Temporal Separation in Reversal and Reversal-Mixed List Verbal Discrimination Learning

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TEMPORAL SEPARATION IN
REVERSAL AND REVERSAL-MIXED LIST
VERBAL DISCRIMINATION LEARNING

by

Stanley J. Pasko

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CHAPTER I
INTRODUCTION

In verbal discrimination learning (VDL) the subject (S) is first presented a series of pairs of verbal units in which one member of each pair is arbitrarily designated as correct (C). The S is informed which item is the C term and told to learn this word so that he may later recognize and indicate the C unit when the same pair is shown again. Unless a particular design includes a transfer task, the same two items are always paired and the same member of each pair is always the C term. To minimize position effects as well as serial learning, both the position of the correct word in each pair and the order of the pairs are varied randomly over trials. The presentation of pairs occurs at a paced rate, generally exposing pairs for 2 or 3 sec. intervals. Thus, VDL emphasizes recognition rather than recall learning. During the learning phase, a discrimination must be acquired between the C and the incorrect (I) items which can serve to mediate the identification of the C term in the recognition phase.

Background information

As in most experimentation involving recognition tasks, the performance levels in VDL tend to be very high. Inasmuch as the error rate may be related to the specific procedures used, it seems informative to indicate the different variations on the basic VDL design.

The standard variations of the VDL procedure are the anticipation method and the study-test method. In the anticipation method, S is
presented a pair of verbal units, indicates a choice as a C term, and is immediately informed regarding the correctness of this choice. Another pair of words is then presented and the process repeats itself until S either responds to the entire list or until a criterion of errorless trials is reached. Sometimes the first trial is a study trial during which S is presented both pair members and is then told which is the C term. That is, S does not on the first trial make a choice of an item as the C term. On all further trials, S first indicates a choice as the C item and is immediately informed regarding the correctness of this choice. Sometimes the first trial is a guessing trial in which S first selects one word in each pair as the C term on some idiosyncratic basis and is then immediately informed of the C term. Inasmuch as S's responses are then scored for correctness, this guessing procedure guarantees erroneous choices on the first trial.

A second variation is the study-test method. During the study phase S sees or hears the separate pairs of the entire list and is informed at this time which item he will later be asked to recognize as the C term. During the test phase S again perceives both items and indicates for each pair which item he believes is the C term. The alternating study and test trials then repeat themselves until a predetermined criterion is reached.

Thus the basic difference between the two procedures is the temporal separation between the time of S's selection of a term as the C term and the time when information is given as to the actual C term. In the anticipation method, S is informed immediately regarding the
correctness of his choice; in the study-test method, S is not informed again regarding the C item until he has been tested on the entire list. Both procedures have their analogs in paired-associate learning tasks.

The modality of presentation in VDL can be either visual or aural. With the anticipation method in the visual mode, the word pair is first shown (usually on a memory drum) and S indicates a choice as the C item. The C unit is then immediately presented, sometimes while the pair of items is still exposed. With the study-test method in the visual modality, the entire list of pairs of words is shown with the C term underlined or in some manner designated as C. Later when each pair is shown again, S is asked to indicate which word was previously designated as correct. Presentation in the aural modality for the study-test task is analogous except that the experimenter (E) indicates the C term during study by repeating the C term or saying "C is correct." The Ss typically indicate their responses on the test trial by marking one of two positions on an answer sheet.

Aware of the various designs possible in VDL, an E must decide which seems most appropriate as a test of a particular hypothesis. Thus, it may be mentioned that the anticipation method in the visual mode almost demands that S perceive both words during the first trial, whether the initial trial is a study or a guessing trial. The study-test method in the visual modality, on the other hand, makes it more likely that S may avoid looking at the nonunderlined word.
The frequency theory of VDL

A theory which has proven viable in predicting the results of VDL experiments is the frequency theory of Ekstrand, Wallace, and Underwood (1966). The basic postulate of the theory is that each response to an already learned verbal item leads to the accrual of one frequency unit in S's representation for that word. That is, each time a word is read or heard, the word is theorized to receive a hypothetical unit of frequency. Thus, in a VDL task, the differential accrual of situational frequency units for members of a word pair is assumed to mediate recognition of the C term.

Specifically, a word is theorized to acquire a unit of frequency:

(a) each time a word is perceived, whether this be during the learning or recognition phase; (b) every time a word is rehearsed as a correct alternative during the learning phase; (c) each time a word is pronounced as S's response during the recognition phase; and, if the situation should occur, (d) when some other item elicits an implicit associative response (IAR) to the word in question. For the present each of these four kinds of units is presumed to increment frequency by an equal amount.

Thus, if one eliminates an introductory guessing trial in VDL, both the anticipation and study-test methods are theorized to build up a 2:1 frequency differential favoring the C term prior to the first test of recognition. That is, the original perception of both items is hypothesized to add one frequency unit to the memory for each word, while the rehearsal of the correct alternative is hypothesized to add a second frequency unit.
to the representation of the C term. During the test phase, \( S \) is theorized to make a recognition of the correct alternative by selecting the unit with the greater accrued subjective frequency. (In the terminology of the frequency theory of VDL, selecting the more frequent alternative is called "Rule 1," Ekstrand et al., 1966.) As both learning and recognition trials increase, the difference in accrued frequency units between the C and the incorrect (I) items increases if \( S \) has chosen correctly, making the discrimination between the more and the less frequently experienced items easier. If \( S \) selects incorrectly, however, the frequency for the I term will be incremented and during the next learning phase a difference favoring the C term must be initiated again. Inasmuch as the next study trial is theorized to increment frequency differentially in favor of the C item, a correct response is possible on the next test trial.

