, will be examined from their conception in LTM through to their adaptation to STM. The relative explanatory and predictive powers of both interference and decay theories, and their subsequent modifications, will be evaluated and contrasted with a third approach, the habituation hypothesis. A major concern will center upon explaining the decline in retention over time and as a function of the number of prior experimental memory tests. This attenuation of recall is termed inhibition. There are two main types of inhibition, proactive inhibition (PI) and retroactive inhibition (RI). These refer to the temporal location of the hypothesized cause of the decline in performance, either before the to-be-remembered material (PI) or after the to-be-remembered material (RI). A decline in retention as a function of the number of prior items (STM) or lists (LTM) has been observed and termed "the build-up of PI". Discussion will then be narrowed to explanations for this build-up of PI and variables which have been found to achieve a subsequent release of PI (an increase in retention).

History of LTM

Investigation of the variables involved in LTM was usually accomplished by requiring subjects to learn a list of nonsense syllables to some set criterion (i.e. to the point of one error-free recitation of the entire list) and testing retention of that list after a time interval which could be expressed in minutes, hours, or days (typically a 24 hour interval was used). The percentage of items retained by the subjects was employed as a measure of the strength of LTM.

The popular explanation of forgetting, prior to 1924, was the Law of Disuse as postulated by Thorndike. The law of disuse explained forgetting in LTM by the weakening of connections due to the discontinuation of practice, which resulted in forgetting (Hilgard and Bower, 1966). Time, then, was considered an important variable. If other factors are not taken into account (environmental influences in time), a decay or disuse hypothesis is acceptable and plausible. Indeed, decay over time per se was assumed to be the major cause of forgetting. The conception was that, in learning, a trace of the stimulus was formed in the brain and that this trace would decay over time unless it was reinstated via repetition (use/rehearsal) which strengthened the connections of the trace. Although this point of view was strongly supported prior to 1924, a series of studies began to change the opinions of the psychologists involved.

Hall (1971) reports the 1924 studies of Jenkins and Dallenbach (followed by a replication by Van Ormer in 1932) which were performed to investigate the influence on recall of environmental events occurring in the retention interval. The rationale was that if time alone was the significant variable (indicating decay via disuse), then it would not matter if the time was spent sleeping or waking. If, however, other factors in the waking environment were important contributors to forgetting, then, the sleeping condition should produce superior performance, compared to the waking condition. The results, especially after the 2, 4, and 8 hours conditions, were impressive -- 60% to 15% recall in favour of the sleeping team. This appeared to be a severe blow to the decay theorists of the time.

Hall (1971) also discussed a 1932 paper by McGeoch which reviewed the current literature at that time and criticized the conception of time as the main independent variable. The analogy presented was of an iron bar rusting as a function of time rather than of oxidation (in a vacuum rusting does not occur). The environmental events occurring during the retention interval were assumed to be the important factors in forgetting. These events occurred after the original learning of the list and were, therefore, assumed to be retroactively inhibiting the original learning. Thus, RI was employed to explain forgetting. The mechanism underlying RI was believed to be interference. The events occurring during the delay period interfered with the original learning and produced the forgetting. There were three main variables involved in this process: (1) the length of the retention interval (longer intervals allowing more events to occur and interfere); (2) the number of events occurring (larger numbers of events producing more interference); and, (3) the similarity of the events to the original learning (the more similar the events are to the original learning, the greater the interference).

Studies of LTM usually entailed learning a list of criterion and being tested for retention of that list after an interval expressed in many hours or days. Typically, Ss, after a 24 hour delay, recalled about 25% of the list. Again, the popular explanation of the decrement in recall was RI, material encountered during the retention interval (delay) was interfering with the retention of the experimental list. As subjects were not delayed at the experimental lab (and even if they were -- it would be difficult, if not impossible, to control all the stimulus input to eliminate interference), the process involved was assumed to be due to extra-experimental RI.

This RI explanation was criticized by Underwood (1957). Underwood pointed out that Ss in LTM studies were usually college students and as such would not encounter material, during the retention interval, which was highly similar to the nonsense syllables employed for the original learning task. He postulated that the 75% decrement in performance was too large to be explained by intervening events which were very dissimilar to the original task. The methodology of previous researchers had been to use each subject many times and then to average all the scores to obtain the average performance. A subject would learn List 1 and return the next day for the 24 hour retention test, after which he would learn List 2. This sequence would be repeated many times, and the recall scores for Lists 1 to N would be averaged to obtain the 24 hour retention interval performance for that subject. Underwood engaged in the monumental task of reviewing, compiling, reanalysing and presenting the data thus far obtained. In each case he determined, on the average, how many previous experimental sessions (lists) the subjects had had and their retention as a function of the number of prior lists. It appeared to Underwood that the material most like the test material was not an undergraduate psychology course, but rather the previous list. The decrement in retention could then be effectively explained by proactive inhibition (PI). Underwood found that, with no previous lists encountered, retention of the first list, after 24 hours, was between 70 and 80 per cent. Retention steadily declined as a function of the number of previous lists so that by the tenth list recall was approximately 25%. Underwood concluded PI (explained via proactive interference) was the most probable mechanism (explanation) of the decrease in retention.

Underwood, in explaining PI, stated that associations developed on List 1 were extinguished during the learning of List 2. During the retention interval for List 2 the previously extinguished associations of List 1 items spontaneously recovered to interfere with retention (recall) of List 2. Extra-experimental interference (letter sequence and unit sequence habits) was invoked to explain why there was not 100% recall of List 1. Underwood listed four PI variables related to the rate of forgetting of items from LTM: (1) The length of the retention interval interacts with the number of previously learned laboratory lists. Little forgetting will be observed, over time, with no prior lists but the amount of forgetting increases, over time, as the number of prior lists increases. (2) Practice effects interact with the number of previously encountered laboratory lists. Distributed practice, compared to massed practice, produces equal or inferior results when no prior lists have been encountered; but as a function of the number of previous lists, distributed practice produces superior retention. (3) PI increases as the similarity between and within lists increases. (4) As the meaningfulness of the items increases (more associations), retention decreases.

Interference theory has dealt with LTM studies for so long that the terms "proactive inhibition" and "proactive interference" are used interchangeably. Decay theorists, however, had not been idle in their investigations.

History of STM

John Brown (1958) reviewed the literature concerning the evidence for a memory trace which was subject to decay and concluded the paradigms of LTM were not adequate to investigate decay. He believed decay could occur very rapidly over short periods. In a paired-associate (PA) task, Brown found what he believed to be evidence of trace decay, in short periods of time (5 sec.), which could be offset by rehearsal. Extending this hypothesis, Peterson and Peterson (1959) employed consonant trigram (CCC) presentations and measured retention after different retention intervals. Counting backwards was employed to prevent rehearsal (the dissimilarity of the task to the stimuli should minimize interference). They found almost complete forgetting of a single CCC after only 18 seconds. Specifically, Peterson and Peterson displayed a CCC to a subject, the subject read the letter aloud, followed immediately by a three digit number which the subject also vocalized and from which the subject began counting backwards by three's for either 3, 6, 9, 12, 15, or 18 sec. after which the subject was instructed to recall the CCC. This sequence was repeated 48 times for each subject and 8 scores for each delay period were obtained. This was done for a total of 24 subjects. The 15 and 18 sec. delays were blocked, in order of occurrence, into 4 groups of 12 trials. The average proportion of CCC's correctly recalled in the four successive groups of trials was .08, 15, .09, and .12. Peterson and Peterson interpreted this as not indicating interference (performance did not decline as a function of the number of prior trials), but rather decay of trace due to prevention of rehearsal.

The Peterson and Peterson (1959) study indicated the existence of a STM which did not exhibit the same relationships to PI as did LTM. Postulating that the apparent absence of PI was in fact due to Peterson and Peterson having summed over blocks of 12 trials, Keppel and Underwood (1962) employed the same methodology and counterbalanced three retention intervals (3, 9, and 18 sec.) for three trials. They displayed the recall for each retention interval as a function of the trial position (first, second, or third). They found that forgetting of a single item increased as the number of prior trials increased and that the difference between the trials was more pronounced at the 18 sec. retention interval. They attributed this increased forgetting, as trials progressed, to a rapid build-up of PI, within 3 or 4 trials, countered partially by practice effects (PE), which tended to produce a negatively decelerating retention curve. This indicated that PI performed the same function in STM as in LTM.

Thus, at this time, the theoretical emphasis was upon decay vs. interference explanations of forgetting. In decay theory, the to-be-remembered item decays when rehearsal is suppressed, and in interference theory, the interfering properties of previously encountered and subsequently extinguished associations spontaneously recover during the delay interval and interfere with the to-be-remembered item. Attention was focused on the PI effect, and on the experimental variables which influenced it, in an attempt to decide between these two competing explanations of forgetting in STM.

