SITUATIONAL FREQUENCY: AN ENCODED OR DEPRIVED ATTRIBUTE OF MEMORY

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SITUATIONAL FREQUENCY: AN ENCODED OR DERIVED ATTRIBUTE OF MEMORY

by

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ABSTRACT

The purpose of this thesis was to test the validity of conceptualizing situational frequency as an encoded versus derived attribute of memory by using the release from proactive inhibition (PI) technique. Different words were presented 1, 2, 4 or 6 times in a presentation list, following which words of frequencies 1 (low) and 6 (high) were formed into triads for presentation in the release from PI paradigm. The results of the experiment showed that a shift from high to low or from low to high frequency between the third and fourth triads produced a significant release from PI. On a subsequent frequency judgement task, subjects' judgements accurately reflected presented frequency. The results indicate that situational frequency is encoded as one attribute of words in long-term memory.

ACKNOWLEDGEMENTS

I wish to give sincere thanks to Dr. E.J. Rowe, my supervisor, without whose patience, guidance and constructive criticism this work would not yet be complete, and without whose prodding and deadlines it perhaps would not have yet begun. I also wish to thank Mrs. Margaret Rose for typing the final manuscript. Last but not least, I wish to thank my husband, Richard, for the use of his study and for cheerfully coping with an ill-tempered part-time wife while the major work was in progress.

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CHAPTER I

INTRODUCTION

The storage of information about the frequency of occurrence of words has been shown to be a salient characteristic of memory. This applies both to background, or linguistic, frequency as represented by word counts (e.g. Thorndike & Lorge, 1944) and situational frequency, i.e. the number of times a word occurs in a specific situational context. Underwood (1969b) and Shapiro (1969) used subjective estimates of relative word frequency and showed that subjects (Ss) have a valid knowledge of the differential background frequency of words. Other investigators (e.g., Hintzman, 1969, 1970; Howell, 1970; Underwood & Freund, 1970; Underwood, Zimmerman & Freund, 1971) have asked Ss to judge how often words occurred in a presented list and found that their average judgements reflected the actual frequency of presentation. Experiments using a continuous judgement paradigm (Begg & Rowe, 1972; Begg, 1974), where Ss give a judgement for each word as it occurs in the list, have shown a very close correspondence between presented and judged frequency.

At present, there are two general alternatives concerning how frequency of occurrence is represented in memory. The encoded attribute view says that frequency of occurrence is encoded directly as one of the complex of attributes which define the existence of an item in long-term memory. Each time the item is repeated, the frequency attribute updates to a new value. The other hypothesis views frequency as a derived attribute, which is inferred from the general memory representation of the word at the time a frequency judgement is required. By this view, frequency information is not represented directly in memory and thus is only realized if a judgement is made.

The purpose of this thesis is to determine whether the representation of situational frequency is more amenable to an encoded or derived attribute explanation. Specifically, it is asked if frequency of occurrence exists as an independent attribute of memory when such information is not required by the experimental task, as is implied by the encoded attribute, but not by the derived attribute, view. The existence of situational frequency as an encoded attribute was tested using release from proactive inhibition (PI) as the criterion measure (Wickens, 1972). This paradigm has received extensive usage as an effective means of isolating encoded attributes in memory. The remainder of the introduction will discuss some other current hypotheses of frequency representation and their relation to the encoded versus derived attribute positions. Following this, some relevant background to the release from PI paradigm will also be presented.

Memory for word frequency

Hintzman and Block (1971) offered two hypotheses for frequency representation in memory. First, the trace-strength hypothesis claims that repetition of an event increases the strength of a single memory trace, and that any frequency indicator, such as discrimination or estimation, is a matter of reading out the current strength value of the trace. By contrast, the multiple-trace hypothesis states that the effect of repetition is to increase the number of different memory traces of an event, which are then differentiated by temporal information or "time-tags". Frequency estimation from a multiple-trace hypothesis consists of counting the number of traces or time-tags set up by each repetition of an event. Both hypotheses lack a unique frequency representation process. Instead, frequency estimation relies on numerical judgements inferred from the way in which the word is represented in memory.

Hintzman and Block (1971) provided evidence relevant to the two hypotheses. In one experiment, they gave Ss a list of 50 words to study in which there were two instances of some words. The Ss were instructed to judge each word's serial position in the list and to give two judgements if they thought it occurred twice. The results showed that positions for repeated words could be judged independently, suggesting that each presentation established a separate trace. In another experiment, two lists were presented five minutes apart with some words repeated in each. The found that the Ss could readily discriminate the nature of the temporal distribution of the repetitions, i.e. they could judge independently the number of times a word occurred in each of the two lists. This would not be possible if the only effect of repeated presentations were to increase trace strength.

The results demand some mechanism like time-tags of the multiple-trace hypothesis for the separation and discrimination of judgements of the two list frequencies.

Reichardt, Shaughnessy and Zimmerman (1973) used a similar two-list task to examine retroactive interference effects in frequency judgement. The Ss made frequency judgements of each list after it was presented and then did a final recall test for list 1 frequencies. The results showed that recall of list 1 frequencies was independent of list 2 frequencies, as Hintzman and Block (1971) had shown, but that list 2 frequency judgements were not independent of list 1. Again, trace-strength hypothesis cannot account for the independence of judged frequencies found for list 1 whereas the multiple-trace hypothesis can. The relative loss of frequency discrimination in list 2, however, does present a problem which the multiple-trace hypothesis cannot explain.

Howell (1973b), in a review of the frequency judgement literature, discussed two additional hypotheses which might account for frequency judgements. Both of these allow the possibility that situational frequency is specifically represented in memory instead of simply being inferred from the general memory representation, and can therefore be classed as an encoded-attribute hypothesis. Of these two, the numerical inference hypothesis is the more straightforward. It states that Ss can simply count the number of times an item occurs in a list and give the current count as the frequency judgement. A more general version of this type of explanation considers frequency as one attribute of memory set up during storage of an item (Underwood, 1969a).

According to Underwood, an item is remembered as a set of attributes, one of which records situational frequency, and estimates of item frequency are made by reading out the value of the frequency attribute. The frequency attribute could operate through trace-strength, multiple-trace or both. Howell (1973b) recognizes this by calling the frequency attribute a multiple-process view of frequency, which could incorporate features of both multiple-trace and trace-strength theories.

There is some evidence for considering frequency as an encoded attribute which is separate from trace strength, as indexed by recall performance. Underwood (1969b) compared memory for words themselves with memory for their frequency of occurrence. The Ss were set for either recall or frequency judgement and did the two tasks successively. He found high but not complete agreement between the two measures. Underwood concluded that the differences in memorability between words processed under the two different instructions reflected different processes, and that trace strength and the frequency attribute were not the same.

Howell (1973a) wished to compare recall and frequency judgement more directly. He set groups of Ss for either one or the other of the two paradigms, had them study the same word lists, and then tested them on either a recall task or a frequency judgement task. Howell found that frequency was independent of set, but that free recall was not. He concluded that this difference reflected different processes for memory of events and event frequencies.

Research so far does not clearly favor an encoded-attribute view as represented by Underwood's (1969a) position, or a derived-attribute view of frequency representation. The multiple-trace hypothesis seems to fit better with the latter, where Ss would presumably have to count the separate traces at retrieval.

Jacoby (1972) considered frequency as an encoded-attribute view to be rather awkward with multiple-trace representations. He presented Ss with simple sentences, then repeated them intact or recombined words from old sentences to make new sentences. The Ss made frequency judgements of both words and sentences. Jacoby's data supported the multiple-trace hypothesis. Frequency judgements of sentences were influenced only by the repetition of intact sentences, and repetition of words in new sentences did not increase the apparent frequency of the old sentence. This suggests that sentences formed multiple sentence traces and words formed multiple word traces. When these data are considered in terms of encoded attributes, there must be a frequency attribute for each discriminable trace, plus frequency attributes for the sums within possible partitions of repetition traces; or else, as in the case of a noun repeated in many different sentences, the frequency judgements of the noun would be the same as those for the sentences. This becomes very awkward when dealing with several items, and Jacoby therefore favored a derived-attribute explanation.