From so minimal a number of propositions, the frequency theory of VDL allows a large number of specific predictions, some of which will be examined in the following sections.

**Single-list experiments**

From the basic postulate of a frequency attribute of memory, rather strict predictions are possible. Tulving and Madigan (1970) mention four which are of particular interest because of their counterintuitiveness.

The first prediction is based directly on the postulated differential accrual of frequency units for C and I terms. Specifically, if the discriminative cue in VDL is the relative frequency of the C and I units in a pair, it may be predicted that increasing the difference in situational
frequency between pair members will facilitate performance, and decreasing the difference will inhibit performance. Ekstrand et al. (1966) presented one group of Ss with a list in which each C item appeared twice and was always paired with a different I item; another group was presented a list in which each I item appeared twice but was paired with a different C term each time. No instructions as to these relationships were given. Over trials, the group presented the repeated C terms made significantly less errors than did either the control group or the group presented the repeated I items. However, the more interesting result is that the group with the repeated I items made more errors than did the control group. Thus, one is forced to consider the numerical predictions from the frequency theory of VDL.

Specifically, each I item in the repeated I condition is theorized to acquire two frequency units per study trial; each nonrepeated C term is hypothesized to acquire two units of frequency, one from its perception and one from its rehearsal. If frequency accrues from repetition of the I term, the frequency ratio between any C and its paired I item will be equal at a 2:2 ratio. With such a ratio, a frequency attribute for any pair of words cannot mediate recognition for the correct alternative. As such, the greater error rate for the repeated I condition relative to a control in which frequency is theorized to accrue differentially for the C and I terms supports the frequency theory of VDL. However, it ought to be mentioned that if accrued frequency is the dominant attribute mediating recognition, responding should be at a chance level. This level is never achieved.
The second prediction is the same as the first but the "repeated" items are pairs of associates. As in the previous groups, Ss were uninformed as to the pairings. The results are that the group with associated C item pairs again performed better than did the control group. However, the group with paired I items made the same number of errors as did the control group (Ekstrand et al., 1966).

A third experiment is one that may be viewed as an attempt at controlling for idiosyncratic rates of rehearsal for the correct and incorrect alternatives. Specifically, if Ss vocally pronounce the C and the I terms at differential rates, it may be predicted that pronunciation of the C term will facilitate discrimination and that pronunciation of the I term will inhibit discrimination. Carmean and Weir (1967), Kausler and Sardello (1967), and Underwood and Freund (1968) all indicate effects of significant magnitude due to varying the amount and locus of pronunciation. For instance, in the Underwood and Freund (1968) experiment, one group of Ss was required to pronounce each pair member twice while another group pronounced the C item four times during the study phase. As expected, the group which pronounced the C items four times performed almost perfectly from the first test trial onwards. On the other hand, the group which pronounced each word twice during the study trial averaged one error less than chance on the first test trial and by the end of 10 trials was at the level of responding that the nonpronouncing group reached on its 2.5th trial. Such strong effects support the theory that VDL is normally the result of a frequency discrimination.
A final prediction from the frequency theory of VDL with regard to single-list experiments is that familiarization on the C and I terms will lead to differential effects in a following VDL task. Specifically, it is theorized that the frequency which accrued to the C term during familiarization will lead to improved performance for this group relative to a nonfamiliarized control group because the greater accrued frequency for the C items can better mediate the choice of the correct alternative in VDL. However, because of this same accrual of frequency, a group familiarized on the I items is expected to perform differently. On the early trials in VDL, the accrued frequency for the I term will be greater than that for the C term. It is hypothesized that S may utilize this difference in selecting the alternative with the lower accrued frequency, a strategy which Ekstrand et al. (1966) refer to as "Rule 2." On the early trials, then, the group familiarized on I items should make less errors than a nonfamiliarized control group. However, as trials progress, the greater frequency accruing to the C term will eventually equal the accrued frequency for the I term. Inasmuch as a frequency attribute can then no longer mediate a discrimination, performance should deteriorate to a chance level. The results support this hypothesis (Underwood & Freund, 1968). However, the performance of the group familiarized on the I items, though it eventually does reach a lower level than that of the control group, does not deteriorate to a chance level of responding.

In sum, these experiments indicate that the counterintuitive predictions from the frequency theory of VDL lead to a large number of fulfilled predictions in VDL. On the negative side, however, the experiments
also indicate that Ss seem to be capable of finer discriminations than the theory permits. As it will be theorized later, these fine discriminations may allow a differential viewing of accrued frequency as a VDL task progresses.

Transfer experiments

The basic tenet of the frequency theory of VDL, then, is that the differential accrual of subjective frequency for a pair of items is sufficiently accessible to mediate the selection of one item as the C term during the recognition phase of the VDL task. A logical further evaluation of the theory consists in the examination of the effects of differentially accrued frequency in transfer tasks.

(To clarify the following discussion, the letters A, B, C, and D will be used in accord with the standard terminology in transfer experiments in paired-associate learning. Thus, the letters A and B will refer to the items involved in the first VDL list; C and D to those in the second. If either A or B is involved in the transfer task, the letter will be repeated as one member of the second pair. The underlining indicates the correct term in each pair.)

In the simplest transfer task (A-B, A-D), the correct word from the first list becomes the correct word in a second list and is paired with a word unrelated either to the previous I term or to itself. The frequency theory of VDL predicts that the accrued frequency of the previously correct word will be instrumental in leading to positive transfer. Underwood, Jesse, and Ekstrand (1964) found that such a procedure led to essentially 100%
positive transfer. Though it should be mentioned that this transfer procedure is basically a further trial on the same C items, the very least that these results would seem to imply is that the frequency which accrued to the C term in first list learning was easily separable from that which accrued to the I term and, obviously, was instrumental in the ease of learning the second list.

