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Imagery And Frequency Effects In Verbal Discrimination Learning

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IMAGERY AND FREQUENCY EFFECTS IN VERBAL DISCRIMINATION LEARNING

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ABSTRACT

In verbal discrimination learning (VDL), the subject is required to learn which member of each pair of presented verbal items has been designated as "correct" by the experimenter. The frequency theory of VDL postulates that the correct items acquire a higher situational frequency than the incorrect items, and that the subject's discriminatory responses are based on this frequency difference. Situational word frequency is thus assumed to be the dominant cue or memory attribute in VDL.

A growing body of evidence suggests that certain additional factors may also be important determinants of VDL performance. One of these, the relative concreteness or image-arousing capacity (I) of the stimulus items, is especially important, in that the ease of learning High-I as compared to Low-I pairs is not readily explainable in terms of frequency theory. The present research was directed toward a further investigation of the effect of imagery in VDL, and a systematic examination of the relationship between imagery and frequency as operationally-defined task variables. The two were contrasted using imagery and frequency mnemonic instructions and within-list manipulations of the I value and situational frequency of pair members.

In Exp. I, the effects of a repetition (frequency) instruction was compared with two different imagery instructions and a control condition. Instructions to image to the correct word of each pair in a 32-pair list produced more correct responses than repeating the correct word aloud several times, and both were superior to an instruction to image to both words of a pair. On a subsequent cued recall test, however, the compound image instruction was better than the other two, which were not different from each other. The implications of the results for imagery theory in both VDL and paired-associate learning were discussed.

In Exp. II the relationship between imagery and frequency was examined by comparing performance on a mixed list of 16 High-I and 16 Low-I pairs presented under either repetition instructions or no-instruction conditions. Both factors showed significant main effects but they did not interact significantly, suggesting that imagery and frequency effects are independent. The results indicate, moreover, that frequency is not a dominant cue in VDL, as postulated by frequency theory, since the influence of I was unaffected even when use of a frequency strategy was encouraged. This conclusion was supported by Ss' subjective reports concerning their use of imagery and frequency strategies during list learning.

The effect of a Single Image instruction was examined in Exp. III as a function of repeated-right *versus* repeated-wrong conditions. Imagery and frequency again produced significant main effects. The interaction was not significant. There was some indication that the size of the frequency effect was reduced under imagery instructions, but the results on the whole again indicated that imagery and frequency have independent effects in VDL. A preference on the part of Ss for the use of imagery as a learning strategy was indicated by the subjective report data.

Exp. IV compared learning of a mixed list of High-I and Low-I pairs under repeated-right or repeated-wrong conditions. Further support for the independence of imagery and frequency was obtained through the non-significant interaction of the two factors. The subjective report data were not consistent with the analogous findings in Exp. II and III, but this was attributed to the confounding influence of two types of reported repetition strategies.

The independence of imagery and frequency factors in VDL, and their related underlying processes, was analysed within the framework of a model which postulates different levels of cognitive processing of verbal material. Frequency was conceptualized as operating at a verbal representational and verbal associative level, while imagery was seen as characteristic of a referential level of processing. The effect of imagery in VDL was accounted for in terms of a differential encoding response (DER) to the right and wrong members of a pair. It was suggested that frequency theory is most applicable in those situations where verbal processes alone are operative and imaginal encoding is minimal.

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INTRODUCTION

This study investigated the roles of imagery and frequency factors in verbal discrimination learning (VDL). In VDL, the subject (S) is required to learn which member of each pair of presented verbal items has been designated as "correct" by the experimenter (E). Among existing theoretical accounts of the processes involved in learning this task, the most influential by far is the frequency theory (Ekstrand, Wallace, & Underwood, 1966), according to which a correct discrimination is based on the differential frequency acquired by the correct and incorrect items of each pair of discriminanda as a result of repeated exposure to the list.

This analysis has successfully predicted a wide range of experimental findings in VDL, and has been invoked as the most probable interpretation for many others. However, sufficient evidence is now available to question the applicability of the theory as a satisfactory explanation of performance in all situations. Specific attempts have been made to account for Ss' performance in transferring from one VDL list to another (Kausler, Fulkerson & Eschenbrenner, 1967), and in the acquisition of reversal shifts (Paul, 1968) using theoretical constructs in addition to or in lieu of acquired frequency. Moreover, many experiments which have examined the role of associative similarity in VDL have produced results which are contradictory to frequency theory, and in a number of cases where results have conformed to prediction, the operation of additional processes has been implicated.

The main concern of the present research is with the role of nonverbal imaginal processes in VDL, and the consequent implications for frequency theory. A number of studies (e.g., Paivio & Rowe, 1970) to be reviewed presently have shown a consistent effect of the image-evoking capacity of words in VDL, which appears to present difficulties for the theory. In the present series of experiments, imagery and frequency factors were contrasted using two types of defining operations -- instructional sets and within-list manipulations of rated imagery value (I) and frequency of items -- in an attempt to determine the relationship between the two processes involved. A question of particular interest was whether the effect attributable to imagery could be accounted for in frequency-theoretic terms.

LITERATURE REVIEW

The literature review will be centered around experimental findings and issues relevant to frequency theory, although additional proposed interpretations will also be discussed. Beginning with a brief note on the VDL task itself, early research in the area is summarized, followed by a description of frequency theory and the results of initial empirical tests. Three sections containing research findings that generally support predictions derived from frequency theory are then presented. These studies have been grouped into three main categories: (a) those involving manipulations of item frequency, including both experimental and extraexperimental (Thorndike-Lorge) frequency, (b) studies on the effects of interpair and intrapair similarity, and (c), constituting the smallest group, those involving the investigation of pronunciation effects. The remaining three sections of the review are concerned with research on transfer effects in VDL, the acquired equivalence explanation, and the effects of item attributes, all of which have suggested that frequency theory does not give a completely satisfactory explanation of certain data. In the final section, the nature of the effect of word imagery, the most potent item attribute isolated so far, is examined closely.

The VDL Task

In a typical VDL experiment, the S is required to select, from a pair of alternative verbal items, that item which has been designated as "correct" by the experimenter. Usually, the pairs are presented by the method of anticipation, i.e. S first sees each pair, makes a choice as to the correct response, and is then given feedback either by a second presentation of the pair with the correct word underlined, or by the presentation of the correct item alone. Other procedures are possible as well, and these are beginning to receive general usage. They include a modified anticipation method, whereby S responds to each pair and is told "right" or "wrong" either verbally by E or through some nonverbal signal, a study-test procedure, where the pairs of items with the correct alternatives underlined are presented on the study trials and the pairs presented again without the underlining on the test trials, and, more recently, a continuous presentation procedure (Zeaman, Campione & Allen, 1970), where presentation and test trials for different pairs are intermingled in a continuous sequence of items.

Early Research

Although the importance of the process of discrimination among items in verbal learning tasks had previously been pointed out (Gibson, 1940), initial studies involving VDL were concerned primarily with the value of the paradigm as a tool in the investigation of other learning and memory phenomena rather than with discrimination processes *per se*. Thus, McClelland (1942a, b), in a series of experiments on reminiscence effects, devised the VDL procedure in order to test independently the rates of forgetting of right and wrong items in this learning situation. McClelland found that learning of a 20-pair list of dissimilar adjectives by a modified anticipation procedure was significantly more difficult under a 2-sec than a 4-sec presentation rate (1942a), and that performance on a second list was significantly impaired when new right items were paired with wrong items from the first list as compared to a condition where new wrong items were paired with old right items (1942b). These findings were, however, incidental to the main purpose of the experiments, and the new paradigm did not arouse much immediate interest, despite McClelland's conclusion that "discrimination learning at a controlled rate of presentation is a useful additional tool for studies of learning and memory" (1942a, p. 55).

The task next appeared in two studies by Underwood and his associates on the role of intralist similarity in acquisition by massed and distributed practice. Underwood and Viterna (1951), using 10-pair lists of adjectives, found slightly inferior performance on high as opposed to medium similarity pairs, and no difference between a 2-sec and 4-sec presentation rate. The discrepancy between the latter finding and that reported by McClelland was attributed to differences in list length for the two studies. In a second experiment, Underwood and Archer (1955) used 14-pair lists of high and low similarity consonant syllables and found a facilitative effect of a slower presentation rate for the high similarity list. In addition, learning was consistently faster for low similarity items, a result which was noted to be opposite to similarity effects in paired-associate learning (PAL) and serial learning.

Following these initial studies, research in the area was sporadic and lacking an adequate theoretical foundation until the appearance of the frequency theory of VDL (Ekstrand, et al., 1966). The latter precipitated a large number of studies and it is to these that we now turn. Relevant research which appeared in the period between 1955 and 1966 will be reviewed in the context of frequency theory.

Frequency Theory

The theory was presented in its original form by Underwood, Jesse and Ekstrand (1964) to account for results obtained in a VDL transfer experiment. These investigators used McClelland's (1942b) transfer paradigm, where either right (R) or wrong (W) items from the first list were paired with new items in List 2. The relationships may be represented as W_1-R_1, W_2-R_1 and W_1-R_1, W_1-R_2 respectively, where the subscripts 1 and 2 refer to List 1 items and new List 2 items.

The results of the study, which were later confirmed by Lovelace (1966) and Raskin, Boice, Rubel and Clarke (1968), were much the same as McClelland's, i.e. the first condition showed extremely high transfer while the second showed a high, but significantly lower, degree. Furthermore, performance did not improve across transfer trials in the W_1-R_1, W_1-R_2 paradigm, being initially positive, but negative on later trials compared with a W_1-R_1, W_2-R_2 control condition. To explain these findings, the authors suggested that subjects were using a frequency cue as the basis for discrimination on List 2, so that, in condition W_1-R_1, W_2-R_1 the correct item could be selected by choosing that member of a pair which was "old", or which had accumulated the greater amount of experimental frequency, and conversely, in condition W_1-R_1, W_1-R_2 a correct discrimination could be made by choosing the more infrequent member. However, during List 2 practice, the new R words would acquire frequency as well, and at a faster rate than W items, for reasons given below. Thus the difference in frequency between the items of a pair would become less as practice continued, making the discrimination more difficult, or at least retarding any improvement in performance.

The theory was expanded and extended to the single-list situation by Ekstrand et al. (1966). They postulated that, with repeated exposure to a VDL list, differential accrual of frequency "units" to R and W items occurs, and this is used by the subject as the cue for discrimination. Four different kinds of responses that can produce frequency units were proposed: (a) the representational response (RR), or the "act of perception of each alternative" (Ekstrand, et al., 1966, p. 568), (b) the pronunciation response (PR), which occurs when S chooses one of the two items on an anticipation or test trial and pronounces it, (c) the rehearsal-of-the-correct-alternative response (RCR), an implicit or explicit pronunciation of the correct item on feedback or study trials, and (d) the implicit associative response (IAR), a verbal associative reaction to one item in a list that occurs in some other pair. The overall result of the operation of these responses, especially the RCR, during practice, is a build-up of frequency units which favors the R items, and enables S to respond correctly to each pair by choosing the alternative that has developed the higher situational frequency.