Rowe and Rose (1974) tested instructional and spacing effects in frequency judgements. The Ss studied a long list of words in which items were presented two, three or five times. They were given either instructions which forewarned them of the frequency judgement test, nonspecific instructions which did not specify the type of test, or incidental learning instructions, where they were instructed to rate words for perceived "strength" only. Rowe and Rose found that judged frequency was a positive function of presented frequency even under incidental learning instructions, suggesting that storage of frequency information is not a voluntary process, i.e. it may not be under the S's direct control. To the extent that encoding of frequency information in Underwood's (1969a) model is voluntary, these results also support a derived-attribute, as opposed to an encoded-attribute hypothesis.

To date then, research has given us two main hypotheses of frequency representation in memory. First, the trace-strength hypothesis which entails strengthening of a single trace with each presentation of an item, and second, the multiple-trace hypothesis where each item repetition produces a separate trace, each trace identifiable by a time-tag. Most of the experimental evidence seems to favor a multiple-trace, rather than a trace-strength hypothesis. The evidence does not clearly decide whether frequency should be conceptualized as an encoded or a derived attribute, although several investigations have recently favored the latter hypothesis. The purpose of this thesis was to provide additional evidence on this point.

Release from proactive inhibition

If frequency is an encoded attribute, it should be possible to demonstrate its existence independent of the frequency judgement test. There are several techniques for isolating attributes of memory, but the one which appears to be most successful is the release from PI technique as derived by Wickens and his associates. This research is based on the Brown-Peterson paradigm for the study of short-term memory (Brown, 1958; Peterson & Peterson, 1959). Peterson and Peterson (1959) showed Ss a consonant trigram for one second, followed by a three-digit number for one second (from which Ss counted backwards by threes or fours for an interval of 3, 6, 9, 12, 15 or 18 seconds), and then gave a cue to recall the trigram. They found substantial forgetting after three and six seconds, and by 18 seconds retention was only about 10 percent.

Keppel and Underwood (1962) demonstrated the existence of PI in this task, indicated by the fact that, with a constant retention interval, the level of recall declined across three trials containing different trigrams. Wickens, Born and Allen (1963) suggested that the PI effect was specific to the class of material used in the presentation. They modified the task so that the retention interval was constant, and changed the category of material presented after three trials. When the items were changed from numbers on the first three trials to consonants on the fourth, they obtained a "release from PI" on the fourth trial, where retention went back up almost to what it had been on trial one. The release obtained in this and other experiments has been attributed to a change in the way in which the items on the fourth trial are encoded in memory. The PI of the first three trials builds up via a set of encoded attributes. If one of these changes (e.g. the class to which the item belongs, as in letters and numbers), the PI does not affect the new class, and this is reflected in a release on that trial.

A large number of studies have now been reported using the release from PI procedure as a means of identifying psychologically-prominent memory attributes. The usual procedure is to present these triads composed of items drawn from one class of material, with each triad followed by a filled retention interval (usually counting backwards by threes) for 20 seconds before the triad is recalled. The class of material is changed for the triad presented on the fourth trial, and the amount of release measured. An idealized example of the type of results obtained when release is found is given in Figure 1, which is taken from Wickens (1972). The experimental group has the class of items "shifted" on trial four, while the control group continues to receive items of the same class as on the first three trials. A standardized measure of release is to take the ratio of the difference between the two groups on trial four to the overall difference between trial one and four for the control group alone, as shown in Figure 1.

Wickens (1970, 1972) has summarized the data obtained from this paradigm. Figure 2 shows the percentage release obtained for shifts of various types. Although additional evidence has been reported for some of these, the pattern of results shown in Figure 2 remains

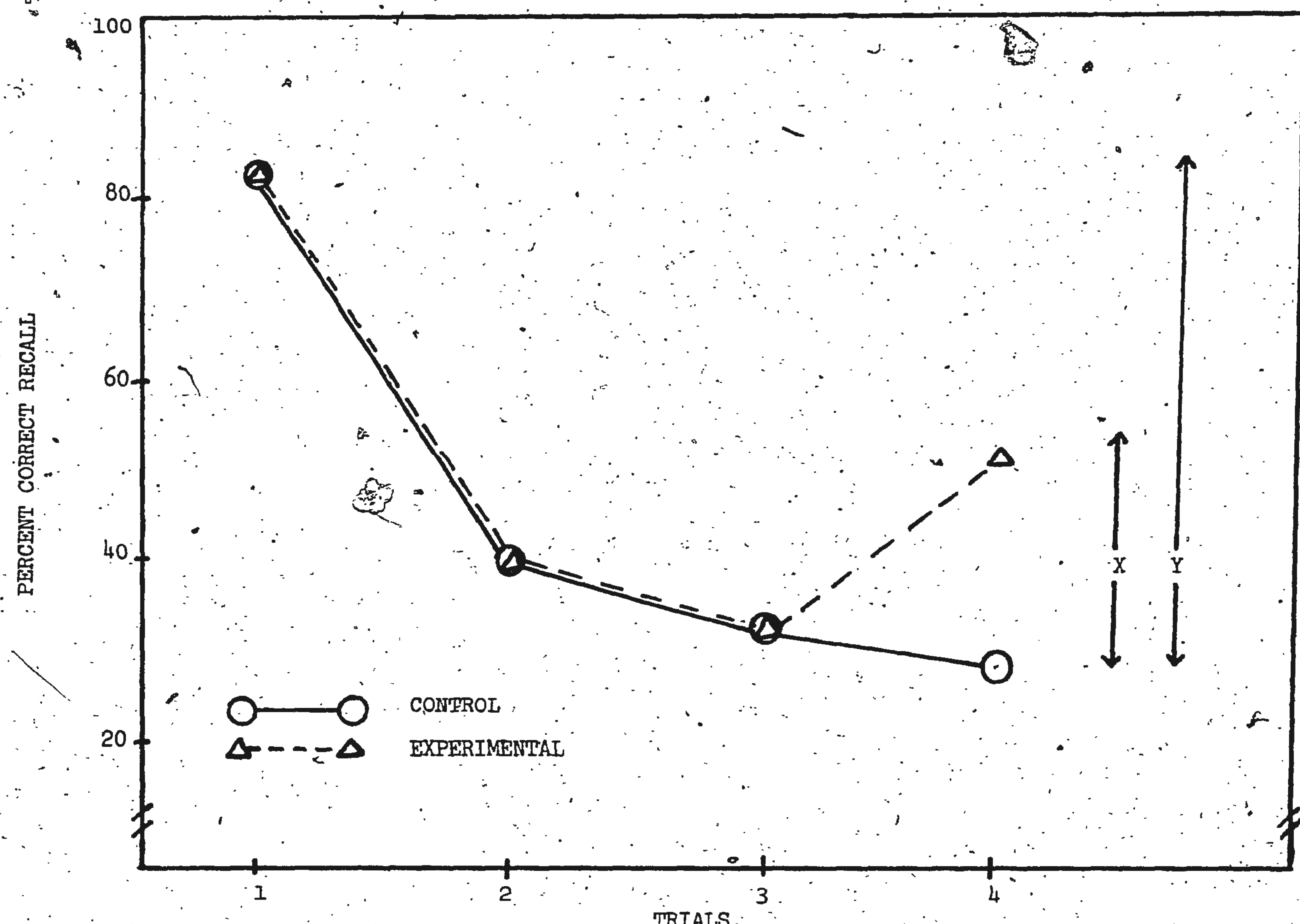

FIG. 1 IDEALIZED RESULTS TYPICAL OF THOSE OBTAINED IN THE RELEASE FROM PI PARADIGM. PERCENTAGE RELEASE = X/Y x 100 (WICKENS, 1972)