A slightly different transfer task involves associates of the original C terms in the second list paired with new I items (A-B, A'-D). Raskin, Boice, Rubel, and Clark (1968) presented evidence that this procedure leads to a transfer of the frequency units from the first list to highly associated items in the second list if Ss are informed about this relationship. However, facilitation did not occur for an uninstructed group.

If the situation is reversed and a previously incorrect word is paired with a new correct word in a second list (A-B, C-B), the frequency theory of VDL predicts that the accrued frequency of the previous I word will carry over into the second list so that on early List 2 trials, S can adopt "Rule 2" and choose the item with the lower subjective frequency in each pair. Because of this it is expected that a group familiarized on the I items will make less errors on the early trials than a nonfamiliarized control group. Studies such as that by King and Levin (1971) confirm this. The frequency theory of VDL further postulates that the subjective frequency for a new C item increases at a faster rate over trials than that for an I item so that eventually the subjective frequencies should be equal for C and I terms, making discriminations on the basis of previously accrued
frequency difficult. A strict interpretation of the frequency theory of VDL predicts that performance should then drop to a chance level since frequency cues are no longer useful for discrimination. However, experimentation has failed to confirm this drop to chance levels of responding (Underwood & Freund, 1968; Underwood, Jesse, & Ekstrand, 1964). Nevertheless, the results of the above mentioned experiment (King & Levin, 1971) in which the dependent measure was errors per trial, as well as that by Eschenbrenner (1969), in which the dependent measure was trials to criterion, indicate a general inability of a group familiarized on I items to perform as well as a nonfamiliarized control group on later trials. The frequency theory of VDL hypothesizes that this failure to improve is due to a breakdown in frequency discrimination between pair members.

A third design is one in which a previously correct word becomes incorrect and is paired with a new correct item (A-B, C-A). As in the A-B, C-B paradigm, the theory predicts that the frequency which has accrued to the repeated word from its role in first list trials will serve as a discriminative cue in the transfer task so that S on the early trials can follow Rule 2 in choosing the less frequent alternative. However, since the subjective frequency will eventually become equal for both C and I items, one may again expect a deterioration to chance levels of responding relative to a control group. As might be expected from the previously mentioned results, the predictions of initial facilitation coupled with a later inability to perform as well as the control group was confirmed (King & Levin, 1971). The anticipated reduction to chance levels of responding was again not found.
It is interesting to note that this experiment by King and Levin (1971) allows a comparison of the A-B, C-B and A-B, C-A paradigms. (It should be mentioned that this experiment utilized a design in which Ss were not told of the relationship between List 1 and List 2. It may thus be expected that the differences between a guessing control group and a guessing familiarized group will be at their minimum.) If frequency accrues differentially to C and I items in a first list and transfers differentially to a second list, then the initial differences between a control group and a familiarized group which transfers the I items from the first to the second list (the A-B, C-B paradigm) should be less than the initial facilitation difference between a control group and a familiarized group which transfers the C items to become I items in the second list (the A-B, C-A paradigm). That is, the greater frequency accruing to a C item than to an I item in List 1 should lead to more facilitation on the early trials on List 2 for the group which transfers the C items. Over the three levels of familiarization trials (2, 4, and 8 trials), the prediction is borne out. For all three conditions on the early (1-2, 1-4, 1-5) trials, the hypothesized greater accrued frequency for C items than for I items leads to greater facilitation for groups which transfer C items than for groups which transfer I items.

A final transfer design is a reversal of the C and I words (A-B, A-B). The frequency theory's predictions, of course, are the same as for the other paradigms: early facilitation for the familiarized group and later superiority for the control group. Raskin, Boice, Rubel, and Clark (1968), as well as Underwood and Freund (1970), have obtained just these results.
In summarizing the results of transfer experiments in VDL, one may first mention that predictions from the frequency theory of VDL have been borne out rather strongly. Its parsimonious and rather clear predictions of the ultimately deleterious effect of familiarization on the I term in transfer tasks lends the theory a particular attraction, as does its explanation of differential rates of acquisition for previous C and I items. Inasmuch as verbal discrimination tasks generally involve a rather small number of errors, the consistency of the results is intuitively pleasing.

However, the frequency theory of VDL also predicts an ultimate deterioration to chance levels of responding for the familiarized I items in certain transfer tasks. Yet, even after individual pair frequencies for each S are adjusted to include a previous erroneous response so that the items for every S can be observed at the point of presumed equality (which was possible because Ss pronounced the C and I items at a 2:1 ratio), the sharp deterioration to chance levels of responding does not occur (Underwood & Freund, 1970). This paper is an attempt at a further evaluation of this nonconfirmed prediction.

The Hintzman-Block hypothesis

Hintzman and Block (1971) investigated two hypotheses concerning the effect of frequency on memory. Specifically, they contrasted the theory that repetition increments the cumulative strength of a single memory trace with the theory that repetition of a single item results in multiple traces for that item, each of which is identifiable by its separate "time tag." The Ss heard two word lists separated by about 5 min. to provide a possible temporal discrimination between the two lists. Within the two list
presentations, all combinations of zero, two, and five repetitions of the same word were represented, together with a larger number of filler items. That is, Ss heard the same word zero, twice, or five times in the first list and zero, twice, or five times in the second list. After the presentation of the second list, Ss were asked to make separate List 1 and List 2 frequency judgments for the entire set of target words.