Ekstrand et al. (1966) reported an experiment designed to test the efficacy of response frequency as a discriminative cue in VDL. In one set of conditions, repeated items within the same list were used to enhance or decrease the effectiveness of the frequency cue. Thus if the same R item occurs in two of the pairs, the number of frequency units accruing to that item from RR's and PR's alone will be twice the number that occurs for each W item and this should produce rapid acquisition. On the other hand, placing the same

W item in two pairs will result in a greater accumulation of units to that item than would ordinarily occur, and this will lessen or eliminate the usual difference in favor of R items, creating a difficult learning situation. A third condition, in which the same word is correct or incorrect in two different pairs, was designed to produce maximum disruption of learning, since in this case one pair develops a frequency differential favoring the R item, while for the other, greater frequency is acquired by the W item. In a second set of conditions, the three types of lists described above were repeated, this time inserting a strong associate to an item elsewhere in the list instead of repeating the item itself. Here the same predictions concerning task difficulty can be made, with frequency being affected via the operation of IAR's. The results of the experiment were exactly as predicted, but with larger differences occurring with repeated than with associatively-related items; in fact, differences obtained in the latter case have failed to replicate in two subsequent studies (Kanak, Cole & Thornton, 1970; Mueller & Pickering, 1970). Nonetheless, this initial test provided strong support for the theory.

A number of more recent experiments have tested predictions derived from frequency theory and a large amount of supportive evidence has accumulated, although a number of findings have suggested that additional factors are also operative. These studies will be reviewed in subsequent sections, beginning with the effects of experimental frequency manipulations.

Experimental and Extraexperimental Frequency Effects

One effective method of testing the validity of frequency theory is to manipulate the experimental, or situational, frequencies of R and W items in a list. Underwood and Freund (1968b, Exp. 1) accomplished this by administering zero, two or five free learning trials for either R or W members of VDL pairs prior to list learning. Their results were in agreement with predictions from the theory, in that lists with prior free learning of R items were easier in discrimination than control lists which lacked the free learning stage. Also, performance was initially high on the list for which W items had been learned for 5 free recall trials, but failed to show much improvement during VDL and, in fact, this group was surpassed by the control groups after 5 VDL trials, presumably because of a breakdown of a frequency discrimination based on choosing the less frequent item as correct (cf. Underwood et al., 1964). The experiment was replicated with some modifications by Wallace and Nappe (1970) with essentially the same results, and similar trends have been obtained when simple prior familiarization trials are used instead of free learning (Lovelace, 1969; Runquist & Freeman, 1960).

Within-list manipulations of frequency similar to the conditions used by Ekstrand et al. (1966) have since been reported. A systematic variation of the number of different R or W items occurring in a 12-pair list was carried out by Underwood and Freund (1969). Performance decreased monotonically as the number of different R items increased from 2 to 12, while learning was more difficult for 4 and 6 different W items than for 2 or 12. Both findings are in accord with frequency theory. In particular, the increased difficulty for 4 and 6 different W items is predictable on the basis of smaller differences in item frequency within pairs in these conditions than for conditions 2 and 12. Yelen (1969) varied the frequency differential between R and W items in CVC pairs by having each item in the list occurring on every trial or changing W items from trial to trial. Fewer errors were made when W items were changed during list learning, and this was taken as evidence in support of the theory. Kausler and Boka (1968) tested the effect of double functioning, where each R item serves as a W item elsewhere in the list and *vice versa*, on VDL. According to frequency theory, this task should be virtually impossible, as the accrual of frequency units is the same for both R and W words. Kausler and Boka found the double function list to be more difficult than a partial double function list, which was in turn more difficult than a control. However, the fact that the double function list could be learned, albeit with difficulty, is contrary to the theory, and suggests that a discrimination can be made in terms of other attributes than frequency when this is necessitated by particular experimental conditions.

One interesting notion regarding the effect of item frequency in VDL is the Weber-law postulate, which states that pairs of items of low initial frequency should be easier to discriminate than pairs of high initial frequency, since the addition of one frequency unit to an item should produce a larger increment in the former case. This prediction has received some support in studies involving experimental frequency manipulations. Berkowitz (1968) pre-trained subjects on a 16-pair VDL list, followed by transfer to a 24-pair list where 8 pairs were composed of all the R items from List 1, 8 pairs contained the W items, and 8 pairs were all new words. Performance on the transfer list was highest for new pairs, less for pairs of W items and poorest for R items from List 1, as was predicted from the Weber-law analogy. Evidence bearing on the prediction is also available from other experiments in which situational frequency of pairs has been studied, with both positive (Skeen, 1970; Wallace & Nappe, 1970) and negative (Lovelace, 1969; Runquist & Freeman, 1960) results being reported.

In a more exhaustive test of the postulate, Underwood and Freund (1970a) conducted two experiments where varying amounts of item familiarization preceded VDL. They found that subjects were able to respond to each pair on the basis of induced frequency differences between the items, both with and without instructions to do so, and performed more efficiently on pairs of low base frequency than on pairs for which induced frequency was high. The subjects also made frequency judgements of the familiarized items. It was noted that these judgements varied greatly as a function of the particular word being judged, thus again implicating the importance of other item attributes in the accrual of frequency units as proposed by the theory. More will be said about this in a later section.

It is important to note that the Weber-law postulate does not receive the same degree of support from studies in which the extraexperimental, or background, frequency of items has been varied. Postman (1962) compared VDL for pairs of words which were of high, medium or low frequency as indexed by the Thorndike-Lorge count. He found that subjects did not perform as well on the high frequency pairs as compared to the other two types in a relearning test given after a 7-day retention interval, but no effect of frequency occurred in original learning. Similarly, Ingison and Ekstrand (1970) and Paivio and Rowe (1970) obtained nonsignificant differences between high and low frequency pairs, although a consistent trend across trials in accord with Weber's law was obtained in the latter study. In a more recent report involving four experiments on imagery and frequency effects, Rowe and Paivio (1971b) obtained significant effects of frequency, with fewer errors on low-frequency pairs, but the effect was restricted to pairs that were relatively abstract occurring in a mixed list. The authors concluded that the Weber-law postulate, as far as Thorndike-Lorge frequency is concerned, remains tenuous, but that this is probably not a serious drawback for frequency theory which is concerned primarily with situational frequency differences. That the two types of frequency may not have the same effects was pointed out by Ekstrand et al. (1966). Underwood and Fruend (1970b) concluded that situational frequency can assimilate to background frequency in VDL and interfere with the retention of a dicrimination, since they found more rapid forgetting for pairs in which the R word was of low background frequency and the W word high than in the reverse condition. However, in a more recent study (Underwood, Zimmerman & Freund, 1971), no evidence that the merger of situational and background frequency can explain the loss of a frequency discrimination over time was obtained. Thus there is no compelling evidence to suggest that the two types of frequency are related, and, for the present, the scope of frequency theory is best restricted to situations involving experimental frequency alone.

Further tests of frequency theory may be classified under the dual headings of similarity and pronunciation effects. Each of these will be examined in turn in the following sections.

Similarity Effects

We have already mentioned three experiments in which the effects of interpair associative similarity in VDL were examined (Ekstrand, et al., 1966; Kanak, et al., 1970; Mueller & Pickering, 1970) with disparate results concerning predictions made on the basis of frequency theory being reported. A number of additional studies (Battig & Brackett, 1963; Edwards, 1966; Underwood & Archer, 1955) have included formal interpair similarity as a factor and have found a general inhibitory effect on overall learning scores. The results are thus in agreement with predictions from frequency theory.

Increasing the degree of intrapair similarity in a VDL list is also predicted to inhibit learning, again because of a retardation of the growth of a frequency differential for each pair. This prediction was tested by Palermo and Ullrich (1968) using lists of high-associative, low-associative and unrelated word pairs. High-associative pairs resulted in more errors than unrelated pairs in four experiments involving various presentation conditions and groups of college students and young children. High- and low-associative pairs did not differ significantly in every case, but the results were generally in accord with the theory. Analogous effects of formal similarity have also been reported (Putnam, Iscoe & Young, 1962; Youniss, Feil & Furth, 1965) and VDL has been shown to be more difficult for both synonym (Youniss et al., 1965) and homonym (Kaulser & Olson, 1969) pairs than for unrelated words.

The results of several other studes, however, while largely in agreement with the findings cited above on inter-pair similarity, show a null or opposite effect of intrapair variations in similarity (Buschke & Lenon, 1969; Eberlein & Raskin, 1968; Edwards, 1966; Fulkerson & Kausler, 1969; Putnam, et al., 1962; Radtke & Foxman, 1969; Schwartz, 1970; Underwood & Viterna, 1951). Such lack of convergence of research findings on this particular problem is further evidence that a frequency mechanism is not operative in all situations, or at least is not the only active process. Eberlein and Raskin, for example, point to the possible importance of intrapair relations as an aid to discrimination. They postulate that the subject may be able to reduce the memory load under such conditions by "tagging" one member of each pair as correct and collapsing the pair and tag together for memory storage. This interpretation is of course speculative, but whatever the reason for the contradictory findings on intrapair similarity, it appears necessary to begin seeking possible explanations outside the sphere of frequency theory.

Pronunciation Effects

Evidence from the study of pronunciation effects in VDL lends support to a frequency analysis, but again suggests that a frequency differential is not a *sine qua non* for discrimination learning. Underwood and Freund (1968b, Exp. II) required subjects to pronounce each pair of words in an 18-pair list twice during study trials, the prediction being that learning would be retarded because of the adverse effect on differential frequency accumulation. The results showed much slower learning as compared to a no-pronunciation control group, which was in turn surpassed by a second control group where *S*s pronounced each R word four times (cf. Smith & Jensen, 1971). However, as in the experiment on double functioning (Kausler & Boka, 1968), learning was still evident when the frequency cue was eliminated or at least greatly reduced, again indicating the influence of additional processes. Nonetheless, the detrimental effect of pronunciation of both intrapair items is a highly replicable finding, occurring both with college students (Hopkins & Epling, 1971; Kausler & Sardello, 1967; Rowe & Paivio, 1971c; Sardello & Kausler, 1967) and young children (Goulet & Hoyer, 1969). A facilitative effect of having *S*s make extra pronunciations of R items during list learning has also been reported for both age groups, and for pictorial as well as verbal stimuli (Carmean & Weir, 1967; Deichman & Horne, 1971; Deichman, Speltz & Kausler, 1971: Weir & Helgoe, 1968). The positive nature of these findings for frequency theory cannot be discounted.

The research reviewed above shows that the frequency theory of VDL has undergone a large number of experimental tests and in most cases has survived well. It was noted that some results suggest the presence of additional unknown factors that influence performance, thus indicating the need for modifications in the theory as originally proposed, and proponents of the frequency notion readily admit this to be the case (Underwood & Freund, 1970a). The question of the adequacy of the theory to account completely for VDL under all conditions has been raised in two additional areas of research, namely, transfer effects and effects of item attributes, and an alternative interpretation has been provided by the acquired equivalence notion. These topics are dealt with in the following sections.