Release of PI

Wickens, Born and Allen (1963) investigated the effects of item similarity upon PI by varying the number of similar items presented before introducing dissimilar items. They used CCCs and three-digit numbers (NNNs) as the dissimilar classes of material. Their procedure was similar to the Peterson and Peterson procedure, differing in that colour naming was used to fill the delay period. The two control groups had either CCCs or NNNs for all 10 trials. The six major experimental groups had either CCCs or NNNs for the first 3, 6, or 9 trials, after which, they were "shifted" to the opposite class of material. The control group performance declined rapidly over the first few trials, remaining approximately constant over the remaining trials. The performance of the experimental groups increased dramatically on the shift trials. The decline in performance over the first few trials replicated the build-up of PI, observed by Keppel and Underwood, and was similarly interpreted as support for interference theory. An interference explanation was also offered to account for the release of PI on the shift trials. Thus, the associations developed on the trials prior to the shift were highly dissimilar to the material to be remembered on the shift trial, and therefore produced less competition and consequent forgetting when they recovered during the retention interval of the shift trial. The discovery that PI could be released was followed by a surge of investigations of the phenomenon.

Loess (1967) found an increase in recall following a shift in taxonomic class and believed his results indicated "that the development of PI is limited to items from the same category ..." (p. 258). Wickens and Clark (1968) separated words into different classes by selecting them from the ends of the Osgood semantic differential scale.

When these classifications were shifted in presentation, recall increased, indicating a release of PI. Releases of PI have also been reported with shifts involving arabic and spelled-out numbers, continua of Osgood's semantic differential scale, frequency of usage in language, and the sense impression of nouns (Wickens, 1970).

The ability to achieve a release of PI supposedly allowed STM experimenters to investigate the dimensions by which material is encoded in STM. The increase in recall indicates a different encoding dimension being employed since the previous items no longer interfered with the recall of the present item. However, while the previously mentioned studies have involved manipulations of the stimulus content, other experiments have investigated manipulations of the context in which the stimulus is presented.

Turvey and Egan (1969) observed a release of PI when they changed the size of the stimulus background. Gumenik and Rossman (1970) outlined the ninth trial stimulus with a dark rectangle and produced a release of PI. Wickens (1970), in his review of the release of PI, reports that releases have been obtained by shifting the figure-ground relationship and by shifting the presentation modality.

Along with the releases of PI involving shifting of the stimulus content and of the stimulus context, there have been investigations in which the nature of the shift involved changing the temporal pattern of the stimulus presentation.

Investigating the intertrial interval (ITI) effect upon PI, Loess and Waugh (1967) found that an ITI beyond 2 minutes inhibited a build up of PI. Kincaid and Wickens (1970) also obtained a release of PI by varying the ITI. Recall increased progressively as a function of ITIs (0, 15, 45, and 120 sec.) between the third and fourth of a series of 4 trials. They interpreted their results as presenting difficulty for interference theory unless in fact there was a decay of the interfering properties of prior items. As the mechanisms underlying interference should produce more interference as a function of time between trials (more interfering associations spontaneously recovering as time increases), this does raise questions about the hypothesis that the release of PI indicates the use of a different encoding mechanism. Interference theory should also predict that the ITI would be less effective in releasing PI as the degree of learning of the prior items increases. However, Wickens and Glittis (1974) found the degree of learning of the prior items did not influence the release of PI with an ITI. It should be noted that Gorfein (1974) found less release as a function of the amount of PI when recognition latency was employed as the measure of STM.

It appears that PI can be released by varying the stimulus content, the stimulus context, and the temporal pattern of stimulus presentation. If, as previously thought, the shift in material class denoted encoding dimensions, then encoding variables include the stimulus context and temporal pattern, as well as the stimulus content.

The assumption that conceptual verbal encoding categories are indicated by a release of PI (Wickens, 1970, 1973) follows from the acceptance of interference theory. The decrement in recall is explained in interference theory by the spontaneous eruption of previously extinguished associations, which require a time interval to occur, and the number of these associations increases as a function of the length of the interval.

Whether or not interference theory explanations of the release of PI effect warrants acceptance depends partly on its predictive ability concerning the main effects and interactions of basic STM variables.

Critique of Interference Theory

The interaction of number of trials and build-up of interference should produce a retention curve which rapidly decreases as a number of prior trials increase, eventually to the point of zero performance. Actually retention falls to some low point (between 10% and 20% and remains fairly stable through a large number of trials). Keppel and Underwood (1962) explained the lack of zero performance by a practice effect (PE) which builds up as trials increase and offsets the continuing build-up of PI. It is a unique coincidence that the relative facilitative effects of practice are about equal in strength to the decremental effects of interference, especially when the items to be remembered in the task are often CVCs with associational values (AVs) between one and nine (Archer, 1960) on a zero to one hundred scale.

Spontaneous recovery of previously extinguished items as a function of the length of the retention interval, and a lack of first trial forgetting, are both vital observations for interference theory. Wright (1967), however, found prior-item intrusions to be an increasing function of similarity, but unrelated to the length of the retention interval. Wright theorized that the decrease in retention over a delay period was due to a decay of the memory trace. The lack of intrusions with a delay period in his study led him to conclude that a decay mechanism, rather than an interference mechanism, was responsible for the decline in performance. The second observation, the lack of first trial forgetting, was investigated by Baddeley and Scott (1971). They used 5 digits as stimuli and varied the retention interval between subjects, and found first trial forgetting as a function of the length of the retention interval. They conclude by indicating the tenability of Conrad's (1967) modified decay hypothesis and suggesting dual mechanisms for STM and LTM were in operation. They also stated that forgetting in a multitrial technique is due to difficulty in discriminating the temporal cues which allow separation of successive items.

Interference theory also predicts an interaction between the meaningfulness of an item and the retention interval. The meaningfulness (M) of an item is defined by calculating, over a one minute interval, the mean frequency of associations elicited by that item (Hall, 1971). Gojey, for example, rates an M-value of 0.99 while

Kitchen received an M-value of 9.61. A common correlate of both AV and M-value is the frequency of usage in the general population. The expected interaction of M-value and length of retention interval should, according to interference theory, produce the most efficient retention when low M-value items are presented at short retention intervals and the poorest performance with the pairing of high M-value items and long retention intervals. The shorter retention intervals allow less time for spontaneous recovery to occur and the high M stimuli would give rise to more interfering associations than low M stimuli. There should also be a steeper decline in performance when the high M-value item condition is plotted as a function of increasing retention intervals than when the low M-value item condition is plotted. Melton (1963) presents data comparing the results of experiments done by Peterson and Peterson which employed, as items, CCC trigrams of not more than 33% associational value, and by Murdock who used as items single words, which occurred more frequently than CVCs in the general usage of the population. Although there are difficulties involved in comparing the results of two different experiments, the same basic STM paradigm was used in both cases. For retention intervals of (3, 6, 9, 12, 15, and 18 sec., Murdock got 97, 95, 90, 87, 86 (estimated), and 85 per cent recall, respectively, with his high frequency meaningful words; Peterson and Peterson obtained values of approximately 80, 57, 33, 22, 11, and 10 per cent correct, respectively, with their low AV CCCs. The results are in the opposite direction from interference theory predictions.

In a more direct investigation of M, Peterson, Peterson, and Miller (1961) employed the single item STM methodology and with a 6 sec. constant retention interval manipulated the M of CVCs by using Glaze 0 and 100% AVs. Recall was superior for the 100% AV CVCs compared to the 0% AV CVCs. Lindley (1963) manipulated M (three-letter words, syllables, and low AV CVCs) and retention interval (3, 13, and 39 sec.) and found that high M was associated with superior retention and that this effect was more pronounced at the longer retention intervals. The decline in performance was steeper, across retention intervals, for the low M stimuli (the reverse of interference theory predictions). In summary, the strength of interference theory is its ability to account for the initial (over the first four trials) rapid decline in performance. Beyond this initial build-up of PI, interference theory has difficulty accounting for the effects and interactions of basic variables in STM. This was also recognized by Postman (1975) when, in his review of verbal learning and memory, he explained his omission of interference theory by stating "Interference theory today is in a state of ferment if not disarray [p. 327]."

experimental conditions and can be classified into three major categories: (1) changes of the stimulus content; (2) changes of the stimulus context; and (3) changes of the stimulus temporal pattern. The first category includes such shifts as CVCs to three digit numbers, arabic to spelled-out numbers, and names of birds to names of occupations. The second category contains shifts relative to properties of presentation such as changing the background area, the colour of the stimulus, the intensity of the stimulus, the presentation modality, or even the room lighting. The last category, although related to the properties of presentation, is listed separately and contains temporal changes (ITIs).