The results indicate that Ss were rather accurate in discriminating the number of recent as opposed to remote repetitions of the same word. As such, the findings support the hypothesis that each repetition of the same word produces its own memory trace and that traces for events separated in time can be discriminated from each other. The basis for the temporal discrimination is assumed to be a temporal attribute of the memory for a particular word which is referred to as its "time tag." Nevertheless, inasmuch as temporal separation was not an independent variable in this experiment, it must be mentioned that the results allow no inference regarding the exact role of the temporal separation between list presentations in facilitating the discrimination of frequencies of occurrence of the same words in the two lists.

On the basis of their results, Hintzman and Block hypothesize that the deterioration to chance levels of correct responding on List 2 in the relevant transfer designs is due to an underestimation of Ss' capability at discriminating recently from remotely accrued frequencies. Thus, these authors theorize that early in List 2 learning Ss can ignore recent frequencies accruing to words during the transfer task and instead are
guided in recognition by the "time tags" present on the older I items. Later in List 2 learning, Ss are hypothesized to ignore these older frequencies and to be guided by the frequencies which have accrued during List 2 learning. Because of such a capability, a deterioration to chance levels of correct responding need not be expected.

Thus, to the extent that Ss cannot distinguish remote from recent situational frequencies, deterioration may be expected. However, if Ss are given cues which facilitate the discrimination of remote from recent frequencies, deterioration need not be anticipated. In VDL transfer experiments, then, in which only one of the two words has been present before, a good cue exists for discriminating the recently from the remotely accrued frequencies. It may also be predicted that the longer the time interval separating the initial and the transfer tasks, the more discriminable will be the "time tags" for the two lists (Hintzman & Block, 1971). For this reason, a longer temporal separation between the two lists' presentation than is normally the situation in VDL transfer experiments may be expected to lead to better performance.

To recapitulate, Hintzman and Block's experiment produced results which indicate that Ss are capable of rather fine interlist and intralist frequency discriminations. They further theorize that the memory for a specific word contains both a temporal and a frequency attribute and that the temporal attribute can mediate the discrimination of recently accrued frequency from remotely accrued frequency for the same word. Lastly, they hypothesize that any manipulation which serves to differentiate the temporal attribute for the same word will lead to a more accurate discrimination of the recently
from the remotely accrued frequencies for that word. In operational terms, a significant temporal separation between presentations of two lists in a VDL task should lead to better performance than essentially no temporal separation.

Accrued frequency and temporal separation in VDL

The present experiment attempts to differentiate the effects of accrued frequency from those of temporal separation between list presentations in VDL. Specifically, the question asked is to what extent a "time tag" on a word can overcome the expected debilitating effects of accrued frequency.

The present experiment involves a VDL transfer task in which the basic design is a 2 X 2 X 2 factorial. All Ss will learn a 16 item (A-B) VDL list and will then have 11 trials on a second list (A-B). Temporal separation between learning of List 1 and List 2 (0- or 7-min.), type of list (reversal or reversal-mixed), and number of List 1 trials (4 or 8) are the three factors. For each type of list there will be a control (A-B, C-D). The frequency theory allows rather specific predictions regarding the expected number of errors for the type of list and number of List 1 trials variables; the Hintzman-Block hypothesis for that of temporal separation between the learning of List 1 and List 2.

To minimize the effects due to a guessing strategy, the anticipation method will be employed on both first and second list learning, with the first trial on each list being a study trial. To minimize further the effects of erroneous strategy selection, Ss will be informed of the relationship between the first and the second list.
The reversal design \((A-B, A-B)\) was chosen as an attempt to minimize any effect potentially due to the fact that only one transfer pair member in most VDL transfer experiments has acquired a frequency input in two tasks. That is, if familiarization consists in merely "studying" words which will later become C and I items in VDL, the transferred item in each pair has received a frequency input in the first task and, after the first trial on the second list, is acquiring frequency a second time. The nonfamiliarized item, however, only acquires frequency one time. Inasmuch as this may be considered confounded with "time tags" for recently and remotely accrued frequency, it would seem best to eschew the normally used paradigms in favor of a reversal procedure. However, under the usual reversal procedure, there exists the possibility of a confound between accrued frequency and whatever organization may occur due to S's having always responded to half the items as C terms and to half the items as I terms in the first task. To emphasize the role of accrued frequency, then, it was decided to include both a reversal and a reversal-mixed list group. In the reversal-mixed list, half the pairs of items reverse their original C and I relationship \((A-B, A-B)\), while half retain the relationship present in the first list \((A-B, A-B)\). Thus, both items appear in both lists and the mediating cue for discrimination in List 2 may be hypothesized to be solely the result of differentially accrued frequency. The task would thus seem to have the dual advantage of rather clearcut predictions based on the frequency theory of VDL and of allowing the possibility of rather strong effects due to temporal separation.
CHAPTER II

METHOD

Design

The design was a 2 X 2 X 2 factorial with temporal separation between the learning of List 1 and List 2 (0- or 7-min.), type of second list (reversal or reversal-mixed), and number of List 1 trials (4 or 8) as factors. Including two control groups, one for each type of list, the experiment involved 10 conditions.

Lists

Sixty-four two-syllable nouns varying in frequency from 20 to 50 were selected from the Thorndike and Lorge (1944) general count with an attempt at minimizing semantic and orthographic overlap. Under the restriction that pair members not begin with the same letter, 32 words were randomly selected to form 16 pairs for presentation to the experimental groups. The remaining 32 nouns were randomly paired under the above restriction to serve as List 1 for the control group.