Acquired Equivalence Explanation

This interpretation arose out of some observations made by Paul (1966; 1968) in two verbal discrimination reversal experiments. In these experiments *S*s were taken to a specified criterion on a 12-pair list and then transferred to a second list in which either 25, 50, 75 or 100 percent of the items were reversed (i.e. R items became W and *vice versa*). The results showed a nonmonotonic relation between second list learning and number of pairs reversed, with fewer trials to criterion being required for the 25 and 100 percent groups than for the other two. In addition, an analysis of the number of errors made on reversed and nonreversed items was carried out, showing that, while the percentage of errors on reversed items was negatively related to percentage of items reversed, the relationship was positive for errors on nonreversed items (excluding, of course, condition 100, where all items were reversed). The results were taken as evidence that, in the 75 percent reversal condition, Ss had formed a "concept of reversal" or a "transfer-activated response set" (Paul & Paul, 1968) to reverse all first-list selections. This acted to produce a relatively large proportion of errors on nonreversed items while facilitating performance on reversed items. The same explanation applies to the rapid reversal learning in the 100 percent group. The overall findings were replicated by Paul, Callahan, Mereness, and Wilhelm (1968) using a three-alternative task. They concluded that the response set activated by a 75 and 100 percent reversal shift was to "suppress first-list responses" rather than to "reverse all first-list responses" in the two-alternative case.

The above analysis of VDL shift performance implies that Ss are able to classify items in a verbal discrimination task on the basis of their "correctness". More specifically, it is assumed that during VDL, the R items acquire the dispositional characteristics of an equivalence class, such that a new response learned to one R item can be generalized to the others. Evidence related to this notion was provided by Paul, Hoffman, and Dick (1970), in two experiments involving a 50 percent reversal shift. They showed that the experimental establishment of equivalence classes consisting of reversed and nonreversed pairs in second-list learning facilitated the acquisition of the second list. More pertinent to the above argument are the results of an experiment by Paul (1970), where a 12-pair list was learned either to a criterion of three successive errorless trials plus 50 percent additional trials, or for at least 12 trials. Following this high degree of practice, Ss were shown each of the 24 list items individually, and were required to learn a different letter response to the R and W words. Very high transfer resulted, beginning with the first trial. By contrast, the performance of a control group receiving unrelated items on the second task did not differ from chance. The experiment thus provides strong evidence that conditional equivalence is acquired by the correct alternatives in a VDL task.

The relationship of the equivalence class notion to frequency theory is a matter of considerable interest, but about which little has been said. The two are probably best viewed at present as complementary, rather than alternative, interpretations, since frequency provides one specific basis for the acquisition of equivalence classes (Paul, et al., 1968). Thus in most VDL studies both explanations are applicable, although there are certain results which are embarassing to one or the other. For example, it is difficult to see how the results obtained in the W_1-R_1, W_1-R_2 transfer paradigm, i.e. initial positive and later negative transfer

(Underwood, et al., 1964) could be interpreted solely in terms of equivalence classes. On the other hand, this type of response process might be used to supplement frequency theory in accounting for the fact that in such a transfer situation, second-list performance never falls to chance, which would be expected at the point where R and W items become equal in frequency if Ss are responding on the basis of this attribute alone. There are also instances where the acquired equivalence notion seems more applicable than frequency theory, e.g. where R items are of a particular taxonomic class (Duncan, 1968; Kausler, Erber & Olson, 1970), frequency level (Kausler & Farzanegan, 1969), or word length (Deichman, Minnigerode & Kausler, 1970), and learning is presumably facilitated by Ss' use of particular "selection strategies", or where correctness of items is reversed on alternate trials of a VDL list but learning is nonetheless still observed (Schwartz, 1970).

Transfer Studies

Two main types of VDL transfer studies may be distinguished: those involving transfer from one VDL list to another, and those involving transfer from VDL to PAL. We shall not concern ourselves with the second type here, except to note that practice on a VDL list positively affects subsequent PAL and associative recall of the same pairs when the items consist of real words (Keppel, 1966; Spear, Ekstrand & Underwood, 1964; Zechmeister & Underwood, 1969) but not for pairs of nonsense syllables (Battig & Brackett, 1963; Battig, Williams & Williams, 1962; Keppel, 1966). Associative recall is also influenced by such factors as degree of practice (Kausler & Sardello, 1967; Sardello & Kausler, 1967), pronunciation (Goulet & Hoyer, 1969; Sardello & Kausler, 1967) and item concreteness (Paivio & Rowe, 1971; Rowe & Paivio, 1971b, Exp. III).

Several experiments involving transfer between two VDL lists were cited above as support for frequency theory (Lovelace, 1966; Raskin, et al., 1968; Underwood, et al., 1964). It will be recalled that these studies showed stronger transfer effects under the W_1-R_1, W_2-R_1 paradigm than for W_1-R_1, W_1-R_2, and that transfer in the second case was at first positive and then negative on List 2 as compared to a control condition. Kausler, Fulkerson and Eschenbrenner (1967) postulated that this negative transfer effect, which may begin on the first trial of List 2 practice (Kausler & Dean, 1967), might be attributable to factors in addition to the inefficacy of a frequency differential. They point to the similarity between the W_1-R_1, W_1-R_2 paradigm and the A-B, A-C transfer paradigm in PA learning, where negative transfer effects have been well documented and attributed to the competition between B and C responses during List 2 practice accompanied by the unlearning of List 1 responses and associations (e.g. Barnes & Underwood, 1959). Since associative learning of pairs accompanies VDL involving real words, the competition-unlearning mechanism may also operate in the W_1-R_1, W_1-R_2 paradigm to produce negative transfer. The hypothesis was tested by Kausler et al. (1967) using an MMFR test following List 2 learning and significant unlearning of both List 1 responses and associations was observed. A similar effect was demonstrated for the W_1-R_1, W_2-R_1 paradigm by Eschenbrenner and Kausler (1968). Later studies (Eschenbrenner, 1969; Kanak & Curtis, 1970; Kanak & Dean, 1969; Lucas & Goulet 1969) have replicated and extended the findings and it is generally agreed by these investigators that the positive and negative transfer effects obtained with replacement of W and R items in VDL may be viewed as resulting from a combination of both frequency and associative competition mechanisms. In short, it appears that frequency cues determine the direction, and associative competition the degree, of transfer in such situations (Lucas & Goulet, 1969).

Effects of Item Attributes

The possible effects of item attributes other than frequency in VDL have been referred to several times above, but most explicitly in the context of the Underwood and Freund (1970a) study, where the influence of such factors independent of a frequency mechanism was implicated. In this section we shall be concerned with studies in which three attributes, imagery (_I_), frequency (F) and meaningfulness

(m) have been examined explicitly. Since the effects of word frequency were already discussed in connection with Weber's law, particular attention will be paid to the remaining two in the present discussion.

Meaningfulness was included as a variable in a study by Schulz and Hopkins (1968), who examined VDL performance on a mixed list of 16 pairs of High-m and Low-m dissyllables under visual and aural presentation conditions. A positive effect of m was found in the latter case, indicating that this variable did influence performance, a conclusion which is further supported by the finding that pairs of nonsense syllables of high association value produce more rapid learning than low association-value pairs (Runquist & Freeman, 1960). However, in both studies the effect of m was confounded with possible effectsof I, raising some question as to which was the more effective variable, since m has been shown to be relatively ineffective when varied independently of I in other verbal learning and memory tasks (Paivio, 1969).

This question was examined by Paivio and Rowe (1970), using three lists in which pairs of items were of high or low values on I, F or m with values of the other two attributes held constant at a medium range of variation. A study-test procedure was used, with subjects receiving eight trials on one of the three 16-pair lists, the pairs being presented on a memory drum at a 3-sec rate. The results showed no effect of m, a negative but nonsignificant trend for F, and a strong positive effect of I, thus singling out the latter as the most effective variable of the three. In a second study (Rowe & Paivio, 1971b), the imagery effect and its possible interaction with F were examined in a set of four experiments. Strong facilitation with High-I pairs was again obtained with both mixed and unmixed list designs, although the difference occurred only for High-F items in two of the experiments. Nonetheless, imagery was the more potent variable overall, as the effect of F was apparent in only two experiments and in those was restricted to Low-I pairs in a mixed list design. Ingison and Ekstrand (1970) also factorially varied frequency and abstractness of items in a 20-pair mixed list. They found no effect of frequency and also failed to obtain a difference between concrete and abstract pairs. However, recent findings discussed by Rowe and Paivio (1971b) show that 15 of the 40 items used by these investigators were not clearly differentiated in terms of I, as reflected in the ratings of 32 subjects. Thus their study did not constitute a clear test of the imagery effect.

Whereas the previous two studies (Paivio & Rowe, 1970; Rowe & Paivio, 1971b) had examined learning of pairs in which both words had either high or low imagery values, the research was extended to include intrapair variations in I by Paivio and Rowe (1971). In addition, the experiment differed procedurally from those cited above in that group testing sessions and written instead of oral responding were used. Fewer errors were made on High-I homogeneous pairs than on Low-I homogeneous pairs, consistent with the previous results, and heterogeneous pairs did not differ from those in which both members were High-I. Furthermore, heterogeneous pairs in which the Low-I item was correct were no more difficult than pairs in which the High-I item was correct. The theoretical implications of these findings will be discussed presently.

The salience of the imagery variable in VDL was again demonstrated in two subsequent studies (Rowe & Paivio, 1971a, c). In one of these (Rowe & Paivio, 1971c), the robustness of the imagery effect was tested in a factorial experimental involving variation in presentation procedures and pronunciation conditions as well as I. The result of interest here was the lack of any significant interactions involving I, which shows that the effect was not qualified by different levels of the other factors, and is thus highly reliable (within the restrictions imposed by the experimental design). Rowe and Paivio (1971a) compared learning of pairs of pictures, High-I words and Low-I words using a study-test paradigm. The superiority of High-I over Low-I pairs was replicated, with the pictures producing the least number of errors. Since the three sets of materials varied along a dimension of ease of image-arousal, the findings are taken to represent a further confirmation of the strong influence of nonverbal (imaginal) processes in VDL.

Two theoretically relevant questions arise from the experiments on imagery effects. The first concerns the explanation of the effect itself, which is sizeable, accounting for about 20 percent of the variance in error scores (Rowe & Paivio, 1971b), and highly consistent. Unfortunately, few concrete statements regarding the reasons behind the obtained differences are possible. It should be pointed out, however, that the available information is uniform in suggesting that the effect is due primarily to the operation of nonverbal (imaginal) coding processes. This is evident both from post-experimental questionnaire data presented by Rowe and Paivio (1971b), where subjects reported using imagery more frequently for High-I than for Low-I pairs, and from the findings with pictorial material, where pictures were significantly easier than their concrete noun labels. Paivio and Rowe (1970) suggested two possible explanations of the effect in terms of the image-arousal properties of the items - differential accrual of imagery reactions to correct and incorrect members of High-I pairs which could be an additional cue not likely to occur for Low-I words, and an image tagging process, analogous to the verbal tagging proposed by Eberlein and Raskin (1968), whereby Ss might be able to tag the image aroused by the R member of each pair in some way, and use this as a mnemonic aid in discrimination learning. Paivio and Rowe (1971) attempted to choose between the two alternatives by comparing performance on pairs of words where the correct items were High-I, but the incorrect items were either High-I or Low-I. Higher performance on High-I - Low-I pairs would support the image frequency interpretation, whereas higher performance on High-I - High-I pairs would argue in favor of image tagging. The results, already referred to above, were inconclusive, as performance in the two conditions was almost exactly the same. Thus the correct interpretation of the imagery effect remains unclear. Experiment I of the present research provides additional evidence on this issue.