The habituation hypothesis, espoused in this paper, has as its main variables the ingredient common to the stimulus content, context, and temporal categories: change or deviation. The changes or deviations are relative to the preceding experimental conditions. Psychological encoding categories (stimulus content) are relevant, as are the conditions under which they occur (stimulus context), not for themselves per se but rather their deviation from the preceding events. The first two categories are best related to the third category by the adage "A change is as good as a rest." The basic principle is that deviations or rest periods will produce increases in the percent recalled in the STM paradigm.

The most probable mechanism underlying this effect is the increased cerebral activity, also termed an orienting response (OR), which follows the activation of the reticular activating system produced by a mis-match of the present event relative to the preceding events. A similar view was proposed by Kessner (1973). An orienting response, then, refers to the physiological response a subject experiences when presented with any stimulus or stimuli. The response is greatest to novel stimuli, and has generally been viewed as a mechanism which facilitates stimulus processing. This hypothesis provides predictions as to the build-up and release of PI under all three main categories as well as summations when more than one category is changed (Wittlinger, 1967). If the OR is a factor, then stimulus deviations which have been found to produce ORs should influence STM. The previously mentioned STM studies which have utilized shifts of the physical properties of stimuli and ITIs in the release of PI paradigm are consistent with evidence that OR variables do influence STM.

The role of an OR in conditioning appears to be to maintain the memory of the stimulus for longer periods of time. If there is no memory of the stimulus, there can be no connection of the relevant events to provide information concerning the value of the stimulus. The specific example to be employed is the ability to condition an OR to a word (for example, one's name). Maltzman and Raskin (1966) report a study, in which the measure was of vasoconstriction in the finger, where a selected test word ("light") was followed by a US (white noise). They not only obtained conditioning of the OR, but also a generalization curve, for the OR, on words associated with "light" on the Kent-Rosanoff test. In another article by Maltzman

(1966) many experiments of this type are presented. That the OR is vital for conditioning and memory, as the subject must maintain the memory of the stimulus until the occurrence of the consequence, is demonstrated by Lynn (1966) in reporting an experiment by Sokolov. In this experiment, if the UCR to a UCS (tone) is habituated prior to conditioning, then conditioning takes longer than if the tone has never been presented to the subject before.

Summary

Thus there is an alternate explanation for the release of PI effect which can also account for the build-up of PI. Some assumptions are in order to relate the OR mechanism, habituation, and the build-up of PI. If the function of the OR is to produce a stronger trace in order to maintain the memory long enough to check the consequences, and if it is assumed that the memory decays as a function of the strength of the trace, then as the OR habituates, the traces produced are weaker (and decay faster) and the trace would not perservere over time. This would produce the curves obtained in STM studies and be a decay interpretation of forgetting. Two experiments were performed to investigate the predictive and explanatory ability of the habituation hypotheses, contrasted with interference theory, in coping with the build-up and release of PI in STM. The first experiment involves a shift of the stimulus context, the physical size of the stimulus. The second experiment incorporates a physiological measure (GSR) of the OR with a shift of the stimulus content (NNN to CVC).

CHAPTER 2

EXPERIMENT I

Introduction

The release of PI has been interpreted as indicating psychological encoding categories (Wickens, 1970, 1973). This interpretation is based upon the assumption that interference varies directly with the psychological similarity of the items and if an increase in retention is observed when the stimulus category is shifted, then the two categories are psychologically different. Wickens interprets the release of PI from an interference theory framework. Other STM researchers have presented a perceptual alerting interpretation of the release of PI.

Turvey and Egan (1969) changed the stimulus background area size of the fifth trial and produced a release of PI. However, the magnitude of their effect was small, when compared with the releases obtained by shifting verbal categories. Gumenik and Rossman (1970) achieved a release of PI by outlining the ninth trial CCC with a dark rectangle. They reasoned that if a release of PI could be obtained by perceptual isolation then an explanation involving attentional responses to stimulus change would be feasible for both their results and the conceptual class change releases. They also suggested this same mechanism could be used to equate the long-term memory (LTM) research on the Von Restorff effect with the STM research on the release of PI. If it is found to be warranted, the use of a single mechanism to relate and explain results from list learning, paired-associate learning, long-term retention and short-term retention studies would be very parsimonious and extremely appealing. It would be expected, however, that methods shown to be effective for isolating a stimulus in a list learning situation would also be effective in a STM release of PI paradigm.

Gumenik and Levitt (1968), in a list learning paradigm, investigated the isolation effect by varying the degree of isolation. They used a list of nine CVCs and isolated the sixth CVC by having it either smaller or larger than the other eight CVCs. The standard sizes were 2.3 x 4.5 inches and 6.7 x 13.0 inches while the isolated items were either 2.3 x 4.5 inches, 3.3 x 6.4 inches, 4.7 x 9.1 inches, or 6.7 x 13.0 inches. They found that size deviation could be effectively employed for isolation and that the degree of learning for the isolated item was directly related to the degree of isolation.

The present experiment was done to investigate the abilities of an effective isolation dimension (size) in a STM release of PI design.

Method

The subjects were 48 male and 48 female volunteers from the Simon Fraser University community who were paid for participating in the experiment.

A Kodak slide projector was coupled with a Gerbrands electric shutter for stimulus presentation. A Uher tape recorder and headphones were used to administer the intervening activity. The temporal parameters and sequences were controlled by Grason-Stadler timers and relays. All equipment was located outside a sound proof booth. The stimuli were projected through a window into the booth and the warning and recall lights, as well as the intervening activity were patched into the booth. The instructions are in Appendix A and the stimuli and list orders are in Appendix B. The stimuli were four low associational value (from 1 to 9) CVCs randomly selected from Archer (1960) and were arranged into four counterbalanced orders such that each CVC appeared equally often on each trial. Each stimulus was contained on a slide and was white on a black background. Each S was tested individually in a sound proof booth and was monitored by a Packard Bell camera. All Ss received four Brown-Peterson trials. A trial consisted of: a 3 sec. warning signal (a green light); a 1 sec. presentation of a CVC; 20 sec. of writing down digits presented aurally at a 2 per sec. rate; and, a 5 sec. recall period (signalled by a red light) during which the S wrote down the response. The warning and recall lights were located in front of the S. The offset of each trial was immediately followed by the onset of the next trial.

The Ss were assigned to one of three groups. Each group was comprised of 16 males and 16 females. The size of the CVCs for one group was 1.27 x 3.81 cm. for all four trials. The second group received 5.08 x 15.24 cm. stimuli for the first three trials and a 1.27 x 3.81 cm. stimulus for the fourth trial. The third group received 10.16 x 30.48 cm. stimuli for the first three trials and a 1.27 x 3.81 cm. stimulus for the fourth trial. The background was a 26 x 28 in. screen.