In List 1, one item of each pair was randomly selected as the C term, the other becoming the I term. For the reversal condition, two forms of List 1 were prepared so that each item might be both a C and an I term. In List 2, the C and I relationships were reversed in the two forms. For the reversal-mixed list condition, two forms of List 1 and four forms of List 2 were created so that each item might serve as both a C and an I term in List 1 and as both a reversed and nonreversed item in List 2. In each form
of List 2, half the pairs reversed their List 1 relationships, while half retained the original C and I relationships. The reversed and nonreversed pairs were randomly arranged under the restriction that no more than two consecutive pairs be of the same form. For the control groups, one form of List 1 was used for all Ss. The reversal list control Ss were then equally assigned to the two reversal lists as List 2; one quarter of the reversal-mixed list control Ss received each form of the reversal-mixed list. Four orders of all the above forms were created and were presented to the Ss in counterbalanced form.

Procedure

After all Ss received standard VDL instructions, the experimental groups received 4 or 8 List 1 trials. The Ss were not informed as to the number of List 1 trials nor as to the future learning of a second list. The pairs were presented at a 2:2 sec. rate by the anticipation method. The C and I items of a single pair were printed in juxtaposition and exposed on a Stowe memory drum. Each pair first appeared for the 2 sec. anticipation interval, after which the C term was shown alone for 2 sec. For each pair of C and I items, the C term appeared spatially on the right for two of the orders and spatially on the left for the other two orders. For each trial the single C item appeared equally often on each side, though not necessarily on the same side as the C item in its pair. The intertrial interval for each list was 4 sec. The first trial was always a study trial (S did not guess). On the second and succeeding trials, S responded to each pair, having been told to guess if not sure. The trial numbers given earlier include the study
trial.

After the requisite number of List 1 trials, Ss in the 7-min. temporal separation condition performed a mathematical filler task while Ss in the 0-min. temporal separation condition were immediately informed as to the nature of the second list and that the first trial would again be a study trial. The Ss were reminded that they should guess if not sure of the correct answer during second list learning. After 7 min. had elapsed, Ss in the delay condition were given the same instructions. After the control group had 4 trials on List 1, the tape was changed and Ss were informed that the second list was unrelated to the first list. The time elapsed was approximately 120 sec. List 2 learning consisted of 11 trials for all Ss, with the first trial a study trial.

Subjects

A total of 24 Loyola undergraduates participated as Ss in this experiment in partial fulfillment of their introductory psychology course requirements. All Ss were naive to VDL. Each of the conditions, which were randomized in blocks of 10, contained 24 Ss. Assignment to conditions was made on the basis of appearance in the laboratory. The experiment was run at the end of the spring and at the start of the fall semesters.
CHAPTER III

RESULTS

In the following notation, minutes of temporal separation (0- or 7-) will be indicated in the first position, reversal or reversal-mixed list (R or NR) designation in the second, and the number of List 1 trials (4 or 8) in the third position.

Reversal lists

Prior to analysis of reversal list data, the experimental groups' total errors per $S$ on the first three List 1 test trials were submitted to a 2 X 4 analysis of variance, with Form of List (A or B) and Reversal List Conditions (0-R4, 0-R8, 7-R4, 7-R8) as factors. Form of List proved a significant variable, $F (1, 88) = p < .05$, but neither Reversal List Conditions, $F$ < 1, nor the interaction, $F (3, 88) = 2.49$, indicated reliability. Inasmuch as the presentation of the two forms was counterbalanced, it may be concluded that any obtained List 2 effects can not be attributed to original group inequivalence.

Figure 1 shows the mean errors per trial for the experimental and control groups on the reversal transfer list. The experimental groups' reversal list errors per $S$ per trial were submitted to a 2 X 2 X 10 analysis of variance with Temporal Separation (0- or 7-min.), Number of List 1 Trials (4 or 8), and Reversal List Trials (10) as factors. Though Reversal List Trials was significant, $F (9, 92) = 29.33, p < .01$, neither the effect of Temporal Separation, $F (1, 92) = 2.42$, nor that of Number of
Fig. 1. Mean errors per trial for the experimental and control conditions on the reversal VDL lists.
List 1 Trials, $F(1, 92) = 3.00$, indicated reliability. The interaction of Temporal Separation X Reversal List Trials was significant, $F(9, 92) = 3.06, p < .01$, indicating the initially higher error rate of the 0-min. temporal separation conditions relative to the 7-min. conditions. Neither Temporal Separation X Number of List 1 Trials, $F(1, 92) = 2.36$, nor Number of List 1 Trials X Reversal List Trials, $F < 1$, were significant. The significant Temporal Separation X Number of List 1 Trials X Reversal List Trials interaction, $F(18, 828) = 2.38, p < .01$, would seem to be due to the initially inferior and later similar performance of the 0-R4 condition relative to the other experimental groups.

To further examine the effect of Temporal Separation, the mean errors per trial in the 0-R4 and 7-R4 conditions were compared. The main effect of Temporal Separation was significant, $F(1, 46) = 5.19, p < .01$, but Temporal Separation X Reversal List Trials did not reach an acceptable level of significance, $F(9, 414) = 1.94, p > .10$. The same comparison for the 0-R8 and 7-R8 conditions failed to indicate group differences for either Temporal Separation, $F < 1$, or Temporal Separation X Reversal List Trials, $F(9, 414) = 1.01$.