A second question involves the implications that the research offers for frequency theory, and it is toward this point that the remaining three experiments of the thesis are directed. Generally speaking, the effect of any attribute of individual words, apart from frequency, on discrimination learning is not readily explainable by a strict frequency interpretation. However, as mentioned above, proponents of the theory have recently modified the original view that differential frequency increments are the sole determining factor of VDL performance; rather, "frequency theory as now conceived assumes that a frequency differential is a *dominant* attribute in learning the usual VDL task; when this attribute fails to serve as a discriminative cue, other attributes will become dominant" (Underwood & Freund, 1970a, italics inserted).

It is suggested that this revision of the theory is still unable to account for certain available data, especially those on imagery effects: why must it be required that the frequency attribute fail to serve a discriminative function before other attributes can be effective? More specifically, why must frequency be an ineffective attribute in the case of High-_I_ words before imaginal coding mechanisms come into play? It is just as reasonable to assume instead that frequency cues are utilized in situations where other cues are inefficient or inappropriate, but, at the same time, these other cues may be effective and indeed preferred as a learning strategy even when discrimination on the basis of frequency is still possible. Thus, in the questionnaire data of Rowe and Paivio (1971b) a frequency strategy (use of RCR's) was preferred for discrimination of Low-_I_ pairs but an imagery strategy was preferred for High-_I_ pairs. This interaction, which was statistically significant, may be seen as representing a qualification of frequency theory by the results involving imagery.

Experiments II, III, and IV below constitute an examination of the relationship between frequency and imagery as operationally-defined attributes in VDL. The two were manipulated using operations which have been previously found to affect VDL performance, the purpose of the present experiments being to determine possible ways in which imagery and frequency interact when both are varied orthogonally within the same experimental design. Imagery was manipulated by the use of imagery instructions as in Exp. I, and by varying the relative concreteness, or I value, of the verbal stimuli (Paivio & Rowe, 1970); the frequency manipulations involved repetition instructions (Underwood & Freund, 1968b) and within-list repetition of R and W items (Ekstrand, et al., 1966). The relationship between the two variables was examined by comparing performance on High-I and Low-I pairs as a function of repetition instructions (Exp. II), by comparing repeated-wrong *versus* repeated-right item conditions as a function of imagery instructions (Exp. III), and by comparing repeated-wrong *versus* repeated-right conditions as a function of the I level of pairs (Exp. IV). As a corroborative measure in each case, Ss were questioned following the experiment regarding their use of frequency and imagery strategies during list learning (cf. Rowe & Paivio, 1971b, Exp. II).

EXPERIMENT I

The first experiment was designed primarily to investigate the effectiveness of imagery and repetition strategies in VDL through the use of instructional sets. As mentioned above, Underwood and Freund (1968b, Exp. II) and Smith and Jensen (1971) have shown that instructing Ss to repeat the R items of each pair aloud several times either during study trials or immediately prior to practice on a VDL list produces a marked facilitation in performance. These results were interpreted in terms of frequency theory, with the facilitative effect of repetition being attributed to a rapid build-up of situational frequency to the R word of each pair.

There have been no reported attempts to determine the effects of imagery instructions in VDL. However, several studies reviewed above (Paivio & Rowe, 1970, 1971; Rowe & Paivio, 1971a, b, c) have shown that pairs of words rated high in image-arousing capacity are easier to discriminate than Low-I pairs, and Ss have reported using imagery strategies to a greater extent for pairs of High-I words. The precise nature of the reported imagery strategies has not been determined, but two possibilities were suggested by Paivio and Rowe (1970). First, Ss may simply form an image to the R word of each pair, making the task one of recalling which word had been imaged to. An alternative, and seemingly less efficient method, would be to form an image to both words of a pair, and then to "tag" the image corresponding to the R word in some way such as making it larger or more vivid. The effects of instructions to use each of these techniques in VDL were examined in the present experiment, and each was compared with a repetition instruction.

An associative recall test was administered following the final trial of VDL, with half of the Ss in each group receiving the R item as the stimulus and the other half the W item. The data gathered here were of interest, not so much for their relevance for VDL, but because the procedure presented an opportunity to test two types of explanations which have been advanced for the effect of imagery in intentional PAL (see Bower, 1970). If instructions to image to a pair of words in PAL predominantly affects processes related to stimulus encoding or response learning, as is postulated by one class of explanations, this should result in improved performance on the part of Ss who image only one word of a pair during VDL, with the locus of the effect depending upon whether the imaged word served as stimulus or response during associative recall. On the other hand, if the use of imagery in PAL affects primarily the formation of associative connections between the items of a pair, as has alternatively been proposed, performance should be better for Ss who image both words of each pair in VDL. The latter interpretation has been supported by Bower (1970), who found that instructions to image the objects denoted by a pair of words in an interactive scene facilitated subsequent cued recall, whereas the performance of _S_s who imaged to each word separately was not different from that of a rote repetition control group. The present design affords a further test of the locus of the imagery effect by comparing incidental cued recall of _S_s instructed to image to either the stimulus or response term or both together on the prior VDL task.

Method

Subjects. Ninety-six introductory psychology students (47 males) at the University of Western Ontario participated in the experiment as part of a course requirement. They were assigned in rotation to the eight conditions generated by the 4x2 design (4 instruction groups x 2 recall conditions). There were six males and six females in all groups except one, where there were five males and seven females.

Lists. The lists were constructed from a sample of 64 two- and three-syllable words four to eight letters in length selected from the Paivio, Yuille, and Madigan (1968) norms. All of the words had _I_ values above 6.06 and were greater than 39 per million by the Thorndike-Lorge G count (Thorndike & Lorge, 1944). Concreteness and _m_ values were uncontrolled. The complete word sample with the values of each attribute are given in Appendix A. Two different sets of random pairings were used to construct the two 32-pair lists.

Procedure. The Ss were tested individually using a Gerbrands model M5 memory drum. A study-test procedure was employed, with the pairs being presented at a 5-sec rate. On the study trials one randomly-selected member of each pair was underlined and S pronounced both words aloud, reading from left to right. Pronunciation was required to ensure that S attended to both items. The Ss in the Repetition instruction condition were told to repeat the underlined word aloud three additional times.[1] The Single Image instruction was to form an image to the underlined word only. The Compound Image instruction was to form a compound image to both words, making the image to the underlined word the larger of the two. The Ss were reminded to keep using the same strategy at the beginning of trials two and three. Control Ss received no instructions concerning particular strategies. The complete experimental instructions are given in Appendix B. On the test trials the underlining was absent and S chose the member of each pair that he thought was correct. Guessing was encouraged. One study-test trial on

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[1]The use of the term "instruction" to describe the independent variable in the Repetition and the two imagery groups alike should not be taken to imply that repetition (frequency) and imagery were represented by equivalent operations. The manipulation in the Repetition group involved an instruction plus overt rehearsal of R items, while the imagery groups received only an appropriate instruction. This does not affect the conclusions to be drawn from the various reported experiments, however, where imagery and frequency were compared via manipulations which have been used effectively by previous investigators to study each variable independently.

a practice list of four pairs, presented on flash cards, preceded the four trials on the experimental list. Four different random orders of the 32 pairs were used. Counter-balancing for spatial position of correct and incorrect items was carried out such that, for any given study or test trial subsequent to the initial presentation, item position for half of the pairs was changed from the preceding trial but with the items of any given pair changing position an equal number of times (four) across all four trials. The correct and incorrect items occurred equally often in the left and right positions for each presentation of the list. Half of the Ss in each group received one set of pairings and the remainder the other set. Also, within each of these groups, half of the Ss had one randomly selected member of a pair correct, while for the remaining Ss the other word was correct.

Immediately following the VDL task, each S was given a sheet of paper with one word of each of the pairs listed down the left-hand side, and was instructed to write the other word of that pair in the blank beside each. For the Ss in the Correct Cue group the cue words were the correct items from VDL, while for the Incorrect Cue group they were incorrect.

Results

Verbal discrimination learning. The VDL data were corrected for guessing by subtracting the number of errors from the number of correct responses made by each S on each trial.[2] The means are presented in Table 1. An analysis of variance of the corrected data, with Instruction, Cue Type, and Trials as factors was carried out,[3] the second factor being included to determine whether the groups receiving the correct or incorrect items as cues on the recall test were equated on level of VDL performance. The main effect of Cue Type was not significant (F, 1,88 = 1.79, $p > .05$). Instruction (F 3,88 = 8.86, $p < .001$) and Trials (F, 3,264 = 232.45, $p < .001$) both contributed significant main effects, and there were two significant interactions: Instruction X Trials (F, 3,264 = 5.22, $p < .001$) and the three-way interaction of Instruction X Cue Type X Trials (F, 9,264 = 2.67, $p < .01$). The Instruction X Trials interaction is due to the differential steepness of the learning curves for the four instruction groups, with each tending toward the same asymptote (Table 1), i.e. the data exhibit a pronounced ceiling effect. This feature of the results is relatively uninformative and will not be discussed further. The triple interaction may be attributed to the

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[2]In all of the experiments to follow, two parallel sets of analyses were carried out, one using the raw scores and the other using scores which were corrected for guessing in this way. In each case, the results were statistically equivalent, so only the analyses of the corrected data will be reported.

[3]Summary tables for all reported analyses of variance are given in Appendix C.

TABLE 1
MEAN NUMBER CORRECT IN VDL FOR EACH EXPERIMENTAL CONDITION AS A FUNCTION OF TRIALS (EXP I)

	Condition							
	Control		Compound Image		Repetition		Single Image	
Trials	Correct Cue	Incorrect Cue	Correct Cue	Incorrect Cue	Correct Cue	Incorrect Cue	Correct Cue	Incorrect Cue
1	16.00	13.83	13.67	19.83	21.67	19.50	24.17	23.83
	(9.60)	(4.63)	(5.39)	(7.36)	(4.82)	(4.87)	(5.99)	(7.16)
2	20.83	25.17	24.00	26.50	26.67	26.50	30.17	28.17
	(7.39)	(4.62)	(4.43)	(4.64)	(4.53)	(3.09)	(2.09)	(3.99)
3	27.33	29.00	28.00	29.67	28.50	30.17	30.83	30.67
	(4.19)	(2.76)	(4.31)	(3.12)	(4.15)	(2.07)	(1.91)	(2.45)
4	28.83	31.17	29.83	31.33	30.67	30.83	31.67	31.67
	(2.49)	(0.80)	(4.67)	(1.17)	(2.24)	(2.41)	(0.74)	(1.11)

Note:- The figures in brackets are the standard deviations.

fact that the learning curves for the four instruction groups were more similar in shape and closer together in the Incorrect Cue than in the Correct Cue condition. No obvious reason for this difference suggests itself, since Cue Type was a dummy factor in the analysis, the Ss in the two Cue Type conditions not being treated differently in VDL. In any event, this finding also is unimportant for our purposes, since the two groups were approximately equal in terms of terminal acquisition performance, and the main effect of Cue Type was not significant. Both of these results indicate that any differences between the Cue Type conditions on the associative recall test cannot be attributed to a differential level of performance in VDL.