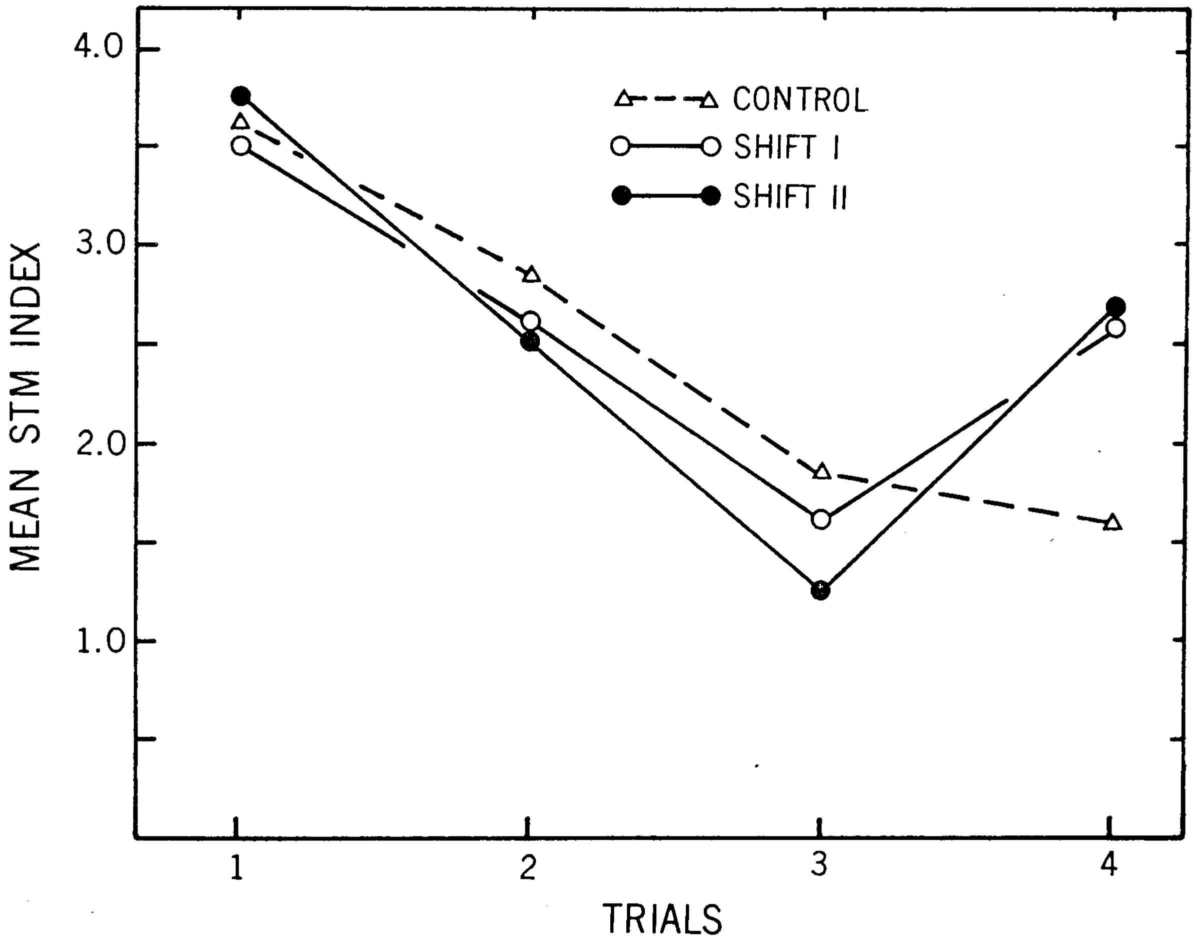
Results

The scoring method employed was the one used by Kincaid and Wickens (1970) wherein each correct letter received one point and an additional point was awarded if all letters were correct and in their correct position.

The effects of stimulus size, gender and the three trials prior to the shift were investigated by an analysis of variance. The only significant effect was that of trials, $F(2,180)=83.076$, $p < .001$, indicating the build-up of PI. The means for trials 1, 2 and 3 were, respectively 3.63, 2.60, and 1.55. The raw data are in Appendix C and all source tables are in Appendix D.

A separate analysis of variance was calculated on the shift trial data for gender and prior stimulus size. The main effect of gender and the interaction of gender and stimulus shift were non-significant, while the main effect of stimulus shift was significant, $F(2,90)=6.247$, $p < .005$ (see Figure 1 for the build-up and release of PI). The means for the nonshift group (1.27 x 3.81 cm. to 1.27 x 3.81 cm.), the medium shift group (5.08 x 15.24 cm. to 1.27 x 3.81 cm.), and the large shift group (10.16 x 30.48 cm. to 1.27 x 3.81 cm.) were, respectively, 1.594, 2.594, and 2.635. A Duncan's Test of Means was performed on these groups (see Appendix F). The medium shift condition and the large shift condition were not significantly

Figure 1. Mean STM scores for the control (1.27 x 3.81 cm. to 1.27 x 3.81 cm.), Shift I (5.08 x 15.24 cm. to 1.27 x 3.81 cm.), and Shift II (10.16 x 30.48 cm. to 1.27 x 3.81 cm.) groups over all four trials.


CONTROL
SHIFT I
SHIFT II
4.0
3.0
2.0
1.0
MEAN STM INDEX
1
2
3
4
TRIALS

different from each other but were both significantly better than the nonshift condition ($p < .005$).

Discussion

Although the degree of release did not vary directly with the degree of deviation, the results did demonstrate that changing the physical size of the stimulus produces a release of PI. Wickens' (1970) formula for estimating the relative magnitude of release was calculated for the shift I and shift II groups. The shift I and shift II groups achieved respectively, 50% and 52% releases of PI. This finding increases the viability of relating the isolation effect with the release of PI and postulating the same mechanism for both. The mechanism could be interference (Wickens, Born, and Allen, 1963) or perceptual alerting (Gumenik and Rossman, 1970).

Wickens (1970) has pointed out that it would appear to be incumbent upon a perceptual alerting hypothesis to also explain the observed decline in retention over the first four trials. This could be attempted by viewing the first stimulus as a deviation from the just prior environment and as such is itself a change. The following stimuli then possess many of the same properties (size, color, background, and conceptual class, as examples) and thus become less deviant as trials progress. This explanation, increased attention in response to stimulus deviation, becomes very similar to the retrieval cue hypothesis discussed by Wickens (1970). One only has to assume that the unique retrieval cues, provided by the stimulus deviation, produce a perceptual alerting (or vice versa). The attractiveness of adding the attentional/ perceptual concept is in its ability to draw together not only verbal learning and retention studies, but also data and measures from the areas of perception and attention.

CHAPTER 3

EXPERIMENT II

Introduction

There are two major interpretations of the release of PI, one by interference theory and the other by a perceptual alerting hypothesis.

The interference interpretation approaches the release of PI from the viewpoint that interference is specific to a verbal psychological encoding category and the interfering associations are minimized when a different psychological category is introduced. This approach has led interference theorists to investigate verbal psychological encoding categories by introjecting conceptually different categories into the Brown-Peterson paradigm. If a release of PI is noted, then a different category has been defined. It should be noted that this approach is circular and lacking of independent measures or empirical validation of the hypothetical constructs of interfering associations, their extinction and subsequent spontaneous recovery, or the nature of how they interfere.

The perceptual alerting approach has used the stimulus isolation procedures found in the Von Restroff type of LTM verbal learning studies and applied those procedures to the Brown-Peterson STM paradigm. This approach has led to experiments emphasizing shifts of the physical properties of stimuli. There are no obvious verbal psychological encoding categories involved in isolating the shift item by enclosing it with a dark rectangle (Gumenik and Rossman, 1970), or by reducing its physical size (Experiment I). This approach defines a releasing dimension of priori and introduces it as a shift category to determine its effectiveness in the release of PI paradigm.

An assumption of an arousal increment underlies the perceptual isolation hypothesis of increased attention as the mechanism underlying the release of PI. There have been studies emphasizing arousal which have employed the galvanic skin response (GSR) as a measure of arousal and have found a relationship between arousal and subsequent recall, immediate and delayed (Maltzman, Kantor, and Langdon, 1966; Corteen, 1969), and between arousal and paired-associate list learning (Belloni, 1964).

Two previous attempts to obtain physiological measures as indices of arousal in the release of PI paradigm have not been successful. One was by Wittlinger (1967) employing GSR and another was by Engle (Wickens, 1974) employing pupillary changes.

A pilot study was done wherein the GSR was monitored in a release of PI paradigm. One group ($N = 4$) received trigrams of random number configurations (NNN), with the exception of any duplication of numbers in any NNN, for the first 3 trials and a CVC on trial 4. A control group ($N = 5$) received CVCs for all 4 trials. The shift group had a mean trial 4 STM score of 4.0 (on a 0 to 4 scale) and the control group had a mean score of 1.2. The difference was analysed by a t-test and was significant, $t\ (7) = 6.60$, $p < .001$. The GSR score was obtained by taking the value of resistance at stimulus offset

(Rb) as the baseline and the lowest point of resistance occurring within the next 5 sec. (Ra) and calculating the percentage change for each subject (Rb-Ra÷Rb) (Davis, 1952, 1974). The mean percent scores for the shift and control groups were 4.118 and 0.678 respectively. This difference was also analysed by a t-test and found significant $t\ (7) = 8.623,\ p < .001$. It should be noted that only the trial 4 GSR data could be used, and that trial 4 data from several subjects was rejected, leaving Ns of 4 and 5. This was due primarily to "drift" forcing excessive balancing during the course of the experiment. This "drift" could have been produced by a DC offset potential (Biophysical Measurements, 1971), or polarization (Montagu and Coles, 1966). This will be discussed further in the methods section.

The present experiment was done to further investigate arousal interpretations of the release of PI.

Method

The subjects were 8 male and 8 female volunteers from the Simon Fraser University community who were paid for participating in the experiment.

The instructions are in Appendix A. The stimuli and list orders are in Appendix B1. The procedure and equipment are the same as employed in Experiment I except that the warning signal was increased to 6 sec. and GSR was monitored. The control group had CVCs for all 4 trials. The shift group had NNNs for the first 3 trials and a CVC for trial 4.

A constant current (10 microamperes) DC pulsating circuit was employed to measure resistance (see Appendix G). Three 40 msec. pulses per second were delivered to the subject. This rate produces an off-time of 88% and should minimize polarization to a negligible factor (Biophysical Measurements, 1971). The circuit also employed a sample and hold operational amplifier for the final output. Each 40 msec. pulse was sampled for 1 msec. between 38 and 39 msec. That value was then held until the next pulse. The output was delivered to a Health Model SR-255B strip chart recorder.

The subjects non-preferred arm and hand (all subjects were right-handed) were placed on foam padding to reduce movement artifacts. Beckman Lot #650951 electrodes, filled with Beckman offner electrode paste, were affixed to the non-preferred hand, one in the centre of the palm and the other on the back of the hand between the final thumb joint and the final first finger joint. The skin was prepared by wiping the skin with alcohol on cotton.

The resistance value of each subject was obtained by insertion of a resistance substitution box in place of the subject.