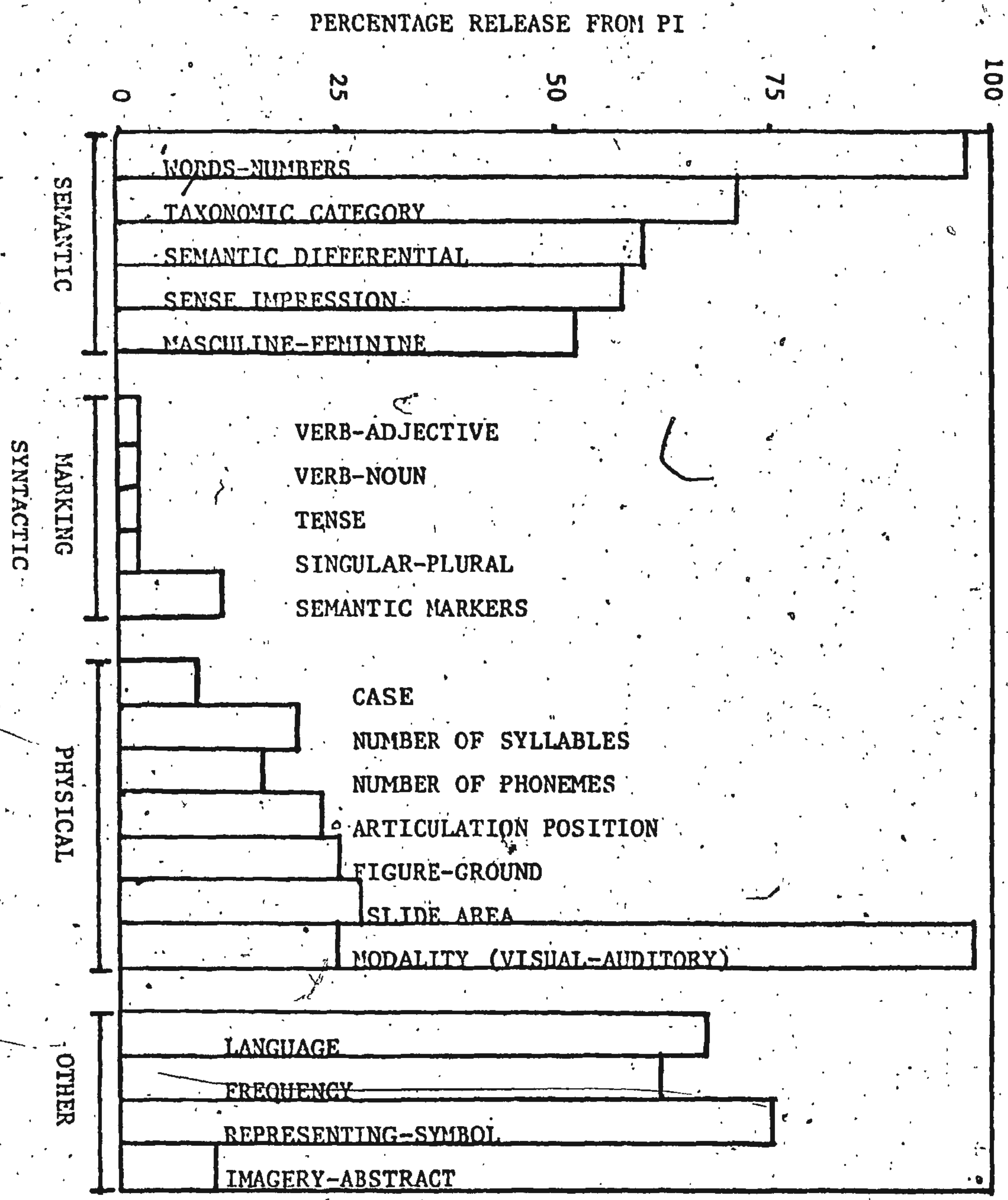

FIG. 2 PERCENT RELEASE FROM PI FOR VARIOUS SHIFTS (WICKENS, 1972)

unchanged. In general, the greatest amount of release has been obtained with shifts in semantic categories, and the least release with syntactic categories. The results for physical categories and "others" are mixed: some of these reach criterion release of approximately 20 percent needed for significance at the .05 level, while others do not.

The release shown in Figure 2 for the frequency category was obtained by Swanson and Wickens (1970), who tested for memory organization on the basis of background frequency. The Ss were tested with words of high and low background frequency, both nouns and verbs, drawn from the Thorndike-Lorge (1944) count. An average release of about 50 percent was obtained when shifts from high to low words (or from low to high) defined a class change. Swanson and Wickens concluded that the background frequency of words is an encoded attribute of memory.

This experiment uses release from PI to test the validity of conceptualizing situational frequency as an encoded attribute of memory. Sets of words, all of which were relatively high in background frequency, were given either high or low situational frequencies in the context of a presentation list. Triads were constructed from these words for a series of four trials in the release from PI paradigm. If a significant release is obtained, we can conclude that situational frequency is also an encoded attribute. If there is no significant release from PI, it will be more reasonable to think of frequency as a derived attribute of memory. As a check that the situational frequency of the words did differ as intended, an unexpected frequency judgement test was administered following the release from PI phase of the experiment.

CHAPTER II

METHOD

Design

The procedure consisted of three phases. In Phase 1, the Ss studied a long list of visually-presented words in which different items occurred 1, 2, 4 or 6 times. Phase 2 consisted of four trials on the release from PI task. The Ss were randomly divided into four groups, HH, LH, LL or HL, where the first letter of the group name indicates the frequency of the triads (frequency 6 or frequency 1) on the first three trials and the second letter denotes the frequency of the fourth triad. Finally, in Phase 3, the Ss received a frequency judgement test on the items from Phase 1 which had not been used in the release from PI task. Approximately 20 minutes were required to complete the three phases.

Lists

Eighty-three four-letter nouns, excluding homonyms and synonyms, were selected from the items with frequencies greater than 10 in the Kucerá-Francis (1967) word frequency count (Appendix B, Table 1). The words were randomly assigned to five frequency conditions, 0, 1, 2, 4 and 6, such that frequency 0 had 15 words and all the others had 17 words each. Words of frequencies 1, 2, 4 and 6 were used for the list presentation, the release from PI task and the frequency judgement task. The words of frequency 0 were used only in the frequency judgement task.

Two lists, A and B, were constructed from the 68 non-zero frequency words such that words with frequencies 1 and 2 in list A were assigned to frequencies 4 and 6 in list B, and vice versa. Thus no word occurred the same number of times in both lists.

The words were typed in lowercase IBM Orator type on index cards, one word per card, and photographed as 35 mm. slides. Including repetitions, this made a total of 221 slides. The slides were ordered for presentation by sorting those of each frequency condition into six piles such that each word appeared no more than once in a pile, and all piles had an equal proportion of slides of each frequency. This provided for the maximum average separation between instances of the same word. Each pile was then shuffled separately before being ordered randomly in the slide trays for presentation.

Twelve words were randomly selected from frequency conditions 1 and 6 in each list (A and B) for the release from PI task. The words of each frequency were arranged in triads so that there appeared to be no semantic, acoustic or connotative similarity between any of the words. This produced four triads of each frequency, for a total of sixteen. The three words for each test triad were typed on index cards in IBM Orator type. They were arranged vertically with each word being typed two spaces to the right of the one above it. The triads were photographed as 35 mm. slides for presentation.

The release from PI task was arranged separately, but identically, for lists A and B. Two control groups and two experimental groups were established for each list. The experimental groups had either high frequency triads (frequency 6) or low frequency triads (frequency 1) on the first three trials, then shifted to triads of the other frequency on trial 4. The appropriate control group for experimental group HL is one which receives low frequency triads on all four trials, i.e. LL; similarly the control group for group LH is HH (e.g. Wickens & Engle, 1970). Eight test groups were established in this manner: ALL, AHH, BLL and BHH as controls, and AHL, ALH, BHL and BLH as the corresponding experimental or shift groups. These triads are shown in Appendix B, Tables 2 and 3.