The effect of Instruction can be seen most clearly when the data are collapsed across Cue Type, as has been done in section A of Table 2. A second analysis of variance was carried out on these data to obtain the appropriate sums of squares for the calculation of ω^2. The analysis produced a significant effect (F, 3,92 = 8.61, $p < .001$), with the instruction variable accounting for about 19 percent of the total variance in performance scores (Hayes, 1963, pp. 406-407). Comparisons between the means were carried out using Duncan's test (Edwards, 1968, pp. 131-134) with an adopted significance level of .05. The results are shown in Table 2A, where the underlined means are those which did not differ significantly. Thus the Single Image group was superior to all others, and the Repetition group was superior to the

TABLE 2
MEAN NUMBER CORRECT IN VDL AND ASSOCIATIVE RECALL (EXP I)

A. VERBAL DISCRIMINATION LEARNING

	Instruction		
Control	Compound Image	Repetition	Single Image
24.02	25.33	26.77	28.88
(4.21)	(3.99)	(2.77)	(2.75)

B. ASSOCIATIVE RECALL

		Instruction		
Cue Type	Single Image	Repetition	Control	Compound Image
Correct	13.92	18.25	19.08	23.67
	(7.63)	(8.02)	(8.28)	(5.98)
Incorrect	19.75	19.42	22.58	27.67
	(5.58)	(7.39)	(7.31)	(4.73)

Note:- The figures in brackets are the standard deviations.

Control.

Associative recall. The mean number correct in associative recall is shown in Table 2B. The analysis of variance showed significant main effects for both Instruction (F, 3,88 = 6.95, $p < .001$) and Cue Type, (F, 1,88 = 6.37, $p < .05$). The interaction was not significant ($F < 1$). Instruction accounted for about 15 percent of the total variance and Cue Type accounted for about five percent. Recall was generally higher when the incorrect word in discrimination learning was the stimulus term, but this difference was significant only in the Single Image condition (t, 88 = 2.03, $p < .05$). The differences between the means for each Cue Type were tested separately by Duncan's test as before, and similar results were obtained for both conditions (Table 2B). The Compound Image group was superior to the others regardless of the type of cue, and in addition, the Single Image group was superior to the Control in the Correct Cue condition only.

Discussion

The results show that one type of imagery strategy, i.e. imaging to the R word of each pair, can be used as an effective mnemonic in VDL. Instructions to image to both words of a pair were less effective than the Single Image instruction, and in fact, this group's performance was not different from the control group's. Of course, these results do not eliminate the possibility that some other type of compound-image-plus-tagging strategy can be used to advantage, since only one type of image tagging was explored. Indeed, because of the obvious advantage of compound imagery in associative learning of pairs, it would be important to investigate alternative tagging devices with a view to finding a strategy which would benefit both discrimination and associative learning of pairs concurrently. Perhaps the process of forming associations between a pair of words retards the development of a discrimination between them - this might be one reason for the ineffectiveness of compound imaging in VDL - thus making equal facilitation of both associative and discrimination learning at the same time unlikely. But since little is known about the relationship between the two processes, the question can be answered only by further research.

The present results, however, allow us to conclude that imaging only to the correct word of a pair in VDL is more effective than imaging to both words. This suggests that a differential accrual of images to R items, as postulated by the "image frequency" interpretation of the imagery effect, is a more accurate description of Ss' strategies in learning High-I pairs than is the image-tagging notion. Presumably, Ss will tend to use the simpler and more effective of two possible strategies when left to their own devices. Again, the use of other strategies with High-I pairs is not excluded by the results, but of the two proposed imagery strategies, single imaging appears more likely. This matter will be raised again in the General Discussion section of the thesis, where issues related to the relative effectiveness of the Single Image instruction versus Repetition will also be discussed.

The pattern of results for the various instruction conditions in associative recall is quite different from that obtained in discrimination learning, suggesting that different types of strategies facilitate the two types of learning. In particular, the Single Image group produced the best performance in VDL, but was the poorest overall in associative recall, whereas the Compound Image group was not different from the lowest (control) group in VDL, but was superior to the other three on the associative recall test. Similarly, the Repetition instruction benefitted discrimination learning but not associative recall.

The recall data are congruent with the theoretical position that the effect of imagery in PAL can be attributed to associative, rather than stimulus encoding or response learning, factors. Proponents of the second viewpoint have typically stressed stimulus encoding as the locus of the effect (see Bower, 1970), but the present results show clearly that when only the stimulus term in associative recall had been imaged during VDL, recall was not enhanced compared to the control group. In fact, a significant depression effect occurred. By contrast, recall was substantially improved by use of a compound image incorporating both stimulus and response items. A localization of the imagery effect in the associative, rather than the stimulus encoding phase of PAL, is thus strongly indicated. Moreover, examination of recall when the incorrect item from VDL served as the stimulus term shows a similar trend with respect to the differences between the two imagery conditions and the control. This finding eliminates the operation of processes specific to response learning or availability as an explanation of the effect.

The fact that associative recall was lower when the imaged member of each VDL pair, rather than the non-imaged member, served as the recall cue, might appear to be inconsistent with the conceptual peg hypothesis (Paivio, 1969), which predicts a larger effect of I on the stimulus than on the response side of pairs in PAL. The hypothesis states that, whereas the formation of a mediated association (in the form of a compound image) between the members of a pair is affected by the imagery value of both the stimulus and response, recall of the response term depends primarily upon the imagery value of the stimulus, which "must serve as the cue that reinstitutes the compound image from which the response component can be retrieved and recoded as a word (Paivio, 1969, p. 244)." Thus the image aroused by the stimulus term at recall functions as a redintegrative cue for response retrieval, given that an associative link between the pair members through a compound image has already occurred. Clearly, this condition is not satisfied by the Single Image instruction of the present experiment, and superior recall under high stimulus-term imagery would therefore not be expected. The overall superiority of the Compound Image instruction is, of course, consistent with the conceptual peg hypothesis as well as other mediational interpretations, since here imagery presumably served both a mediating and cueing function.

EXPERIMENT II

As outlined above, the frequency theory of VDL postulates that *Ss* learn to discriminate pairs of items in a VDL task through a differential accumulation of frequency "units" to the words of each pair. While the influence of other word attributes is not denied, frequency is assumed to be the *dominant* attribute affecting performance, with other attributes becoming dominant when frequency fails to serve as a discriminative cue (Underwood & Freund, 1970a). Research on the effects of noun imagery in VDL (e.g. Paivio & Rowe, 1970) appears contradictory to this formulation, since the imagery attribute produces a consistently strong effect even though situational frequency cues are presumably readily available to the subject.

The purpose of this experiment was to determine whether *I* is an effective attribute in VDL even when use of a frequency cue is encouraged by *E*. The frequency cue was provided by having *Ss* make extra overt pronunciations of the R items in a list of High-*I* and Low-*I* pairs as in the Repetition instruction of Exp. I. If frequency is the dominant cue in VDL, or at least if frequency predominates over imagery as a learning strategy, then the differential ease of learning High-*I* and Low-*I* pairs should be reduced under repetition instructions. Thus the crucial prediction from the point of view of frequency theory is an interaction between instruction and imagery level of pairs, such that the difference between High-I and Low-I pairs is less for the Repetition group than for the control.

Method

Subjects. The Ss were 32 introductory Psychology students (20 males) who participated as part of a course requirement. None had served in previous VDL experiments. They were assigned in rotation to the Repetition (11 males) and the Control (9 males) conditions.

Lists. Sixty-four two- and three-syllable words four to eight letters in length were selected from the Paivio, et al (1968) norms. Half of the words belonged to the sample used in Exp. I; the remainder had I values below 3.61 (Low-I). The Low-I words had F values greater than 39 per million (Thorndike & Lorge, 1944) and concreteness and m uncontrolled (Appendix A). Two sets of 16 High-I and 16 Low-I pairs were constructed by a random pairing procedure, and these were combined to form two separate 32-pair mixed lists.[4]

Procedure. The VDL procedure was similar to that used in Exp. I, with the Ss again being tested individually using the memory drum. A study-test procedure was employed, and the pairs were presented at a 5-sec rate. On each study

[4]The mixed-list design was necessitated by the fact that an insufficient number of Low-I words meeting the desired requirements, i.e. bisyllabic, medium length, and high F, were available from the word pool to construct a homogeneous list long enough to ensure suitable task difficulty.

trial one randomly-selected member of each pair was underlined and S pronounced each word aloud. In addition, Ss in the instruction condition were told to repeat the underlined word aloud three additional times, and that this should help them remember what the correct word was on the test trials. Control Ss received no mnemonic instructions. On the test trials the underlining was absent and S chose the member of each pair that he thought was correct. Four study-test trials were given, with appropriate counterbalancing for serial order of pairs and the spatial position of R and W items. Half of the Ss in each group received one set of pairings and the remainder the other set. Also, within each of these groups, half of the Ss received the same pairs with the opposite items underlined.

Following the VDL task, Ss received an additional self-paced test trial, where they were required to (a) give the correct word for each pair, and (b) state the type of strategy, if any, they had used to learn that pair. The strategy was selected from a list of four alternatives - Repetition, Imagery, Other, and None - which were printed on a card kept in view of the S. A description of each strategy as given to the Ss may be found in Appendix B.

Results

Verbal discrimination learning. The data were corrected for guessing as before. The means are presented in Table 3. An analysis of variance of the mean number correct was carried

TABLE 3
MEAN NUMBER CORRECT IN VDL FOR EACH EXPERIMENTAL CONDITION AS A FUNCTION OF TRIALS (EXP II)

Trials	Condition			
	Control		Repetition Instruction	
	High-I	Low-I	High-I	Low-I
1	5.88 (5.29)	4.50 (3.06)	9.63 (3.32)	8.00 (3.61)
2	10.25 (6.02)	6.38 (6.07)	12.13 (3.57)	9.88 (4.32)
3	11.75 (4.84)	7.63 (6.08)	14.13 (2.63)	11.25 (4.06)
4	11.88 (6.02)	10.00 (4.84)	15.13 (2.12)	13.13 (3.22)

Note:- The figures in brackets are the standard deviations.

out with Instruction, Imagery, and Trials as factors, the latter two having repeated measures. Significant main effects were found for Instruction (F, 1,30 = 6.27, $p < .05$), Imagery (F, 1,30 = 36.61, $p < .001$) and Trials (F, 3,90 = 36.09, $p < .001$). None of the interactions was significant. Collapsed across trials, the results are presented in Figure 1. An analysis of variance of these data produced significant main effects of Instruction (F, 1,30 = 6.10, $p < .05$) and Imagery (F, 1,30 = 37.24, $p < .001$). The interaction was not significant ($F < 1$). It is therefore clear that, while repetition facilitated overall performance, the effect of I was equally strong in both instruction groups. Since the Imagery factor involved repeated measures, it was necessary to determine whether the data conformed to an additive model before ω^2 was calculated (Vaughan & Corballis, 1969). Tukey's test (Myers, 1966, pp. 166-169) indicated that the additive model is applicable (F, 1,30 = 2.46, $p > .10$).[5] The Instruction factor accounted for about 41 percent of the total variance and Imagery accounted for about 32 percent.