To evaluate the hypothesis of an initial reversal list superiority for the experimental conditions relative to the control group, mean errors on the first reversal list test trial for all five groups were analyzed by a Newman-Keuls multiple range test. The results indicated that the 0-R4 and control conditions were significantly different, $p < .05$, both from each other and from the remaining groups, which did not differ among themselves. A Newman-Keuls multiple range test of the mean overall errors on 10 trials
for the five conditions indicated that there were significantly more errors in the O-R4 condition, p < .05, but that the other four conditions were equal. Reversal-mixed lists

To establish the equivalence of the experimental groups, the total errors per S on the first three List 1 test trials were submitted to a 2 X 4 analysis of variance in which Form of List (A or B) and Reversal-Mixed List Conditions (O-RM4, O-RM8, 7-RM4, 7-RM8) were factors. The results indicated that neither the main effects of Form of List, $F(1, 88) = 1.63$, nor of Reversal-Mixed List Conditions, $F(3, 88) = 2.31$, were significant. Their interaction also was not reliable, $F < 1$. It can be concluded that any effects in List 2 learning can not be attributed to original group or list inequality.

The experimental groups' errors per S per trial on the reversal-mixed list were subjected to a 2 X 2 X 2 X 10 analysis of variance with Temporal Separation (O- or 7-min.), Number of List 1 Trials (4 or 8), Reversal (R) or Nonreversal (NR) Items, and Reversal-Mixed List Trials as factors. Both R-NR Items and Reversal-Mixed List Trials were within subject variables, i.e. errors on the reversal-mixed list were evaluated as stemming from two eight item lists. The main effects of both Temporal Separation, $F(1, 92) = 1.92$, and Number of List 1 Trials, $F(1, 92) = 2.20$, proved nonsignificant, while those of R-NR Items, $F(1,92) = 25.84$, $p < .01$, and Reversal-Mixed List Trials, $F(9, 828) = 75.83$, $p < .01$, were reliable. Of the interactions, only that of R-NR Items X Reversal-Mixed List Trials was significant, $F(9, 828) = 3.50$, $p < .01$. This significance would seem to
be due to the greater number of R item errors during the early and middle trials on the reversal-mixed list as compared to the initially inferior and later similar number of NR item errors.

The mean errors on R and NR items in both the experimental and control conditions are listed in Table 1. Separate analyses of the two types of errors indicated that the mean R item errors in the 0-RM4 and 0-RM8 conditions were significantly greater than the mean NR item errors, \( t \) \((23, \text{two-tailed}) = 2.96, p < .01\), and \( t \) \((23, \text{two-tailed}) = 3.25, p < .01\), respectively. Though in the same direction, the differences in R and NR item errors in the 7-RM4 and 7-RM8 conditions failed to be reliable. It should also be noted that the control group made significantly more errors on NR items than on R items, \( t \) \((23, \text{two-tailed}) = 2.35, p < .05\), a factor which would seem to underscore the effects of List 1 facilitation on R items and to overestimate that on NR items when the experimental groups are compared with the control.

Figure 2 shows the mean errors per trial on R and NR items for the experimental conditions relative to the control. Conditions in Figure 2 are separated on the bases of Number of List 1 Trials and Temporal Separation. The same control group data is presented in both Number of List 1 Trials conditions. With errors on R and NR items again considered as separate lists, the mean errors per trial for the temporal separation and control conditions were compared by 3 X 10 factorials in which Groups and Reversal-Mixed List Trials were factors. The comparison of errors on R items between the 0-RM4, 7-RM4, and control groups (upper-left panel) indicated a nonsignificant effect for Groups, \( F \) \((2, 69) = 2.88, p > .10\), but a significant Groups X Rever-
### TABLE 1

**MEAN ERRORS ON R AND NR ITEMS**

<table>
<thead>
<tr>
<th>Conditions</th>
<th>R Item Errors</th>
<th>NR Item Errors</th>
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<td>4.62</td>
</tr>
<tr>
<td>7-RM4</td>
<td>6.54</td>
<td>4.88</td>
</tr>
<tr>
<td>0-RM8</td>
<td>7.25</td>
<td>4.00</td>
</tr>
<tr>
<td>7-RM8</td>
<td>3.58</td>
<td>2.42</td>
</tr>
<tr>
<td>Control</td>
<td>3.83</td>
<td>5.46</td>
</tr>
</tbody>
</table>
Fig. 2. Mean errors per trial on R and NR items for the experimental and control conditions. Conditions are separated on the basis of Temporal Separation (0- or 7-min.) and Number of List 1 Trials (4 or 8). The same control group data is presented in both Number of List 1 Trials conditions.
Mixed List Trials interaction, $F_{(18, 621)} = 1.86, p < .025$. The result would seem to be due to the variable middle trial performance of the 7-RM4 group contrasted with the steady improvement of both the 0-RM4 and control groups. The same comparison for NR item errors for the four List 1 Trials groups (upper-right panel) failed to indicate reliable differences for either the main effect of Groups or for the Groups X Reversal-Mixed List Trials interaction, $F < 1$.

When the R item errors for the 0-RM8, 7-RM8, and control groups were evaluated (lower-left panel), the results indicated a significant main effect for Groups, $F_{(2, 69)} = 3.16, p < .05$, but a nonsignificant Groups X Reversal-Mixed List Trials interaction, $F_{(18, 621)} = 1.14$. The significant effect of Groups would seem to demonstrate the similarity of the 7-RM8 and control groups in contrast to the performance of the 0-RM8 group. To indicate the effect of temporal separation more clearly, errors on the first reversal-mixed list test trial, as well as overall errors, were submitted to Newman-Keuls multiple range tests. The results indicated that, while the three groups were equal on the first test trial, the 0-RM8 condition made significantly more overall R item errors, $p < .05$, than either the 7-RM8 or the control condition, both of which were equivalent. The analysis of variance performed on NR item errors in the 0-RM8, 7-RM8, and control conditions (lower-right panel) failed to provide either a reliable effect for Groups, $F_{(2, 69)} = 2.38, p > .05$, or for the Groups X Reversal-Mixed List Trials interaction, $F < 1$. 
CHAPTER IV
DISCUSSION

The frequency theory of VDL hypothesizes that Ss respond differentially to correct (C) and incorrect (I) items during the learning phase of VDL and that the memory of these differential frequencies allows a correct response during the recognition phase. Thus, in the early trials of a reversal transfer task (A→B, A→B), the accrued frequency for List 2 I items is theorized to be greater than that for C items. Utilization of Rule 2 is proposed to lead to initially superior performance for a familiarized group relative to a nonfamiliarized control. As frequency continues to accrue differentially for C and I items in List 2 learning, the frequency difference between the two terms disappears for the experimental group and Ss are expected to decline to chance levels of responding, with the familiarized group eventually performing more poorly than the nonfamiliarized control.