Procedure

The Ss were told that they would see a long list of words in which some of the items appeared more than once. They were told that they would be tested on this list later and that the nature of the test would be explained at that time. They were instructed to read each word to themselves as it was presented. The complete instructions are given in Appendix A.

The Ss were presented either list A or list B slides at a 2 sec. rate by a Kodak Carousel projector, controlled by an automatic timer. They were tested in groups of up to 7 at a time. All Ss received the same word order for each list.

After the list presentation, the Ss were given a nine-page answer booklet for the release from PI task. The first page of the booklet was for the distractor task practice and identification purposes only. Each subsequent page was used for one aspect of the task, either recording the distractor task numbers or recalling the triad after the distractor task. The Ss turned the page and recorded the portion of the PI task required when told to do so. These instructions are included in Appendix A.

The Ss were read instructions typical of a Peterson-Peterson paradigm (Appendix A), and asked if there were any questions. They were then given a practice trial for the distractor task, which was counting backwards by threes. A three-digit number was presented by the slide projector, the Ss wrote it down in the answer booklet, then continued writing each successive number in the booklet as they counted backwards. The distractor task continued in this manner for 20 seconds.

Groups of Ss were randomly assigned to test conditions LL, HL, LH or HH for the word list they had been shown. Half of the 20 Ss receiving each list in each condition had the first three triads in one order and the other half had them in another order. However, the same triads were seen on each trial by the experimental and corresponding control Ss. For example, the experimental or shift group ALH had the first three triads identical to the control ALL and the same fourth triad as the control AHH, and similarly for group AHL. The second ordering of the test triads are given in Appendix B, Tables 4 and 5.

Each of the four test trials consisted of the spoken word "ready", followed by a triad exposed for 2 seconds, a number for 2 seconds, and a dark screen for 30 seconds. After 20 seconds of the dark screen, Ss were told to "turn the page and recall". The remaining 10 seconds of the dark interval were used for recall, at which time the words "stop writing, ready" occurred and the next trial began. These instructions were pre-recorded on tape from which the projector was also controlled via a Kodak sound synchronizer.

When the release from PI task was completed, Ss were given an answer sheet for the frequency judgement task. This was a list of 35 words, 15 of which had not occurred during the presentation list i.e. frequency 0, and 20 (five from each frequency level) which had not appeared in the PI task triads. The words were arranged in random order. The Ss were instructed to fill in the space opposite each word with the number of times they thought the word had occurred in the presentation list. If they did not remember seeing the word on the screen, they were told to put a zero in the space. They were told to guess the frequency of the words if they could not remember and to fill every space. The frequency test sheet was the same for both list A and B.

<u>Subjects</u>

There were 160 paid Ss, 40 in each of the two experimental (LH and HL) and two control (HH and LL) groups. Most of the Ss were first-year psychology students, but also included were other students and university personnel not acquainted with frequency judgement research or the release from PI paradigm. The psychology students were selected from a human subject pool and contacted by phone or mail. The others were contacted in person by the experimenter. All Ss were told only that they would be doing a visual memory task before the formal instructions were given.

The data for six Ss were replaced by other Ss because of failure to follow instructions. Four of the Ss recalled the distractor task numbers instead of the word triad and two Ss simply ticked the familiar words of the frequency judgement task and left the unfamiliar words blank instead of giving judgements.

CHAPTER III

RESULTS

PI task analysis

The basic analysis for the build-up of PI was a 2 x 2 x 3 analysis of variance of the number of words correctly recalled from each triad, with conditions (experimental and control), triad frequency (high and low) and trials (1, 2 and 3). The conditions factor refers to shift condition on trial 4, i.e. shift or no shift, and was included as a dummy factor to check that the two conditions showed equivalent build-up of PI. The data for this analysis are included in Appendix C, Table 1.

The data analysis (Appendix D, Table 1) showed a main effect of trials, $F(2,312) = 22.33$, $p < .01$, and an interaction between trials and triad frequency, $F(2,312) = 4.66$, $p < .01$. There was no significant effect for conditions $F(1,156) = 2.44$, nor for triad frequency $F(1,156) = 2.76$. Also there were no other significant interactions. The trials main effect confirmed that there was significant build-up of PI across trials. The interaction between trials and triad frequency (Figure 3) is due to a more rapid build-up of PI for the low frequency than for the high frequency triads over the first two triads. Separate one-way analyses of variance showed that the amount of build-up of PI was significant for both high, $F(2,237) = 7.20$, and low, $F(2,237) = 13.37$, frequency

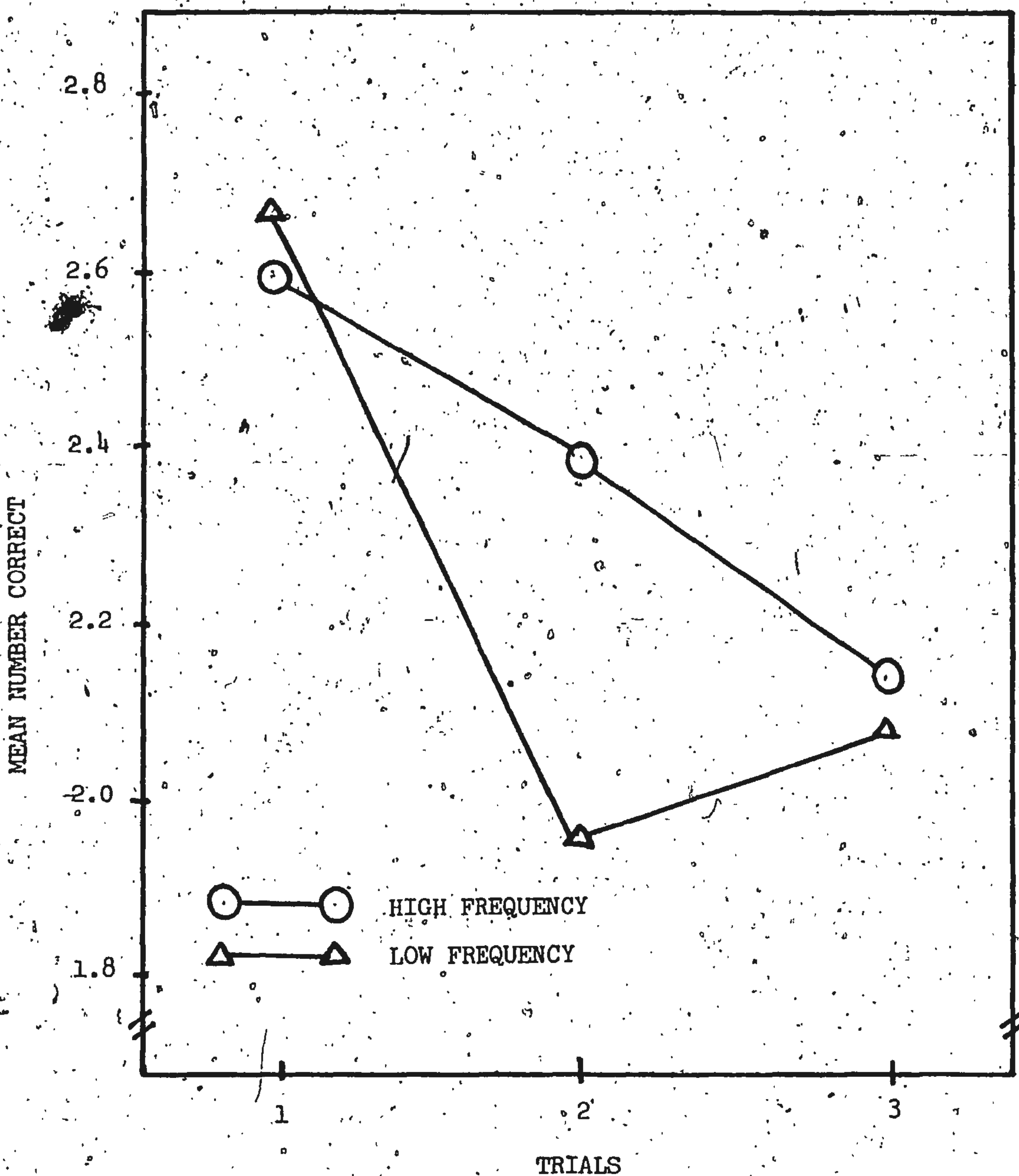

FIG. 3 RECALL PERFORMANCE ON FIRST THREE TRIALS OF THE PI TASK AS A FUNCTION OF TRIAD FREQUENCY

triads (both p's. $< .01$). Details of these analyses are given in Appendix D, Tables 2 and 3. Performance on both triad types was equivalent on trial 3, $t(38) = 1.40$, $p < .05$.