Reported strategies. The pertinent aspect of the

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[5]Winer (1962, p. 269) recommends that the .25 level of significance be used with Tukey's test in order to lower the probability of a type 2 error, i.e. using the additive model when it is inappropriate. If the nonadditive model is actually applicable to the present data, this would result in a slight overestimation of the ω^2 values.

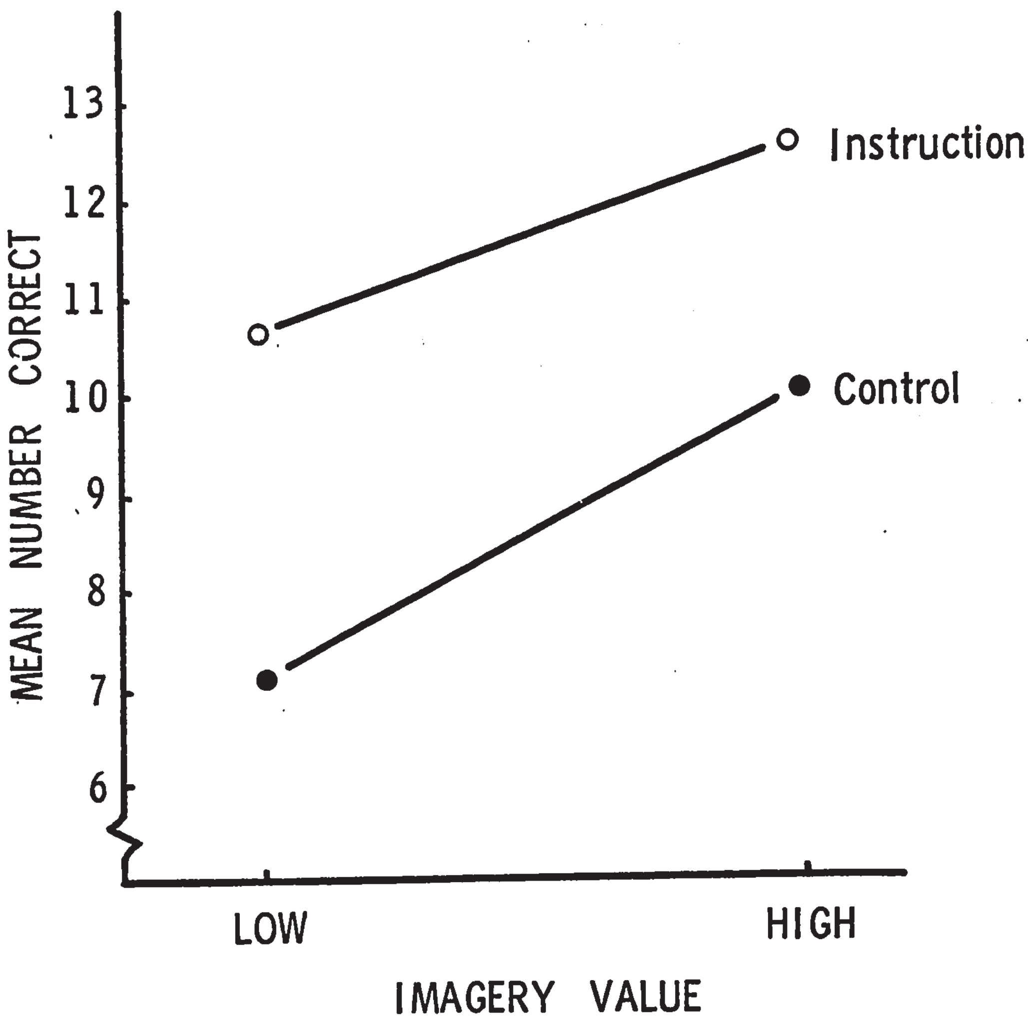

Figure 1. Mean number correct in VDL as a function of imagery value of pairs and repetition instructions (Exp. II).

questionnaire data involves comparisons between the different conditions on the relative use of imagery and repetition strategies. "Other" and "None" responses, which respectively constituted 24.4 and 9.3 percent of all responses, were therefore not analysed. The mean number of pairs for which imagery and frequency (repetition) strategies were reported is shown in Figure 2. A three-way analysis of variance with Instruction, Strategy, and Imagery as factors produced significant main effects of Instruction (F, 1,30 = 9.06, $p < .01$) and Imagery (F, 1,30 = 33.98, $p < .001$), but these were qualified by two significant interactions: Instruction X Strategy (F, 1,30 = 5.11, $p < .05$) and Strategy X Imagery (F,1,30 = 116.59, $p < .001$). The first interaction reflects the finding that repetition was reported more frequently by Ss in the instruction group (t, 30 = 2.87, $p < .01$), while reported imagery was the same for both ($t < 1$). The Strategy X Imagery interaction is due to the fact that imagery was reported more frequently for High-I than for Low-I pairs (t, 30 = 11.14, $p < .001$), whereas the reverse was true for reports of repetition (t, 30 = 5.31, $p < .001$).

Relationship between reported strategies and learning. As a gross measure of the relationship between each reported strategy and VDL performance, product-moment correlations were computed between mean recall and number of pairs for which each strategy was reported for the Ss in each group, with High-I and Low-I pairs being treated separately. The results are shown in Table 4. Reports of Repetition were not consistently or significantly related to performance in

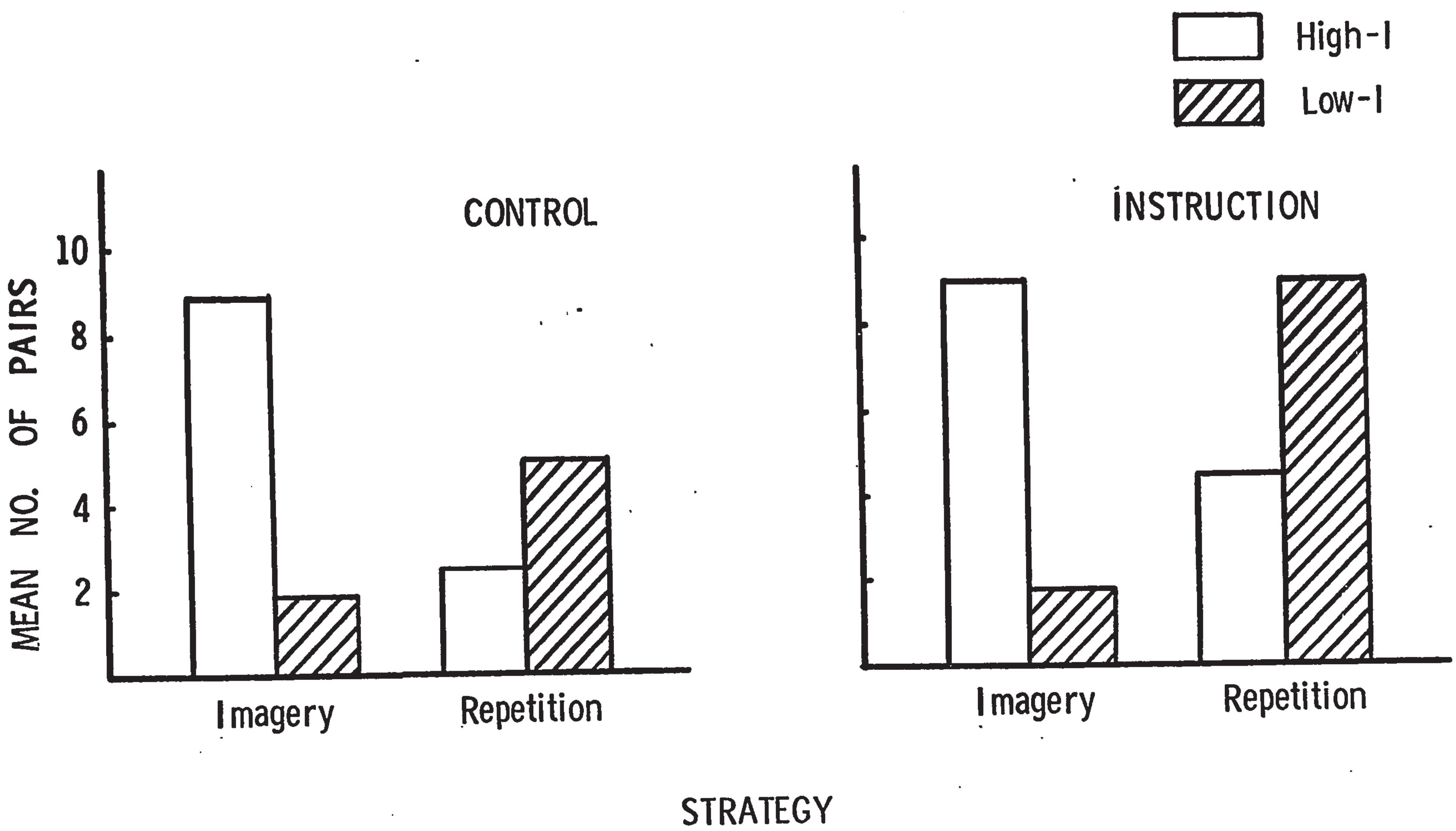

Figure 2. Mean number of pairs for which imagery and repetition strategies were reported as a function of pair type and instruction (Exp. II).

TABLE 4
CORRELATIONS OF LEARNING STRATEGIES WITH
VDL PERFORMANCE (EXP II)

	Condition			
	Control		Repetition Instruction	
Strategy	High-I	Low-I	High-I	Low-I
Repetition	-.30	.43	.13	-.47
Imagery	.75**	.55**	-.09	.42
Other	-.24	-.16	.07	.36
None	-.64**	-.45	-.22	-.19

*$p < .05$
**$p < .01$

the four conditions. The same was true of "Other" responses. Learning was negatively correlated with reports of no strategy usage, but the relationship was significant only for High-I pairs in the control group. Imagery reports were positively and significantly correlated with learning for control subjects only, and the relationship was stronger for High-I pairs. Thus, while keeping in mind the usual caveat against inferring causality from correlations, these findings show that the degree of reported imagery usage bears a stronger and more consistent relation to performance than reports of repetition, at least for uninstructed Ss.