Results

The scoring method employed for the STM data was one wherein each correct letter was assigned one point and position of the letters was ignored. This scoring method differs from the scoring method used in Experiment I in that the position of the letters is ignored resulting in a 0 to 3 range rather than a 0 - 4 range. It was also observed, in Experiment I, that of 384 total scores there were only eleven scores of 3. The GSR was scored by the method used in the pilot study (per cent change).

The STM and GSR data were separately analysed for the effects of stimulus class, and gender, over the first three trials prior to the shift by an analysis of variance. In the STM data, the only significant effect was that of trials (T), $F(2,24) = 4.7203$, $p < .025$, while for the GSR data the only significant effect was that of stimulus class (C), $F(1,12) = 11.4735$, $p < .01$. The STM means for trials 1, 2, and 3 were 2.75, 1.81 and 1.81, respectively. The GSR means for stimulus class were .05805 (NNNs) and .02731 (CVCs). The raw data are in Appendix C.

The STM and GSR trial 4 data were subject to separate analysis of variance. All source tables are in Appendix D. Stimulus shift (C) was the only significant effect in either data set; STM data -- $F(1,12) = 6.39139$, $p < .05$; GSR data -- $F(1,12) = 7.60941$, $p < .025$). The STM means were 3.00 and 2.125 for the shift and no shift conditions respectively. The GSR means were .06687 and .01882 for the shift and no shift conditions respectively.

An additional analysis was performed on all the data prior to the shift trial. The STM memory scores were classified as either correct (STM score of 3) or incorrect (STM score of 0, 1, or 2) and used as a separation criterion for the GSR scores. GSR average score was calculated for each subject by separately averaging the GSR scores related to the STM classification of correct or incorrect. If a subject scored either all correct or all incorrect STM scores the data were removed from the analysis (only data from one subject had to be removed). An identical subjects t-test was done on the GSR data and displayed a significant difference between the two sets of scores $t(14) = 3.17$, $p < .01$. The mean for the correct condition (.051) was superior to the mean for the incorrect condition (.038).

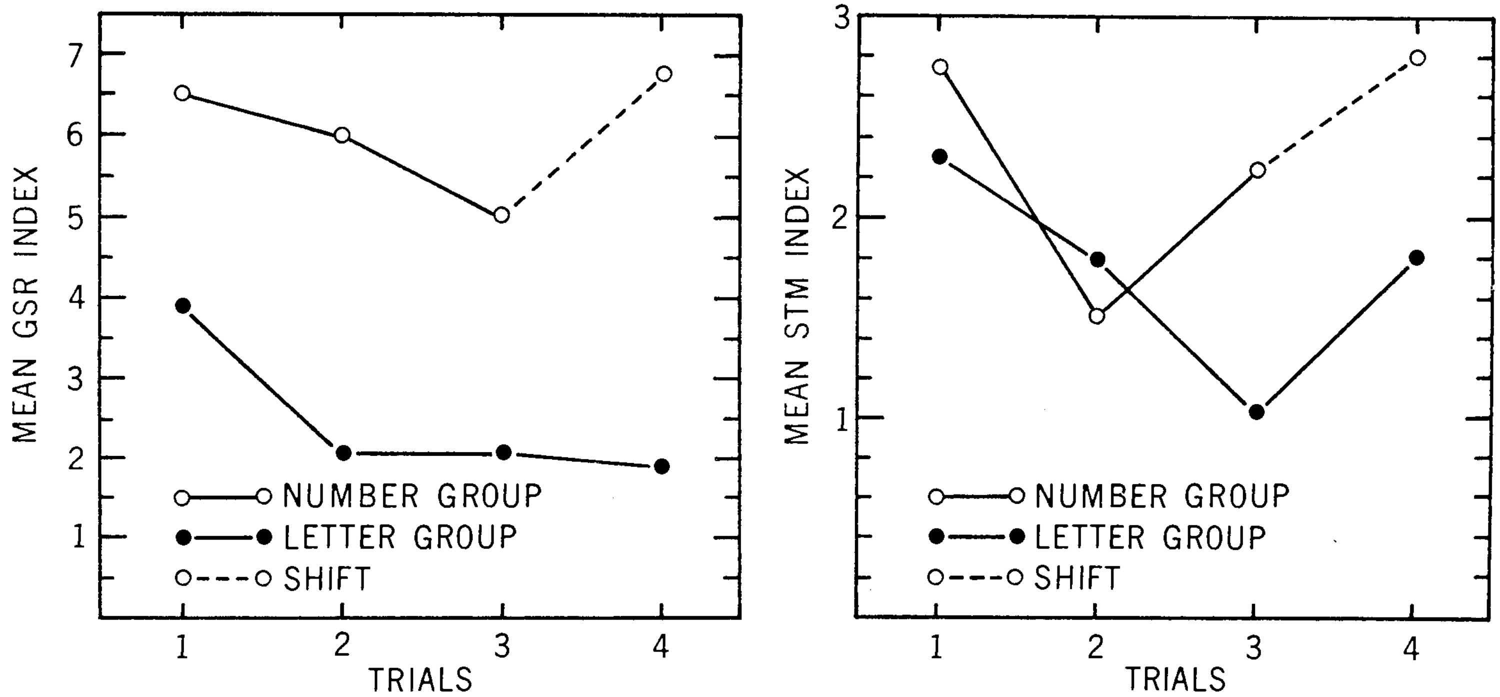
A t-test was also performed on the GSR responses to the first warning signal. This indicated that there was no significant difference in GSR responses between the shift and no shift groups prior to the introduction of the first stimulus $t(14) = 1.38$, $p < .10$. The means for the shift and no shift groups respectively were .0775 and .0479.

The means for the GSR and STM data for the shift and no shift conditions for all trials are displayed in Fig. 2.

Discussion

The significant effect of stimulus class in the GSR scores is in accord with prior research displaying superior STM performance of NNNs compared to CCCs (Wickens, Born and Allen, 1963) and in keeping with the slight, but nonsignificant trend in the STM data of this experiment. Had the number of trials been extended, it is felt this trend would have become more clearly established, as the difference in STM performance in the Wickens, et al. study was not apparent until after the fourth of ten trials. The significant effect of trials in the

Figure 2. Mean short-term memory (STM) and galvanic skin response (GSR) scores for the shift and control groups over all four trials.


MEAN GSR INDEX
7
6
5
4
3
2
1
1
2
3
4
TRIALS
NUMBER GROUP
LETTER GROUP
SHIFT
MEAN STM INDEX
3
2
1
1
2
3
4
TRIALS
NUMBER GROUP
LETTER GROUP
SHIFT

STM data portray the build-up of PI. The same trend was apprent, but nonsignificant, in the GSR data.

The a priori t-test performed on the GSR data (blocked on correct and incorrect memory scores) indicates that even during the build-up of PI (trials 1, 2, and 3) and across stimulus class (the difference was greater in the CVC condition than in the NNN condition), the GSRs were significantly greater when an item was correctly recalled than when an item was incorrectly recalled. Therefore, it is concluded that the data from the first 3 trials are supportive of a perceptual alerting, or arousal hypothesis.

The trial 4 data provide the strongest evidence for the arousal hypothesis. In both the STM and GSR data, the shift group trial 4 means surpassed the trial 1 shift group means and were significantly superior to the appropriate non-shift trial 4 means, although all groups received identical stimuli and conditions on trial 4 and differed only in stimulus class received prior to trial 4. Wickens' (1970) formula for estimating the relative magnitude of release of PI was calculated for the STM and GSR data and yielded releases of 175% and 233%, respectively.

The major criticism of studies of the arousal hypothesis states that there should be an independent physiological measure of arousal (the intervening variable) and that two prior attempts to obtain this measure have been unsuccessful (Wickens, 1974). These unsuccessful attempts are in contrast to the previously mentioned studies involving immediate and delayed relation in list learning. One unsuccessful attempt involved GSR (Wittlinger, 1967). Wittlinger used a contingency table blocked on correct or incorrect STM shift trial scores and GSR responses on shift trial greater than GSR responses on preshift trial or GSR responses on shift trial less than GSR responses on non-shift trial (for all groups). This method ignores magnitude of differences in the GSR (especially for shift groups), and excessively weights the minor GSR fluctuations of the control group, as well as ignoring that a subject could have achieved a correct STM score on the pre-shift trial and a correct STM score on the shift trial and produce a slightly lower GSR score on the shift trial. Wittlinger also treated any decrement in skin resistance (relative to the skin resistance at onset of stimulus) as an arousal response. This discounts magnitude or degree and measures drift and polarization as well as GSR. In short, the noise could have well been stronger than the signal, producing statistically insignificant results.