The data for the shift trial are shown in Appendix C, Table 1. A separate 2 x 2 analysis of variance was performed on these data (Appendix D, Table 4), the factors being conditions (shift and no shift) and triad frequency (high and low). The analysis showed that the shift conditions were significantly higher than the two controls, $F(1,156) = 5.95$, $p < .01$, so there was release from PI. The effect of triad frequency (high and low), was also significant, $F(1,156) = 5.96$, $p < .01$, reflecting the fact that high frequency triads were recalled better than low. However, the interaction between the two was not significant, $F(1,156) = 1.30$, showing that equivalent release was obtained both for the high-to-low and low-to-high shifts. Since the shift and no shift conditions were not significantly different, and did not interact with each other on the build-up trials, the curves for the two conditions on trials 1 to 3 can be combined. This has been done in Figure 4, which also shows the overall amount of release on the shift trial. Using the Wickens (1972) method of calculation, the percentage release was 54.5 percent.

<u>Distractor task analysis</u>

The number of subtractions per trial for the distractor task was analysed by a 4 x 4 analysis of variance (Appendix D, Table 5), with groups (LL, HL, LH and HH) and trials as factors. The means are shown

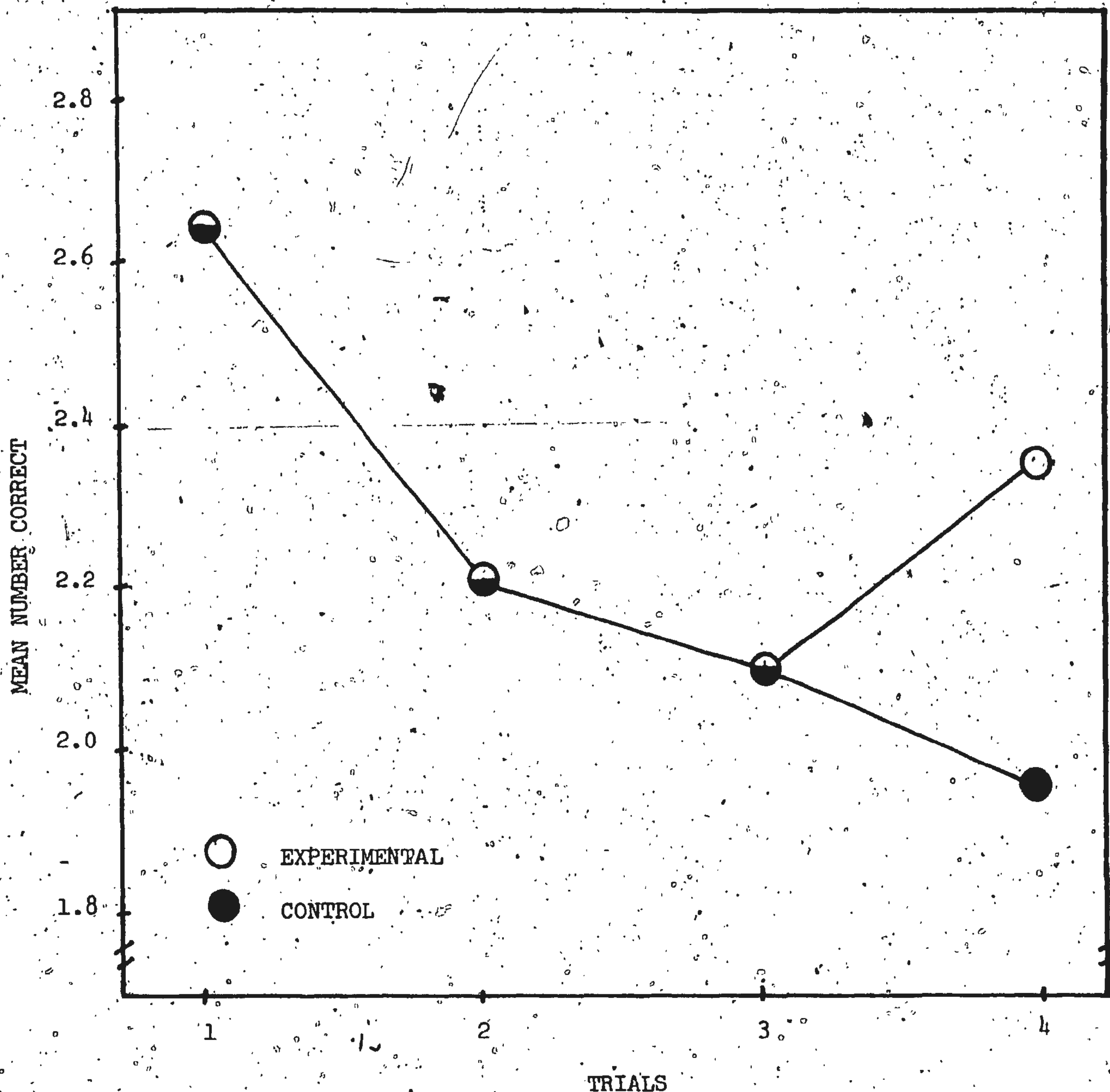

FIG. 4 RELEASE FROM PI FOR SHIFTS IN TRIAD FREQUENCY. EXPERIMENTAL AND CONTROL GROUPS HAVE BEEN COMBINED OVER THE FIRST THREE TRIALS.

in Figure 5. The group effect was not significant, $F(3,156) = 0.87$, but the number of subtractions changed significantly across trials, $F(3,468) = 41.38$, $p. < .01$. There was no significant interaction between groups and trials, $F(9,468) = 0.87$.

These data serve two purposes. The between-group effect was not significant and performance on the distractor task shows no relation to recall performance (Appendix C, Table 1), thus the difference obtained between conditions in recall on trial 4 cannot be accounted for in terms of differential effectiveness of the distractor task. Second, since there is an overall decrease and levelling off of distractor performance over the first three trials, with a slight increase on trial 4, the pattern of build-up and release from PI shown in Figure 4 cannot be easily attributed to artifacts associated with processing during the retention interval.

A further analysis was carried out on the data for the first three trials only. This analysis paralleled that for the recall data (Appendix D, Table 1) and was intended as an additional check that the differences obtained in recall were not attributable to differential performance on the distractor task. This was confirmed, as only the effect of trials was significant, $F(2,312) = 17.83$, $p < .001$. Neither triad frequency on the first three trials nor frequency on the shift trial had any effect (see Appendix D, Table 6).