It should be pointed out that this analysis reflects only the overall gross relationship between degree of strategy usage and performance and each correlation is based on only 16 Ss, so the results may lack stability. An attempt was made to obtain a more sensitive measure of strategy effectiveness using correlations between number correct and amount of reported strategy usage with pairs of items as subjects. However, no greater consistency was obtained than in the above results, indicating the operation of other unknown factors in determining both individual pair difficulty and overall level of performance.[6]

Discussion

An interaction between repetition instruction and imagery value of pairs in VDL, predicted on the basis of fre-

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[6]This type of correlational analysis was also carried out for Exp. III and IV. The results contributed little over and above the first analysis in each case, so these will not be reported.

quency theory, was not obtained. The results indicate that the effects of imagery and frequency factors were independent, and therefore constitute evidence against any general dominance of frequency cues in VDL. While the frequency attribute may override other item characteristics in certain situations, this was clearly not so in the present case, despite the fact that Ss were instructed to use differences in situational frequency as a response cue. On the other hand, the findings concur with previous results (e.g. Rowe & Paivio, 1971b) in showing the effectiveness of I as an attribute in VDL. The somewhat stronger effect demonstrated by the repetition variable over imagery in terms of the proportion of variance accounted for is important and will be referred to again, but it should be noted here that this finding in no way vitiates the above conclusions concerning the role of frequency cues.

These conclusions are fully supported by the subjective report data (Figure 2). Disregarding pair type for the moment, it can be seen from Figure 2 that the overall use of repetition increased in the repetition group, as expected, while the reported use of imagery as an aid to discrimination learning was almost exactly the same regardless of whether or not Ss were instructed to use repetition. In other words, imagery usage appears to have been unaffected by the repetition instruction. If repetition were the dominant or preferred strategy, imagery usage might be expected to decrease as repetition increased. Clearly this was not the case. A second aspect of these results which deserves comment is the strong Strategy X Imagery interaction. This finding replicates the post-experimental questionnaire results of Rowe and Paivio (1971b, Exp. II), in that a repetition strategy, when used, tended to occur predominantly with Low-I pairs, i.e. where an imagery strategy is relatively unavailable.

Of course, the subjective report data are not sensitive to the possible operation of other factors, such as strategy switching on the part of Ss on different trials. Thus, repetition might have been used more frequently early in learning, with imagery coming into use on later trials, as has been found in PAL (Paivio & Yuille, 1969). In fact, some Ss spontaneously reported using different strategies for the same pairs of words, and in such instances were instructed to select the alternative which best represented the strategy they had used in each case. However, it is difficult to see how the pattern of results shown in Figure 2 can be satisfactorily accounted for on the basis of strategy switching or related factors, even though such factors might have played a role in determining Ss' subjective reports.

EXPERIMENT III

Experiment II showed that instructing Ss to use a repetition (frequency) strategy in learning a VDL list did not affect the relative ease of learning High-I as opposed to Low-I pairs, which presumably reflects differential use of an imagery strategy for the different pair types. In Exp. III, it was asked whether the spontaneous use of frequency cues as a response strategy in VDL would be affected by instructions to use imagery. The design involved the comparison of the Single Image instruction of Exp. I with an uninstructed control condition as a function of the relative availability of frequency cues. Frequency was manipulated by the within-list repetition of either R or W items, as in two of the conditions reported by Ekstrand et al. (1966).

Situational frequency of items is affected by item repetition in the following way. Consider first the situation where the same item occurs in two different pairs and is correct in both cases. We shall call this the same-right (SR) condition after Ekstrand et al. With a study-test procedure such as was used in the first two experiments, frequency theory predicts that the ratio of frequency units of R to W items will be considerably enhanced because of the extra RR's and PR's made to the R items. In a same-wrong (SW) condition, however, the extra accrual of frequency units to W items on the study trials will be offset both by the pronunciation of R items alone (when a correct response is made) and by the use of RCR's on the test trials. Thus there should be little or no frequency difference between R and W items initially, and any differences that do occur should increase much more slowly as practice progresses than comparable differences in list SR.

Ekstrand et al. (1966) found that about four times as many errors occurred on the SW than on the SR list, as predicted by a frequency analysis. The present experiment sought to determine whether this difference could be affected by the use of an imagery strategy. Again, subjective report data on the use of repetition and imagery strategies were gathered at the end of the experiment.

Method

Subjects. Sixty-four introductory psychology students (23 males) participated in the experiment as part of a course requirement. All were naive regarding the VDL task. The Ss were assigned in rotation to the four conditions generated by the factorial combination of two levels of List (SR and SW) and two levels of Instruction (instruction and control). The proportion of males to females in each condition was approximately equal.

Lists. Two separate 32-pair lists were constructed by a random pairing procedure from the sample of 64 High-I words used in Exp. I. Each R item in the two lists occurred twice, each time paired with a different W item, to produce the SR list condition. The two SW lists were obtained by simply interchanging the roles of the R and W items in the SR lists, with each R item becoming a W item and *vice versa*.

Procedure. The testing procedure was basically the same as in the two previous experiments, with the pairs being presented on the memory drum at a 5-sec rate. After receiving the general VDL instructions, *S*s were informed that some of the words would occur in more than one pair (Appendix B). Subjects in the imagery instruction condition were then given the Single Image instruction of Exp. I, i.e. to form an image to the correct word of each pair on the study trials. Control *S*s again received no mnemonic instructions. Four study-test trials were given, with appropriate counterbalancing of items within pairs, pairs within lists, and lists as before. Following the VDL task, *S*s received an additional self-paced test trial as in Exp. II, where they gave the correct item for each pair and selected the appropriate strategy they had used to learn the pair from the same list of four alternatives: Repetition, Imagery, Other, and None. Unlike Exp. II, the Repetition strategy was here defined to include both covert rehearsal of correct items and any use *S*s might have made of the fact that some items were repeated within the list. Subjects who reported using repetition were asked at the conclusion of the experiment which of these two aspects of repetition they had used more often in list learning.

Results

Verbal discrimination learning. The mean number correct (corrected for guessing) for each condition is presented in Table 5. A three-way analysis of variance with List, Instruction, and Trials as factors was carried out on the number of correct responses, producing significant main effects of List (F, 1,60 = 9.84, p < .01), Instruction (F, 1,60 = 8.30, p < .01), and Trials (F, 3,180 = 61.55, p < .001), as well as significant interactions of Instruction X Trials (F, 3,180 = 14.03, p < .001) and List x Trials (F, 3,180 = 5.15, p < .01). The interactions reflect the fact that the largest increase in scores across trials occurred for the uninstructed SW group. This appears due to a general ceiling effect, as the remaining three groups reached asymptote on Trial 2.

The most important aspect of the data from the present point of view concerns the relationship between the List and Instruction variables. This is shown in Figure 3, where the data have been collapsed across trials. An analysis of variance yielded significant main effects for List (F, 1,60 = 9.88, p < .01) and Instruction (F, 1,60 = 8.36, p < .01), and a nonsignificant interaction. The List variable accounted for about 13 percent of the total variance and Instruction accounted for 9 percent, with the remainder being attributable to experimental error. Figure 3 suggests that the List manipulation was less effective in the imagery in-

TABLE 5
MEAN NUMBER CORRECT IN VDL FOR EACH EXPERIMENTAL CONDITION AS A FUNCTION OF TRIALS (EXP III)

Trials	Control		Imagery Instruction	
	SR	SW	SR	SW
1	23.38	13.63	28.35	25.25
	(8.04)	(8.02)	(6.44)	(7.38)
2	29.25	23.50	31.00	28.35
	(5.00)	(8.37)	(3.10)	(7.15)
3	30.88	26.75	31.25	29.63
	(2.48)	(6.81)	(1.61)	(6.14)
4	30.88	29.38	31.88	30.00
	(2.25)	(3.29)	(2.34)	(6.11)

Note:- The figures in brackets are the standard deviations.

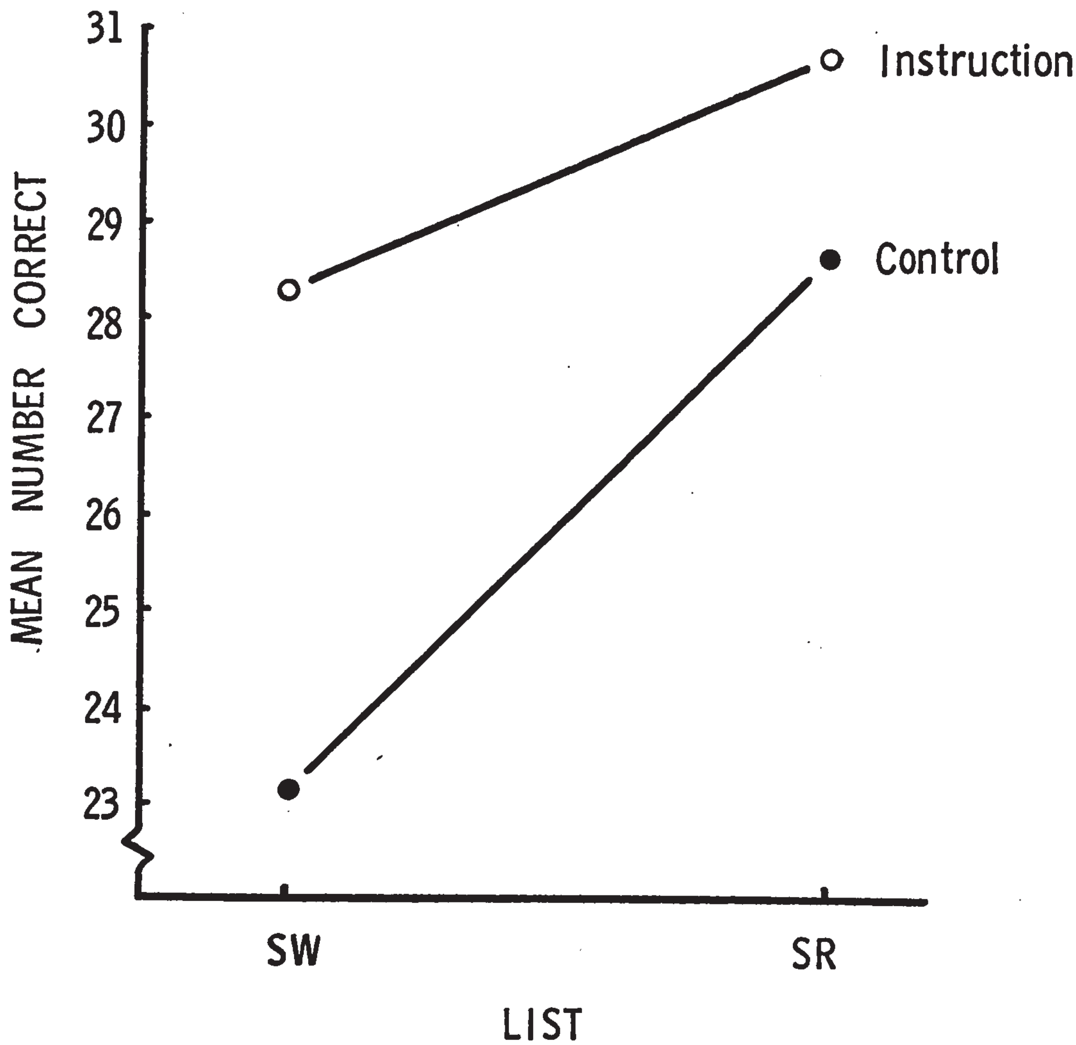

Figure 3. Mean number correct in VDL as a function of type of list and imagery instructions (Exp. III).

struction condition, but the absence of a significant interaction indicates that the two factors may best be regarded as independent. Thus the results are analogous to those of Exp. II, where the same conclusion regarding the effects of repetition instructions and imagery level of pairs was reached.