The present experiment by-passed many of the above pitfalls and demonstrates an independent measure of arousal related to the release of PI, and when coupled with prior research indicating the effectiveness of physical shifts, in releasing PI, presents the most parsimonious interpretation of research in the area. The arousal interpretation also has the advantages of containing an intervening variable which can be investigated and measured (as opposed to the hypothetical constructs of interference theory) and a noncircular approach to investigations of the release of PI phenomenon.

CHAPTER IV

GENERAL DISCUSSION

The Habituation Hypothesis

The major purpose of the present research was to investigate the relevant variables involved in the release of PI in STM. The approach taken stemmed from the observation that all releases (content, context and temporal) contained the common element of deviation from prior experienced events.

The build-up of PI occurs when a particular sequence of events (stimuli) occurs in a predictive, repetitive manner. That the first stimulus is a deviation from prior experience can be ascertained from almost any introductory psychology student who has participated in a STM experiment. Elaborate instructions, written and/or verbal preparation, informing the subject of the events which will occur, do not appear to reduce this first trial effect any more than knowledge and training in parachute jumping would eliminate the emotion occurring with the first jump. As trials progress, however, the events become more predictable (less deviant) and a concomitant decline in retention is observed. Then, after the build-up of PI, if the events again become deviant, an increase in retention is observed (the release of PI).

The hypothesis presented in this paper, which has been variously termed the habituation, arousal, perceptual alerting, or OR hypothesis, places major emphasis upon the concept of deviation and its subsequent physiological correlates (related physiological evidence will be discussed later). Basically, the habituation hypothesis assumes that deviation in the STM paradigm elicits an OR from the subject and that this OR enhances the processing and retention of the item associated with the deviation. In this paper two approaches were taken to investigate the predictive and explanatory abilities of the habituation hypothesis. The first approach involved an operational definition of deviation in a context shift and assumed that an OR would accompany the deviation and would be reflected by increased shift trial retention. The second approach was to introduce deviation in the content (NNNs to CVCs) and simultaneously record the GSR to evaluate the occurrence or nonoccurrence of the OR and its relationship to retention. Thus, the hypothesis was subjected to operational, behavioural, and physiological investigation.

Experiment I clearly indicated that effective releasers are not restricted to content categories or linguistic properties of stimuli. A reduction in the physical size of a stimulus resulted in a release of PI which was comparable to releases obtained with verbal encoding categories. The concept of verbal encoding categories is fundamental to the interference theorists' account of the build-up and release of PI. The initial attractiveness of defining verbal psychological encoding categories, by inserting them into the release of PI paradigm, is reduced when the concept is extended to encompass contextual and temporal releases. The habituation hypothesis, however, can effectively be employed to predict content, context, and temporal releases of PI.

Additional confirmation of the habituation hypothesis was provided by Experiment II. The physiological responses (GSRs) to the shift trial stimuli were significantly larger in the experimental group than in the control group.

Criticisms of the Habituation Hypothesis

A leading interference theorist has offered three major criticisms of the arousal interpretation of the release of PI. They are:
(1) Arousal theorists have not accounted for the build-up of PI;
(2) Physical shifts produce only marginal release of PI; and
(3) Attempts to obtain physiological support have not been successful (Wickens, 1970, 1974).

The first criticism has been answered in the Discussion section of Experiment I. The STM paradigm does contain the basic ingredients for an operational definition of habituation. A stimulus class is repeated in a predictable sequence. [Lynn (1967) reports semantic habituation, wherein a subject habituates to repeated presentation of words of similar meaning and dishabituates when then presented a word of different meaning.] The build-up of PI, then, can be accounted for by the habituation hypothesis.

The second criticism was answered by the Results section of Experiment I. The magnitude of release obtained by shifting the size of the stimulus was on par with the magnitude of releases obtained with semantic shifts. It should also be noted that a shift in the method of presentation (Auditory-Visual) is actually a shift in the physical properties of the stimulus, a context shift, with the semantic properties held constant. Shifts in the manner of presentation have produced releases equal to shifts between letters and numbers. If shifts of a physical nature are included in the classification of psychological verbal encoding categories, along with the rapidly growing list of effective "releasers", then the classification becomes vague and loses its original intent.

The third criticism is the most difficult to answer. There are two basic approaches available for an arousal interpretation of the release of PI. The first approach is an operational one wherein one evaluates previous research concerning arousal and selects a stimulus dimension known to produce an OR when shifted and inserts this shift into the release of PI paradigm. This is a legitimate and valid approach providing that there is a body of research to draw from and the results are predicted a priori in accordance with the related research. This approach is in contrast to the interference approach wherein one draws from intuitive assumptions a conceptual psychological verbal encoding category and inserts the category into the release of PI paradigm and if a release is observed, then a category is defined.

The second approach available for an arousal interpretation is to monitor physiological activity during the experiment, measure the responses to the stimuli, and analyze the relationship between the physiological data and the memory data. This approach, of course, would provide the most direct inquiry into the relationship. A physiological measure does allow a closer investigation of the intervening variable contained in the habituation hypothesis. Experiment II portrayed a significant relationship between the GSR at time of stimulus presentation and subsequent recall and is offered in answer to the third major criticism.

Apparent Negative Release of PI Evidence

In the specific STM release of PI paradigm, the negative evidence consists mainly of failures to obtain physiological support (discussed in Experiment II). There is an experiment, however, which relates evidence seemingly contrary to the habituation hypothesis in a temporal release of PI situation. Cermak (1970) used ITIs in a release of PI experiment. One group, (SL) had ITIs (rest periods) of 6-sec between the first four trials and a 66-sec ITI between the fourth and fifth trials. A second group (LS) had 66-sec ITIs between the first four trials and a 6-sec ITI between the fourth and fifth trials. Two control groups (SS and LL) had constant ITIs of 6 or 66-sec between all five trials. The fifth trial retention means for the SL, LL, LS, and SS groups were approximately 75, 72, 52, and 48 per cent, respectively. The critical finding for the habituation hypothesis is the apparent failure of temporal shifts to produce releases of PI. However, as was pointed out in the introduction, the ITI is relevant as in "a change is as good as a rest". This equates the ITI to a length of time during which habituation can dissipate. Even so, a deviation in the ITI is still a deviation from the just prior experience and a release of PI, relative to a control group, would be expected. The appropriate control group for any shift group is the group that experiences identical conditions on the shift trial, the experimental and control groups differing only in conditions prior to the shift trial. Cermak did not analyze the fifth trial data for the LS vs SS or the LL vs SL, but visual inspection reveals that for fifth trial retention the SL is superior to the LL and the LS is superior to the SS.

Related Verbal Learning Evidence

The insertion of a heterogeneous item into an otherwise homogeneous list of items, in effect isolating the heterogeneous item, results in faster learning of that item in a serial list learning paradigm and some evidence suggests that the isolated item is better retained, compared to its control, in a subsequent LTM recall test (Wallace, 1965). The isolation effect is also found in PA list learning. The isolation is effective with either the stimulus or the response item, but isolating the stimulus item appears to produce the greatest advantage (Hall, 1971). Investigators in serial and PA list learning have employed both stimulus content and stimulus context as methods of producing isolation. Hall (1971) suggests that the isolation effect in PA serial learning (anticipation) is due in main to the building of associations between the stimulus and response rather than the availability of the response. This is a crucial point as it related other research involving arousal and retention and some seemingly conflicting results.

The isolation studies mentioned above employed a modified study-test or "prompting" methodology in a PA task and typically analyzed and presented their data in terms of errors. The standard methodology entails a study trial followed by test trials. The study trial involves presenting a stimulus (S) item for a fixed time (i.e. 4-sec) followed by presentation of the S item and a response (R) item together for a fixed interval (i.e. 2-sec). The presentations of S and SR items continues until all the items in the list have been presented. There is usually a short ITI between subsequent presentations. The test trials then begin. During the test trials, the subject anticipates the R item when the S item is presented. Records are maintained of the errors associated with the SR pairs and the experimental session usually continues until a set criterion has been achieved (i.e. one errorless trial or 25 trials). This methodological review is necessary to relate the isolation studies with later research concerning arousal and retention.

More recent and direct investigations of the effects of arousal upon retention indicate that there is high immediate retention and low delayed retention with low arousal and low immediate retention and high delayed retention with high arousal (Kleinsmith and Kaplan, 1963; Kleinsmith and Kaplan, 1964; Walker and Tarte, 1963; Butler, 1970; McLean, 1969). In contradiction, other investigators have found higher immediate and higher delayed retention with high arousal when compared to low arousal (Yarmey, 1966; Maltzman, Kantor, and Langdon, 1966; Corteen, 1969).