The drop in the distractor task performance for trial 2 may be due to several factors. The limited amount of practice in counting backwards provided by one practice trial was perhaps not enough to

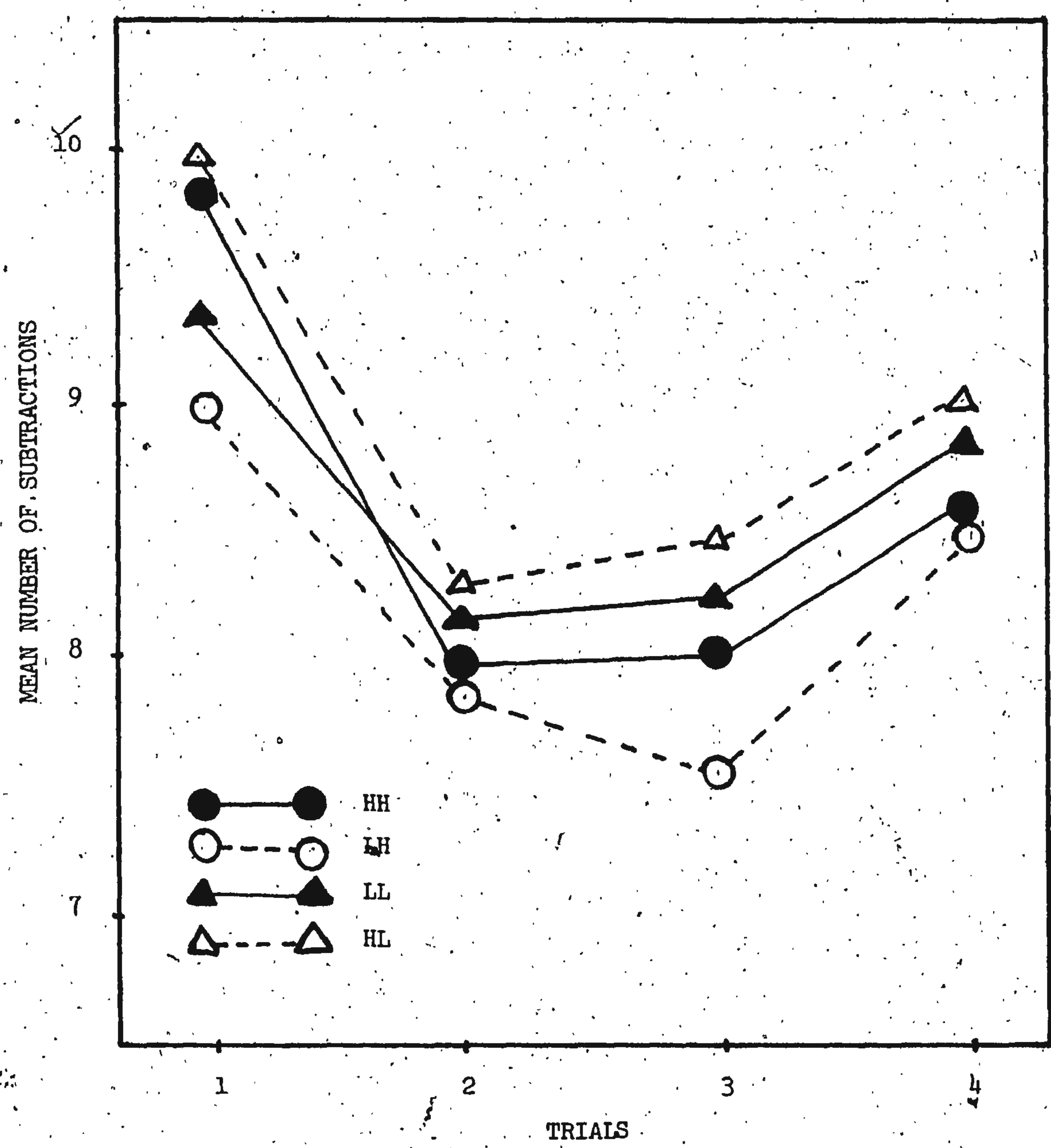

FIG. 5 DISTRACTOR TASK PERFORMANCE AS A FUNCTION OF GROUPS AND TRIALS.

stabilize performance; it could be due to some initial confusion as a result of combining recall and the distractor task on trial 1, at which the Ss had no practice before the first trial; or it could have been a combination of the two. The experimenter informally observed that some Ss appeared confused on the second trial and turned the answer booklet page backwards instead of forwards for the distractor task, then turned to the correct page, but lost time in doing so. Other Ss appeared to hesitate before beginning the distractor task on trial 2, as though they were trying to remember what to do next. This confusion would give them less time in which to do the subtractions.

Frequency judgement task

The frequency judgements (Figure 6) were analysed separately in a 4 x 4 analysis of variance with groups (LL, HL, LH and HH) and situational frequency (1, 2, 4 & 6) as factors (Appendix D, Table 7). This analysis produced a significant effect for frequency only, $F(3,468) = 258.30$, $p < .001$. There were no differences between groups, $F(3,156) = 0.36$, and no significant interaction between groups and frequency, $F(9,468) = 0.74$. These results confirm that the Ss in all four conditions retained information about the situational frequencies of the words in the presentation list. The curves are typical of those obtained in frequency judgement research. The functions are monotonically increasing, with words of frequency 1 being overestimated and those of frequencies 5 and 6 underestimated (cf. Begg, 1974).