Hintzman and Block hypothesized that Ss' memory of a frequency attribute allows separate representations of List 1 and List 2 frequencies. Early in the learning of a reversal list, Ss are theorized to select the C term on the basis of List 1 frequency differences while List 2 frequencies are being accumulated. Later in List 2 learning, Ss are postulated to respond on the basis of List 2 frequencies. Though the predictions from the Hintzman-Block hypothesis are essentially no different from those of the frequency theory of VDL for any specific manipulation,
the postulated multitrace representations of frequencies need not be expected to lead to chance levels of responding. Instead, errors would seem to result from inability to separate List 1 and List 2 frequencies for the same pair of words.

The present experiment attempted to evaluate this hypothesis by allowing a temporal separation between the learning of the two lists. It was proposed that Ss who learn the transfer task after a significant temporal interval would be better able to separate List 1 frequencies from those of List 2 and hence would make fewer errors in List 2 learning than would a group which began List 2 learning almost immediately after having learned List 1.

**Reversal lists**

The significant Temporal Separation X Reversal List Trials interaction, supported by the significant temporal separation effect in the 0-R4 and 7-R4 conditions, offers strong support for the Hintzman-Block hypothesis. After four trials on List 1, Ss with a 7-min. temporal separation between the learning of two lists manifested a lower error rate on all 10 test trials when compared to a 0-min. temporal separation condition.

The lack of any facilitation due to temporal separation in the 0-R8 and 7-R8 conditions seems plausibly explained by hypothesizing that a temporal cue has only a limited utilizability in comparison with other cues. As learning increases, other cues are more likely to be used.

Because the performance of the 7-R4 group is initially superior to
that of the control group, it would seem implausible to posit the forgetting of List 1 frequencies during the temporal interval as the causal factor for the superiority of the 7-R4 over the 0-R4 group, as would the failure of the 7-R4 group to outperform or parallel the control group on any of the last nine test trials. Since the nonsignificant interaction indicates that the performance of both experimental groups is similar in kind if not degree (cf. Figure 1), it may be argued that both groups are utilizing the same type of cue but that the 7-R4 group is better able to employ this cue.

Inasmuch as overall performance deteriorated to a chance level (eight errors on any one trial) for only one S in either the 0-R4 or 7-R4 conditions and because Ss erred on a mean 6.25 different pairs in the 0-R4 and on 4.17 different pairs in the 7-R4 conditions (as opposed to a predicted minimum of eight different items), it would appear that an explanation based on multiple memory traces for List 1 and List 2 frequencies is better able to handle the evidence related to VDL reversal tasks than an explanation based on a strength concept of the memory trace (cf. Hintzman and Block, 1971) in which List 1 and List 2 frequencies are added.

**Reversal-mixed lists**

Though any theorizing regarding the learning of a reversal-mixed list is tenuous, fulfillment of predictions from the frequency theory of VDL can be interpreted as offering further support for the role of frequency in a VDL task. Likewise, since a reversal-mixed list offers an opportunity to observe the effects both of frequencies consistently
incremented in both lists (NR pairs) and of frequencies reversely incremented in the two lists (R pairs), the extent to which a temporal separation can differentially facilitate performance on both types of pairs may be considered indicative of the extent to which Ss utilize List 1 frequencies in reversal VDL and hence support the Hintzman-Block hypothesis.

A first prediction stemming from the frequency theory of VDL is that, since frequency is theorized to accrue differentially to C and I items in VDL, better List 2 performance ought to be expected for NR pairs in which frequencies for both items are consistently incremented in the two lists (A-B, A-B) than for R pairs in which frequencies are reversely incremented in the two lists (A-B, A-B). The significantly lesser number of errors for NR pairs as compared to R pairs in both the 0-RM4 and the 0-RM8 conditions supports this prediction. That the same comparison proved not reliable in the 7-RM4 and 7-RM8 conditions may be understood in terms of the Hintzman-Block hypothesis. That is, if Ss utilize List 1 frequencies in the learning of reversal items while List 2 frequencies are increasing, a manipulation which differentiates the two lists can be expected to facilitate performance on R items. However, if List 2 frequencies are merely incrementing those of List 1, as on NR items, a better list differentiation need not be expected to offer additional cues. Under the prediction of facilitation due to temporal separation for R but not for NR items, the nonsignificant differences between R and NR items in the 7-RM conditions may be seen as offering support for the Hintzman-Block hypothesis. As can be gleaned from Figure 2 (and supported by the
significant R-NR Items X Reversal-Mixed List Trials interaction), R and NR differences were less evident on the first test trial than over the entire 10 trials, a result which is consonant with the positing of a utilization of Rule 2 for reversal items in early List 2 learning. This differential performance on R and NR items as trials proceed also offers considerable difficulty to a hypothesis which maintains that Ss in the temporal separation conditions "forget" List 1 frequencies and effectively learn List 2 as a new list.