When the methodological procedures of the two conflicting groups of experiments are considered, important differences emerge. The group reporting the inverse relationship between arousal and retention have all employed the basic paradigm, a single study-test PA presentation. There were minor differences in the methods of cueing the start of the study trial, but the study trial for all consisted of a 4-sec S presentation followed by a 4-sec SR presentation, a 4-sec presentation of colors to name and, another 4-sec presentation of colors. The second S item followed the last color presentation and the previous sequence repeated. The sequence continued until all items had been presented once. A test trial was then, at varying intervals, presented. The test trial was comprised of a 4-sec presentation of the S item (during which the subject attempted to recall the R item associated with the S item in the study trial) followed by two 4-sec presentations of colors to name. This sequence continued until all S items had been presented once. A slight deviation exists in that some of the studies used three 4-sec color presentations during the test trial. Arousal, when measured, was measured in terms of percent deflection of the GSR when the S item was presented in the study trial. It should be noted that the item to be recalled was the R item. In other words, the arousal measured was the arousal related to the S item and not to the R item, which was the item evaluated for retention. The arousal measured could have been related to the strength of the associations developed between the S and R items and unrelated to the retention of the R item (as indicated in the isolation studies involving PA list learning) and the developing of the associations for the ability of the S item to recall the R item is where the consolidation occurs. Evaluation of the procedures of the research indicating overall superior retention with high arousal is necessary.

Kaplan and Kaplan (1969) reasoned that, as the standard anticipation method was not used in their prior work, it was not necessary to continue the S alone presentation in the study trial. In eliminating the S alone presentation and measuring the GSR to the SR presentation, they were closer to investigating the arousal effects associated with the item to be recalled, although there was still some confusion with the response to the S item. They found a vast reduction in the magnitude of the arousal and time interaction. The results were more in accordance with superior overall retention of high arousal items. A small difference existed at the first (2-min) retention interval, with the low arousal items superior to the high arousal items. It would be predicted, from the habituation hypothesis, that if the GSRs to the R item could be separated from the S item (or that arousal to the to be recalled item could be measured) a direct relationship would exist between arousal and retention. In an indirect way, Yarmey (1966) accomplished this by using high arousal words as the R items and two digit numbers as S items. In this manner, arousal was attributed to the to be recalled item. He also did not use the S alone presentation in the study trial. In six pairings of study-test alternations, he found retention to high arousal items superior to low arousal items throughout all six tests (the first test is equatable to the immediate recall condition of the prior studies).

Another method of separating the responses of the S and R items and measuring the relationship between arousal and the to be recalled item would be to eliminate the S item altogether and to employ a free recall of a single list presentation of the R items. Maltzman, Kandor, and Langdon (1966) used a single presentation of a list which contained high and low arousal words (confirmed by a subsequent analysis of the GSRs to the words). In a free recall (immediate or delayed) situation, they found superior retention, in both immediate and delayed conditions, of high arousal items compared to low arousal items. It is of interest to note that Kaplan and Kaplan (1968) state that results from their laboratory agree with the finding that high arousal produces overall superior retention compared with low arousal when free recall is used. Corteen (1969) related GSRs to items in a single presentation of a list with recall (immediate, 20-min, and 1 week) in a free recall situation and found superior retention of high arousal items compared to low arousal items at all delays.

It therefore seems that to investigate the effects of arousal upon retention, the arousal should be measured at the time of the presentation to the to-be-remembered item and relatively uncontaminated by other items. On the other hand, to investigate the effects of arousal and consolidation upon retention, the arousal should be at the S presentation when the to be recalled item (R) must be associated with the S item.

Related Physiological Evidence

Lynn (1967) reports that the vegetative changes involved in the OR are: (1) the GSR; (2) respiration; (3) heart rate; and (4) dilation of central blood vessels and constriction of blood vessels in the extremities. The arousal of an organism has been inferred from these indices and the reticular activating system (RAS) has been assumed to be the initiator (Van Olst, 1971).

Fuster (1958) implanted rhesus monkeys in the RAS and stimulated the RAS during a discrimination and reaction time task. He found improved discrimination and faster reaction times when stimulation was applied than when stimulation was not applied. In a subsequent experiment, Fuster and Uyeda (1963) again found that mild stimulation of the RAS produced increased discrimination and decreased reaction time in monkeys. In a supportive study, Galin and Lacey (1972) found improved reaction times in cats with RAS stimulation. Nysenbeaum-Requin, Paillard, and Vitton (1972) further extended the evidence by noting an improvement in the reaction times of cats with RAS stimulation. They also noted that the stimulation is most effective when it precedes the stimulus by, at most, .5 sec. This behavioral evidence is in accord with the physiological evidence and reflects a system whose responsiveness is a function of RAS activity.

Bloch, Deweer, and Hennevin (1970) found that mild RAS stimulation during the retention interval (consolidation period) improved retention of rats in a one-trial discriminative learning task. This improvement was further discussed in a review by Block (1970) who concluded that

"...the registration of new information is followed by a short period of processing which requires a minimum level of arousal [p. 573]."

This research, concerning the direct stimulation of the RAS in animals, lends support to the contention that the production of an OR in human learning and retention studies results in enhanced sensory processing of information and its subsequent retention.

Summary

The habituation hypothesis appears to contain predictive and explanatory abilities concerning the release of PI in STM. More generally, these abilities extend to relate the isolation effect, arousal, and the OR across such diverse methodologies as list and paired-associate learning which have employed anticipation and free recall at immediate and delayed retention intervals.

In addition, the habituation hypothesis contains an intervening variable, arousal, which lends itself to empirical investigation and evaluation and affords drawing from a body of data concerning possible physiological substrates.

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Appendix A:

Instructions for Experiments I and II

This experiment has been designed to see how well you can do a task while being required to remember something else. The sequence of events will be as follows:

> The green light will come on indicating the start of the experiment. Two seconds later an item will be displayed, for a brief time, in the center of the screen in front of you. As soon as the item disappears from the screen, you will begin hearing a series of numbers over the earphones. You are to write the numbers down as fast and as accurately as you can, working in rows from left to right. While writing down the numbers, if you should miss one, just pick up where you can and keep going. When the numbers stop coming, the red light will come on. The red light is the signal to recall the item that was flashed on the screen. You will have 5 seconds to write down the item in the square located on the center top of each sheet. At the end of the 5 second period, the red light will go off and the green light will come on. The green light signals the beginning of the next trial, so as soon as it comes on watch the screen as the next item will be flashed within 2 seconds. The entire sequence will be repeated until the end of the experiment.

Appendix B:

Stimuli and List Orders for Experiment I

Order

1	2	3	4
XYH	VUQ	XEF	ZOJ
ZOJ	XYH	VUQ	XEF
XEF	ZOJ	XYH	VUQ
VUQ	XEF	ZOJ	XYH

Appendix B1:

Stimuli and List Orders for Experiment II

Shift Order 1	2	3	4	No Shift Order 1	2	3	4
841	462	215	693	XYH	VUQ	XEF	ZOJ
693	841	462	215	ZOJ	XYH	VUQ	XEF
215	693	841	462	XEF	ZOJ	XYH	VUQ
VUQ	XEF	ZOJ	XYH	VUQ	XEF	ZOJ	XYH

Appendix C:

Raw Data for Experiment I

	NO SHIFT					SHIFT I					SHIFT II				
	TRIAL					TRIAL					TRIAL				
	Ss	1	2	3	4	Ss	1	2	3	4	Ss	1	2	3	4
MALES	1	2	2	0	2	33	4	2	4	4	65	4	1	0	4
	2	4	4	1	0	34	3	4	4	4	66	4	2	0	2
	3	4	4	0	2	35	4	4	1	4	67	2	3	0	2
	4	4	4	0	4	36	4	2	1	4	68	4	2	2	2
	5	4	3	2	0	37	4	4	2	2	69	1	4	2	4
	6	2	2	3	2	38	2	0	2	2	70	3	2	4	4
	7	1	2	0	0	39	2	4	4	2	71	4	1	0	4
	8	4	1	4	0	40	4	4	0	4	72	2	2	0	4
	9	4	4	1	4	41	4	1	2	1	73	4	2	1	4
	10	4	4	4	4	42	4	2	4	4	74	4	4	1	4
	11	4	1	2	2	43	4	2	0	1	75	4	4	1	4
	12	4	1	1	0	44	4	2	0	2	76	4	1	1	1
	13	4	4	1	2	45	4	4	4	2	77	4	1	2	1
	14	4	4	2	4	46	2	2	1	1	78	4	2	1	2
	15	4	4	2	1	47	4	1	2	4	79	4	4	4	2
	16	4	2	1	0	48	3	2	2	4	80	4	2	2	2
FEMALES	17	4	4	2	1	49	4	1	0	2	81	4	4	2	2
	18	4	4	4	0	50	4	4	2	2	82	4	1	1	4
	19	4	4	0	0	51	4	4	2	4	83	4	2	0	1
	20	3	2	2	1	52	4	1	2	2	84	4	2	1	2
	21	4	0	2	2	53	2	1	2	1	85	4	4	2	2
	22	2	0	2	0	54	3	1	1	2	86	4	4	1	4
	23	4	4	2	4	55	4	2	0	1	87	4	2	1	2
	24	3	4	2	4	56	4	4	4	4	88	4	2	4	4
	25	4	4	0	2	57	4	2	1	2	89	4	2	2	2
	26	4	4	2	2	58	4	2	0	4	90	4	4	2	2
	27	4	1	1	0	59	4	4	0	2	91	4	4	0	1
	28	4	2	2	0	60	4	2	0	2	92	4	4	0	4
	29	4	4	2	2	61	2	4	1	4	93	4	1	1	2
	30	4	2	2	0	62	4	4	2	2	94	4	2	0	4
	31	2	4	4	4	63	4	2	1	3	95	4	2	2	1
	32	4	0	3	1	64	2	4	0	1	96	4	2	1	2