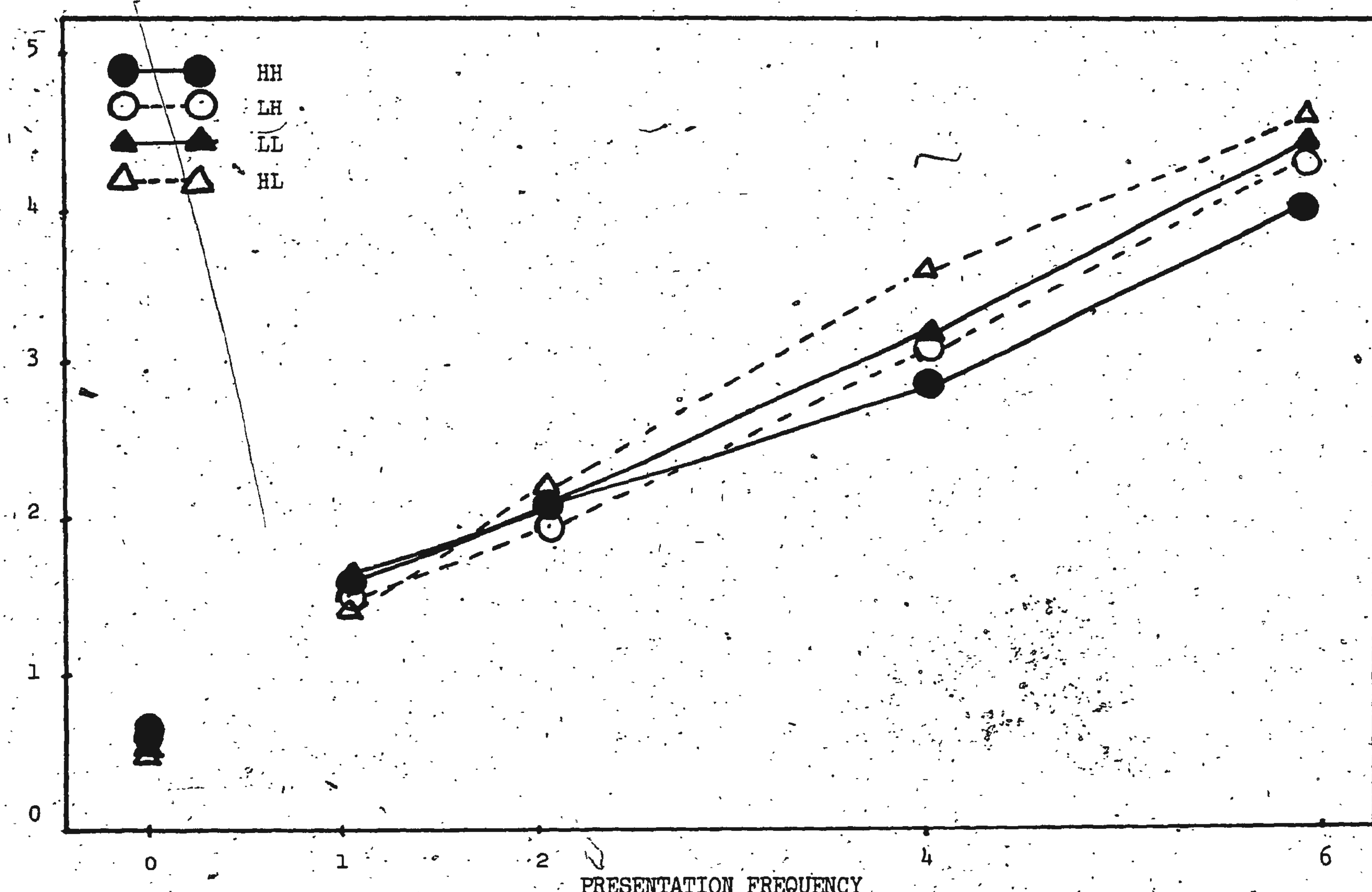

FIG. 6 JUDGED FREQUENCY AS A FUNCTION OF PRESENTATION FREQUENCY

CHAPTER IV

DISCUSSION

The results of the frequency judgement task showed that Ss' judgements of situational frequency were sensitive to changes in presented frequency. They agree with previous studies in that Ss tended to overestimate low frequencies and underestimate high frequencies, but yet kept an accurate view of the overall average (Begg, 1974). The release from PI results showed a significant difference in performance between the experimental and control groups on the shift trial, with the overall release being equal to 54.5 percent. These data indicate that frequency is an encoded, rather than a derived, attribute of memory.

A case can be made for viewing frequency as an involuntarily encoded feature of words. The release from PI task demonstrated that Ss were able to utilize frequency information from the presented word list appropriately when knowledge of frequency of occurrence of the words was not explicitly required. This suggests that processing of frequency information may be automatic. There is independent evidence that encoding as indexed by the release from PI task is in fact involuntary. For example, McIntyre and Duffy (1974) using a release from PI paradigm, showed that Ss who were aware of the release dimension or aware of the release itself, had no more release than Ss who were unaware of either dimension. All three groups showed significantly more release than a control group.

A similar conclusion can be drawn from experiments in the frequency judgement literature. Rowe and Rose (1974) and Rowe (1974) found that Ss who processed information from word lists under incidental instructions did significantly better on a frequency judgement test than those who were given specific or non specific instructions. These results are also supported by Howell (1973c), who set Ss for either a frequency judgement or free recall task and found that frequency information was available to Ss regardless of set, but recall information was not. It appears that frequency information can be processed involuntarily.

As pointed out previously, the trace-strength and multiple-trace hypotheses both consider frequency to be a part of a general memory representation from which frequency is derived when required. These cannot account for an encoded view of frequency without some modifications. A viable alternative approach might be to combine some features of both these hypotheses into a multiple-process model (Howell, 1973b). The following model is a suggestion of one way in which the two conceptualizations might be combined. The basic premise is that a word consists of a collection of semantic attributes in memory which form a memory node (Anderson & Bower, 1972; Underwood, 1969a; Wickens, 1972). The effect of a repetition is to enlarge the node by a constant amount. Thus, with repeated presentations, there is a build-up of "layers" on the node, each thinner than the one before and each clearly distinguishable from all the others. The size of the node increases as a negatively accelerating function of the number of repetitions, i.e., while the amount added by each repetition remains constant, the increase in actual size of the node decreases proportionately to the number of repetitions. The end product of a series of repetitions of a single word can be conceptualized metaphorically as a "super-node" consisting of multiple concentric circles. The S can judge the presented frequency of a word by judging the size of the node. Multiple occurrences of the same word are kept separate, however, by the independent concentric circles.

This model thus incorporates both trace-strength and multiple-trace ideas in its construction. Repetition of a word serves to strengthen or increase the size of one memory node by layers rather than by forming new nodes, but the separate layers are assumed to be easily differentiated (Hintzman & Block, 1971). Frequency judgements can be estimated from the size of the node rather than by counting separate nodes.

The model can handle at least two pieces of evidence which present difficulties for a multiple-trace hypothesis. First, the underestimation and overestimation of frequency in frequency judgement tasks should not happen if Ss were counting increments or time tags. On the other hand, if Ss are simply judging the size of the node, the progressively thinner layers can lead to this kind of consistent error. Judgements of frequency should regress toward the average situational frequency for the experiment, as Begg (1974) has suggested. Second, the model can account for the loss of frequency discrimination in the second of two successive lists followed by a frequency judgement task (Reichardt, Shaughnessy & Zimmerman, 1973). With the thinner layers for the most recently presented items and thick layers for the first items, this becomes understandable. Here the Ss are forced to keep the various repetitions of an item separate, and to make "within node" judgements. The thick layers representing frequency of occurrence in list 1 are more definite in their boundaries and location, allowing for more accurate retention of frequency information, while the thinner layers representing list 2 are easier to confuse and misread.

In conclusion, this thesis has accomplished three things. First, it has produced some vital information for the encoded versus derived attribute of memory conflict regarding frequency of occurrence. Second, it has provided additional data supporting the idea that frequency information is processed involuntarily. And third, it has combined the existing, inefficient hypotheses of frequency representation into a workable model.

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APPENDICES.

APPENDIX A

THE EXPERIMENTAL INSTRUCTIONS

You are going to see a number of words presented on the screen, one at a time. Some of the words will appeare more than once. Read each word to yourself, as it is presented. After you have seen all the words, there will be a memory test which will be described later. For now, just study each word as you see it.

(LIST PRESENTATION)

Now you are going to see some of the same words in groups of threes. Each group of three words will be followed by a three-digit number. I want you to count backwards, by threes, from this number until you are told to turn the page and recall. For example, if you see the number 100, you write down 100 first, then 97, then 94, 91, 88, 85 etc. Please work as quickly as you can as you will be scored on the number of correct subtractions you can complete in 20 sec. If you miss the number, guess at what it was and continue.

After the 20 sec. interval for counting backwards, you will be told to turn the page and recall the three words. You will have only 10 sec. for recall, so you have to work quickly. Are there any questions?

Here is a practice trial for counting backwards. A number will appear on the screen. I want you to write it in the space provided on the first page of your answer booklet, then start counting backwards by threes, recording each number on the page as you count.

(PRACTICE TRIAL)

Are there any questions? .... Now you will see the word triads, do the counting task, and then try to recall the words. When you hear the words "stop writing", do so because the next set of items will follow immediately.

(PI TASK)

Here is a list of words, some of which were presented on the screen and some of which were not. I want you to go through the words and write in the spaces the number of times each word occurred on the screen. If you do not remember seeing the word at all, put a zero in the space provided. Otherwise, put any number you think represents the number of times the word occurred. Please fill in all the spaces. Do not leave any out. You may go through the words at your own rate, but work as quickly as you can.

Are there any questions?

APPENDIX B

TABLE 1

WORDS AND SITUATIONAL FREQUENCIES FOR LIST A AND LIST B.