Secondly, if number of List 1 trials exerts its normal effect in learning experiments, there ought to be more errors for R and NR pairs on a transfer task following four List 1 trials than on one following eight List 1 trials. With respect to R item errors, the lack of statistically reliable differences on the basis of number of List 1 trials would seem to be due to the inability of the 0-RM8 group to profit from the extra List 1 trials. This inability, in conjunction with the capability of the 7-RM8 group to utilize the cue afforded by temporal separation, would seem to indicate the difficulty of separating List 1 and List 2 frequencies for R pairs. With respect to NR item errors, the lack of significant differences due to number of List 1 trials would seem to be due to near asymptotic performance on NR items, inasmuch as the number of overall NR item errors in each experimental condition is less than that of the control condition.

Thirdly, if temporal separation exerts the same effect in a reversal mixed list as it does in a reversal list, performance ought to be better in the 7-min. than in the 0-min. temporal separation conditions. However,
since NR pairs are not theorized to require list differentiation, the
temporal separation is not expected to provide as meaningful a cue for
those items as for R items. The results indicate that Ss in the 7-RM8
condition made significantly less errors on R pairs than did Ss in the
0-RM8 condition. Though in the same direction, the temporal separation
effect in the 0-RM4 comparison was not reliable, a result which again
indicates the large frequency difference needed for a temporal separation
to allow list differentiation in reversal-mixed list VDL. That Ss failed
to show significantly improved performance on NR pairs due to temporal
separation seems again to limit the utilizability of a temporal separation
to conditions requiring list differentiation.

Lastly, the frequency theory of VDL hypothesizes an initial List 2
superiority for a familiarized group relative to a nonfamiliarized
control but a later inability to improve as much as the control group.
The Hintzman-Block hypothesis might be expected to indicate that those
effects can be lessened in the 7-min. temporal separation conditions.
Inasmuch as NR pairs would seem to be less helped by a differentiation
of List 1 and List 2 frequencies, the prediction would seem to be
specific in R pairs. This hypothesized relationship on NR items is
indicated by the nonsignificantly different experimental and control
group performance in both of the comparisons based on number of List 1
trials (Figure 2, upper- and lower-right panels).

The significant interaction in the 0-RM4, 7-RM4, control group
comparison (Figure 2, upper-left panel) may be taken as evidence that
the experimental and control groups were equivalent on R pair errors on the
first test trial of List 2 learning but that the experimental groups failed to improve as much as the control group as trials progressed. Likewise, the conjunction of nonsignificant differences on the first test trial for the 0-RM8, 7-RM8, and control conditions (Figure 2, lower-left panel) and of overall 0-RM8 inferiority indicates initial equality but a later inability for the 0-RM8 group to improve as much as the 7-RM8 or control groups.

Though the frequency theory of VDL correctly predicts the inability of the 0-RM8 groups to surpass the control, it fails to predict the constant equality of the 7-RM8 and control groups. To utilize the Hintzman-Block hypothesis to explain the facilitation acquired to obtain this constancy, one must explain the inability of the 7-RM4 group to profit significantly from the temporal separation. The most parsimonious explanation would emphasize the high number of List 1 trials required in reversal-mixed list VDL before a temporal separation can allow effective differentiation of frequencies in the two lists.

Reversal and reversal-mixed lists

In both types of lists, the familiarized groups without a temporal separation generally fail to improve over trials as much as does the nonfamiliarized control. In both, the number of List 1 trials affects the degree of enhancement afforded by a temporal separation. In the present experiment, the number of List 1 trials appeared to set an upper bound on the capacity of a temporal separation to facilitate performance on a reversal list; a lower bound for a reversal-mixed list.
However, further experimentation is needed to determine if a still larger number of List 1 trials would also set an upper bound on the usefulness of a temporal separation in reversal-mixed list VDL.

A major difference between performance on the two types of lists is the initially facilitated performance (relative to a control) of Ss learning a reversal list compared to the experimental-control group equality found on the reversal-mixed list. Besides stressing the differences between the two types of lists, this lack of facilitation in reversal-mixed list VDL would seem to question the extent to which an approach which postulates the utilization of differentially accrued frequency to individual C and I items can account for initial performance in reversal-mixed list VDL. Though the frequency theory of VDL appears impervious to list length (Freund, 1970), the extent to which the relatively small number of R items in this experiment actually underscored the initially debilitating effects of learning a mixed list and maximized the role of accrued frequency would seem in need of testing.

A second difference between the two types of lists is that performance deteriorates after the first test trial for the reversal list conditions but fails to do so in the reversal-mixed list conditions. However, the relatively small number of reversal items in the reversal-mixed list may be an important factor inasmuch as subsequent performance does generally fail to equal that of the control group.

Summary

In both reversal and reversal-mixed VDL, the effect of a temporal
separation enhanced performance on List 2 learning. In the reversal list conditions, this improvement occurred with four List 1 trials; in the reversal-mixed list conditions, with eight List 1 trials. The Hintzman-Block hypothesis was considered an adequate explanation for the results.
REFERENCES


APPENDIX

LISTS OF CONTROL AND EXPERIMENTAL GROUP ITEMS
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<thead>
<tr>
<th>Control Items</th>
<th>Experimental Items</th>
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APPROVAL SHEET

The Thesis submitted by Stanley J. Pasko has been read and approved by members of the Department of Psychology.

The final copies have been examined by the director of the Thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the Thesis is now given final approval with reference to content and form.

The Thesis is therefore accepted in partial fulfillment of the requirements for the degree of Master of Arts.

[Signature]

Date: 4/12/73

Signature of Advisor: [Signature]