Appendix C1:

STM Raw Data for Experiment II

			TRIALS			
		Ss	1	2	3	4
SHIFT	MALE	1	2	3	2	3
		2	3	2	3	3
		3	3	1	3	3
		4	3	0	2	3
	FEMALE	5	3	3	3	3
		6	3	2	3	3
		7	3	2	3	3
		8	3	0	1	3
NO SHIFT	MALE	9	3	1	2	3
		10	3	2	2	2
		11	3	1	0	3
		12	3	3	0	3
	FEMALE	13	0	3	1	2
		14	3	1	2	3
		15	3	3	0	0
		16	3	2	2	1

Appendix C2:

GSR Raw Data for Experiment II

TRIALS

		Ss	1 R_A	1 R_B	2 R_A	2 R_B	3 R_A	3 R_B	4 R_A	4 R_B
SHIFT	MALE	1	119	130	121	129	130	130	117	135
		2	83	89	85	93	87	95	89	91
		3	107	117	108	112	110	112	102	106
		4	198	220	190	206	224	238	180	208
	FEMALE	5	65	70	64	67	68	70	58	61
		6	92	97	99	106	100	107	98	105
		7	95	96	97	105	86	95	83	89
		8	80.5	84.5	81	83.5	81	85	81	83
NO SHIFT	MALE	9	110	113	116	116	110	110	104	106
		10	97	105	106	109	115	121	111	116
		11	76.5	79	69.5	69.5	72	73.5	72	72
		12	72.5	76	74.5	76.5	75	76	73	73.5
	FEMALE	13	107	107.5	110.5	114	112.5	113.5	111.5	111.5
		14	81	85	85	88	107	108	115	120
		15	77	83	92	96	82	88	84	87
		16	90.5	91.5	92.5	93.5	90.5	90.5	88.5	88.5

Appendix D:

Source Table for Experiment I, Prior to the Shift, for Shift/No Shift (C), Gender (G), and Trials (T).

Source	df	ms	f
C	2	1.010416	.712
G	1	.170139	.120
CG	2	1.732635	1.220
S(CG)	90	1.420097	
T	2	103.135400	83.076*
CT	4	.895783	.722
GT	2	.774239	.624
CGT	4	1.774364	1.429
ST(CG)	180		

* denotes $p < .001$

Appendix Dl:

Source Table for Experiment I, Shift Trial, for Shift/No Shift (C) and Gender (G)

Source	df	ms	f
C	2	11.010410	6.247*
G	1	4.166667	2.364
CG	2	.729246 E-01	.041
S(CG)	90	1.762486	

* denotes $p < .005$

Appendix D2:

Source Table for Experiment II, STM Data, Prior to the Shift, for Shift/No Shift (C), Gender (G), and Trials (T).

Source	df	ms	f
C	1	2.083333	2.586
G	1	.0833333	.103
CG	1	.0833337	.103
S(CG)	12	.805552	
T	2	4.687500	4.720*
CT	2	3.145833	3.168
GT	2	.395833	.399
CGT	2	.520815	.525
ST(CG)	24	.993041	

* denotes $p < .025$

Appendix D3:

Source Table for Experiment II, GSR Data, Prior to the Shift, for Shift/No Shift (C), Gender (G) and Trials (T).

Source	df	ms	f
C	1	.113368E-01	11.474*
G	1	.220995E-01	.234
CG	1	.452980E-03	.458
S(CG)	12	.988090E-03	
T	2	.117140E-02	2.753
CT	2	.187435E-03	.441
GT	2	.136496E-02	3.208
CGT	2	.685572E-03	1.611
ST(CG)	24	.425537E-03	

* denotes $p < .01$

Appendix D4:

Source Table for Experiment II, GSR Data, Shift Trial, for Shift/No Shift (C) and Gender (G).

Source	df	ms	f
C	1	.923713E-02	7.609*
G	1	.719313E-03	.593
CG	1	.111089E-02	.915
S(CG)	12	.121391E-02	

* denotes $p < .025$

Appendix D5:

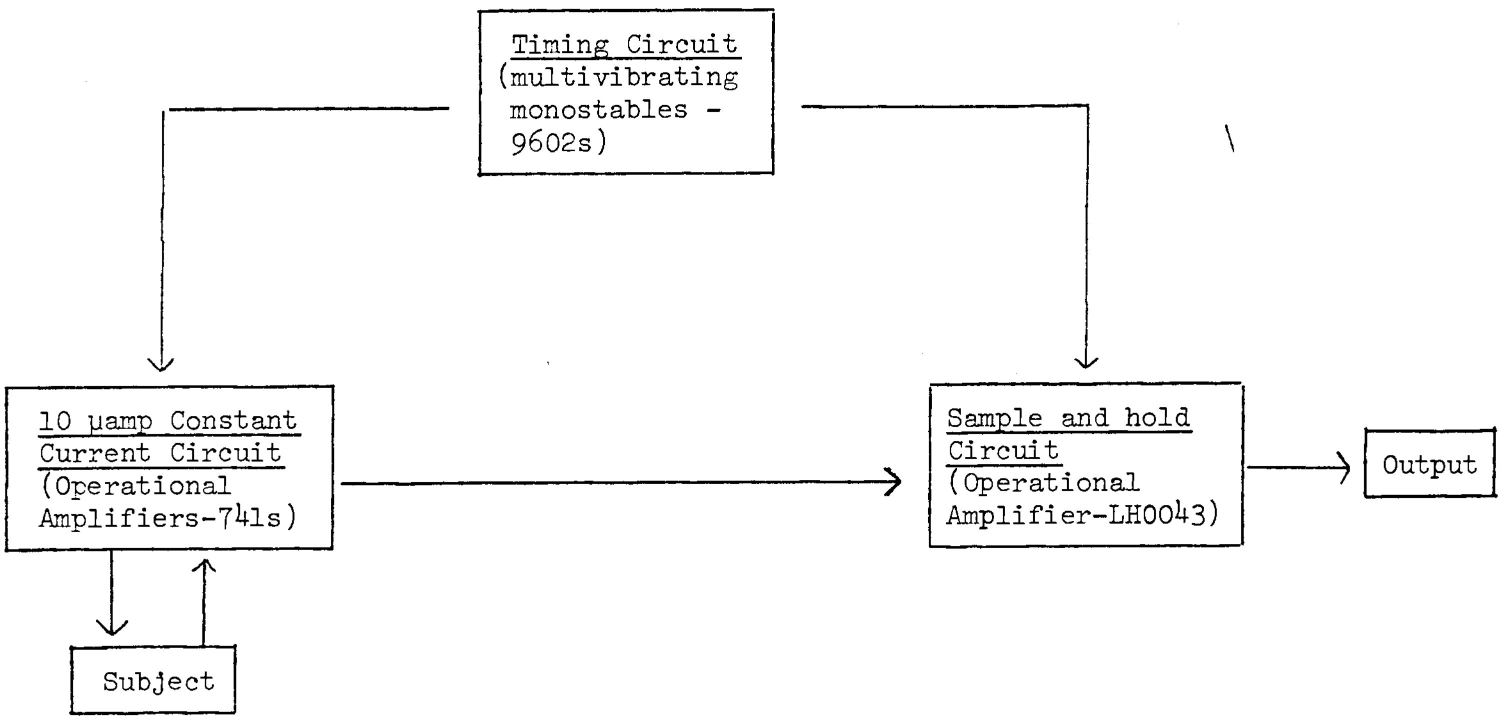
Source Table for Experiment II, STM Data, Shift Trial, for Shift/No Shift (C) and Gender (G).

Source	df	ms	f
C	1	3.063500	6.39139*
G	1	1.562500	3.26091
CG	1	1.562500	3.26091
S(CG)	12	.479160	

* denotes $p < .05$

Appendix E:

Block Diagram of GSR Circuit



Appendix F:

Duncan's Multiple-Range Test on the Fourth Trial

Mean Scores for each Condition

X	Condition			Range
	1.27 x 3.81 cm.	5.08 x 15.24 cm.	10.16 x 30.48 cm.	
	1.594	2.594	2.635	
1.594		1.0000*	1.0410*	R_2 = .9670
2.594			0.0410	R_3 = 1.0050

* $p < .005$