	FREQUENCIES				
LIST A	0	1	2	4	6
LIST B	0	4	6	1	2
	LIFE	PARK	GIRL	GOLD	BOYS
	CLUB	CITY	TOWN	MAID	TALE
	WALL	RACE	TEXT	CAKE	CAPE
	FIRM	BANK	WAGE	LIME	DISH
	ROSE	FEET	PLAN	TILE	DICE
	BOOK	YEAR	LAND	LAMP	SILK
	ROAD	HEAD	SEAT	HERD	SNAP
	IDEA	SHOW	POET	COOK	BITE
	LIST	CAMP	MEAT	BOWL	BULL
	TEST	JURY	SALE	FOAM	COIN
	WISH	ROOM	SEED	TIRE	BARK
	HAIR	AREA	COAT	DIET	WOOL
	WINE	WIFE	DIRT	MAIL	DRUM
	LADY	WEEK	MYTH	MEAL	TANK
	TONE	WORD	BATH	GRIN	NEST
		FACE	STEM	CANE	MILL
		ROCK	BELT	DEBT	JAIL

APPENDIX B

TABLE 2

LIST A TEST TRIADS FOR THE FIRST 10 SUBJECTS IN EACH GROUP, IN ORDER OF PRESENTATION

	GROUPS			
TRIALS	LL	HL	HH	LH
1	YEAR SHOW HEAD	WOOL BARK DRUM	WOOL BARK DRUM	YEAR SHOW HEAD
2	RACE BANK CITY	TANK NEST MILL	TANK NEST MILL	RACE BANK CITY
3	AREA FEET JURY	SILK BITE TALE	SILK BITE TALE	AREA FEET JURY
4	WORD FACE ROCK	WORD FACE ROCK	BOYS CAPE DISH	BOYS CAPE DISH

APPENDIX B

TABLE 3

LIST B TEST TRIADS FOR THE FIRST 10 SUBJECTS IN EACH GROUP, IN ORDER OF PRESENTATION

	GROUPS			
TRIALS	LL	HL	HH	LH
	MAIL	STEM	STEM	MAIL
1	DEBT	TOWN	TOWN	DEBT
	GRIN	BELT	BELT	GRIN
	TIRE	COAT	COAT	TIRE
2	CANE	SEED	SEED	CANE
	DIET	DIRT	DIRT	DIET
	TILE	LAND	LAND	TILE
3	LAMP	SEAT	SEAT	LAMP
	CAKE	GIRL	GIRL	CAKE
	HERD	HERD	TEXT	TEXT
4	COOK	COOK	WAGE	WAGE
	FOAM	FOAM	PLAN	PLAN

APPENDIX B

TABLE 4

LIST A TEST TRIADS FOR THE SECOND 10 SUBJECTS IN EACH GROUP, IN ORDER OF PRESENTATION

	GROUPS			
TRIALS	LL	HL	HH	LH
1	RACE BANK CITY	SILK BITE TALE	SILK BITE TALE	RACE BANK CITY
2	YEAR SHOW HEAD	WOOL BARK DRUM	WOOL BARK DRUM	YEAR SHOW HEAD
3	WORD FACE ROCK	BOYS CAPE DISH	BOYS CAPE DISH	WORD FACE ROCK
4	AREA FEET JURY	AREA FEET JURY	TANK NEST MILL	TANK NEST MILL

APPENDIX B

TABLE 5

LIST B TEST TRIADS FOR THE SECOND 10 SUBJECTS IN EACH GROUP, IN ORDER OF PRESENTATION

	GROUPS			
TRIALS	LL	HL	HH	LH
1	HERD COOK FOAM	TEXT WAGE PLAN	TEXT WAGE PLAN	HERD COOK FOAM
2	TILE LAMP CAKE	LAND SEAT GIRL	LAND SEAT GIRL	TILE LAMP CAKE
3	MAIL DEBT GRIN	STEM TOWN BELT	STEM TOWN BELT	MAIL DEBT GRIN
4	TIRE CANE DIET	TIRE CANE DIET	COAT SEED DIRT	COAT SEED DIRT

APPENDIX C

TABLE 1

MEAN RECALL ON THE PI TASK AS A FUNCTION OF CONDITIONS AND TRIALS

	TRIALS			
CONDITIONS	1	2	3	4
EXPERIMENTAL (LH)	2.65	2.00	2.28	2.45
CONTROL (HH)	2.58	2.28	2.05	2.25
EXPERIMENTAL (HL)	2.68	2.55	2.28	2.25
CONTROL (LL)	2:70	1.98	1.98	1.70
EXPERIMENTAL (BOTH)	2.67	2.28	2.28	2.35
CONTROL (BOTH)	2.64	2.13	2.01	1.98

APPENDIX D

TABLE 1

SUMMARY OF ANALYSIS OF VARIANCE FOR FIRST THREE (BUILD-UP) TRIALS OF THE PI TASK AS A FUNCTION OF TRIALS, CONDITIONS (EXPERIMENTAL, CONTROL) AND TRIAD FREQUENCY (HIGH, LOW)

SOURCE	df	MS	F
Between Subjects			
Conditions (A)	1	2.13	2.44
Frequency (B)	1	2.41	2.76
A x B	1	0.53	0.61
Ss within groups	156	0.87	
Within Subjects			
Trials (C)	2	13.50	22.33 ***
A x C	2	0.59	0.98
B x C	2	2.82	4.66 **
A x B x C	2	0.10	0.31
C x Ss within groups	312	0.60	

*** $p < .001$

** $p < .01$

APPENDIX D

TABLE 2

SUMMARY OF ONE-WAY ANALYSIS OF VARIANCE FOR FIRST THREE (BUILD-UP) TRIALS FOR HIGH FREQUENCY WORD TRIADS

SOURCE	df	MS	F
Trials (A)	2	4.29	7.20 **
A x Ss within groups	237	.60	

TABLE 3

SUMMARY OF ONE-WAY ANALYSIS OF VARIANCE FOR FIRST THREE (BUILD-UP) TRIALS FOR LOW FREQUENCY WORD TRIADS

SOURCE	df	MS	F
Trials (A)	2	10.36	13.37 **
A x SS within groups	237	.78	

** $p < .01$

APPENDIX D

TABLE 4

SUMMARY OF ANALYSIS OF VARIANCE FOR TRIAL 4 (SHIFT TRIAL) AS A FUNCTION OF CONDITIONS (SHIFT, NO SHIFT) AND TRIAD FREQUENCY (HIGH, LOW)

SOURCE	df	MS	F
Conditions (A)	1	5.63	5.96 **
Frequency (B)	1	5.63	5.96 **
A x B	1	1.23	1.30
Ss within groups	156	0.94	

** $p < .01$

APPENDIX D

TABLE 5

SUMMARY OF ANALYSIS OF VARIANCE FOR EACH FREQUENCY GROUP (HH, LH, LL, HL) AS A FUNCTION OF TRIALS FOR THE DISTRACTOR TASK

SOURCE	df	MS	F
Between Subjects			
Groups (A)	3	13.09	0.87
Ss within groups	156	15.04	
Within Subjects			
Trials (B)	3	70.68	41.38 ***
A x B	9	1.49	0.87
B x Ss within groups	468	1.71	

*** $p < .001$

APPENDIX D

TABLE 6

SUMMARY OF ANALYSIS OF VARIANCE FOR THE DISTRACTOR TASK AS A FUNCTION OF BUILD-UP TRIAL FREQUENCY (HIGH, LOW), SHIFT TRIAL FREQUENCY (HIGH, LOW) AND TRIALS (1, 2, 3)

SOURCE	df	MS	F
Between Subjects			
Build-up Frequency (A)	1	1.41	0.74
Shift Frequency (B)	1	3.00	0.16
A x B	1	3.33	0.18
Ss within groups	156	19.04	
Within Subjects			
Trials (C)	2	171.13	17.83 ***
A x C	2	2.03	0.21
B x C	2	9.85	1.03
A x B x C	2	6.84	0.71
C x Ss within groups	312	9.60	

*** $p < .001$

APPENDIX D

TABLE 7

SUMMARY OF ANALYSIS OF VARIANCE FOR THE FREQUENCY JUDGEMENT TASK AS A FUNCTION OF GROUPS AND PRESENTED FREQUENCY

SOURCE	df	MS	F
Between Subjects			
Groups (A)	3	0.94	0.36
Ss within groups	156	2.60	
Within Subjects			
Frequency (B)	3	208.24	258.30 ***
A x B	9	0.60	0.74
B x Ss within groups	468	0.81	

*** $p < .001$