Subjective report data. Reports of Other and None were again ignored in the data analysis. These constituted 10.2 and 12.3 percent of all responses, respectively. The mean number of pairs for which repetition and imagery strategies were reported is shown in Figure 4. An analysis of variance with Instruction, Strategy, and List as factors yielded significant main effects of Instruction (F, 1,60 = 18.60, $p < .001$) and Strategy (F, 1,60 = 16.66, $p < .001$), but these were qualified by a strong Instruction x Strategy interaction (F, 1,60 = 63.74, $p < .001$). No other effects were significant. The interaction is due to the finding that, as expected, imagery was reported more frequently than repetition in the instruction group (t, 60 = 5.24, $p < .001$), while the opposite was true for the control group (t, 60 = 2.75, $p < .01$).

Relationship between reported strategies and learning. Correlation coefficients were calculated between number correct and number of reports of each strategy for the Ss in the four groups (Table 6). These results are subject to the same cautions advanced for the analogous data in Exp. II,

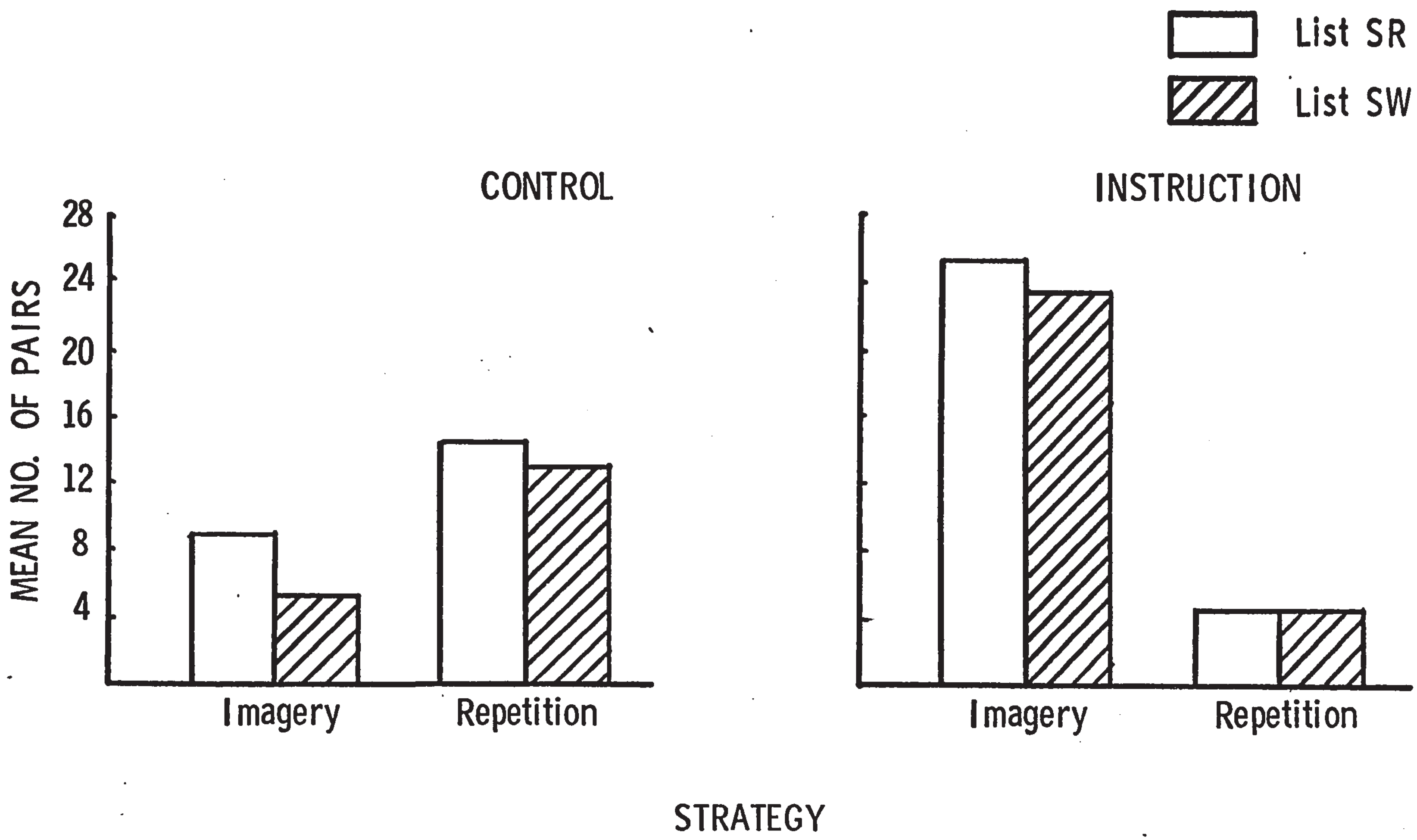

Figure 4. Mean number of pairs for which imagery and repetition strategies were reported as a function of type of list and instruction (Exp. III).

TABLE 6
CORRELATION OF LEARNING STRATEGIES WITH
VDL PERFORMANCE (EXP III)

	Condition			
	Control		Imagery Instruction	
Strategy	SR	SW	SR	SW
Repetition	.21	.39	-.41	-.15
Imagery	.31	.16	.66**	.34
Other	-.14	-.25	-.61*	.19
None	-.44	-.64**	-.50*	-.64**

*p < .05
**p < .01

but certain trends can be pointed out. First, the relation between number of reports of no strategy usage and performance is negative, and significant in all but one group. The direction of the relationship agrees with the results obtained in the previous experiment. The one significant correlation for the Other strategy is also negative. None of the correlations involving Repetition were significant, but the values were negative for the imagery group and positive for the control. On the other hand, Imagery was positively correlated with performance in all cases, the values being highest for the lists learned under imagery instructions. These findings for imagery differ from the repetition correlations in Exp. II, which were inconsistent even for the repetition instruction group. Again, reported imagery seems more consistently related to performance than reports of repetition.

Discussion

The results of this experiment are not as clear-cut as those obtained in Exp. II, with respect to the interaction between imagery and list (frequency) effects. Thus, while the interaction indicated in Figure 3 did not approach statistical significance, the plotted functions exhibit quite different slopes. However, it could be argued that the smaller difference between SW and SR under imagery instructions is an artifact of the overall ease of learning in this condition. In particular, very few errors were made by the SR-Imagery Ss, indicating the presence of a ceiling effect. But regardless of such considerations, the nonsignificant interaction obtained in the present experiment must be taken as evidence that the effects of the two variables are independent. The validity of this conclusion will be tested in the final experiment, where imagery and frequency are again contrasted by comparing performance on High-I and Low-I pairs under SR and SW conditions.

Several points related to the subjective report data deserve comment. First, it will be recalled that a repetition strategy was here defined for the Ss as the use of either covert rehearsal or repetition of items in different pairs. Subjects who reported using repetition were asked at the end of the experiment which of the two types of repetition they had used most. It was found that in condition SW both were used about equally, whereas for condition SR the second type was named about four times as often as rehearsal. Thus it is assumed that reports of repetition reflect primarily the use of intralist repetition of items as a frequency cue in the latter case.

Second, it is interesting to note that Ss reported using a repetition strategy to the same extent for the SW and SR lists. In the SW condition, some Ss apparently attempted to increment the frequency of R words through rehearsal, as might be expected by the fact that the list condition acted to keep R and W items about equal in frequency. It is somewhat surprising, however, from the point of view of frequency theory, that an equal number of Ss reported using the fact that W items were repeated in different pairs as a learning strategy. It seems likely that processes other than frequency responding are involved here. The data are interpretable in terms of Paul's (1970) acquired equivalence notion, with repeated items forming one equivalence class and nonrepeated items the other. Nonrepeated items are in this case always correct. The same interpretation can also be applied to performance on the SR list, where reports of repetition reflect a repeated-items strategy almost exclusively. Here, however, a strong case can also be made in favor of frequency theory, for not only did repeated items form the correct equivalence class, but they were also of higher frequency. Thus the two interpretations are confounded, as in most other instances where an equivalence class interpretation can be applied. The use of SW list conditions might offer one possible way of studying the significance of the equivalence class interpretation in VDL, since here situational frequency differences between R and W items appear to be controlled.

The final point to be made regarding the reported use of imagery and repetition strategies concerns the Instruction X Strategy interaction, obtained in the analysis of variance (Figure 4). As was found with repetition in Exp. II, reports of imagery usage increased sharply under the imagery instruction. The pattern of results contrasts with those of the previous experiment, however, in that the increased use of imagery occurred partly at the expense of repetition. In Exp. II, reported imagery usage remained unchanged while repetition increased in the instruction group, and this was taken as evidence of a preference on the part of the Ss for using an imagery strategy when both are available. This claim can not be made for repetition in the present case. Rather, the results reinforce the above conclusion regarding an overall preference for imagery. As noted earlier, repetition does not refer to exactly the same strategy in both experiments, and it is not certain that these reports reflect the same underlying processes, but for explanatory purposes, the two can still be contrasted with responding based on imaginal reactions to items.

EXPERIMENT IV

In this experiment the roles of imagery and frequency in VDL were studied by comparing learning of High-I and Low-I pairs as a function of SR or SW list conditions. The experiment was intended to add to the generality of the previous findings by introducing a different combination of operations to manipulate the two variables, but it also constitutes a further test of the conclusion, drawn from the results of Exp. II and III, that the effects of imagery and frequency in VDL are independent. If this conclusion is correct, we would expect no interaction between the type of list and I value of pairs in this experiment.

One minor procedural change in Exp. IV was that a 3-sec presentation rate replaced the 5-sec rate used in the preceding experiments. This was done in an attempt to increase the difficulty of the task and thus eliminate the occurrence of a ceiling effect such as was observed in the data of Exp. III.

Method

Subjects. The Ss were 32 introductory psychology students (18 males), who had not participated in previous VDL experiments. They were assigned in rotation to the SR and SW list conditions, with an equal number of males in each.

Lists. The 32-pair mixed lists of High-I and Low-I pairs used in Exp. II were modified for use in this experiment.

The two SR lists were formed by replacing the correct items in half of the High-I and Low-I pairs with another R item of the same type from elsewhere in the list, with the restriction that each R item occur exactly twice in different pairs. The SW lists were obtained by reversing the correctness of the items in each pair of list SR.

Procedure. The same basic procedure as used in the preceding experiments was followed here, except that the presentation rate was three seconds. Half of the Ss received one of the SR lists while the other half received an SW list, and within each condition, each of the two versions of the assigned list was given to equal numbers of Ss. The four study-test trials were again followed by the subjective report of learning strategies by the Ss in the same manner as in Exp. III.

Results

Verbal discrimination learning. The three-way analysis of variance of the corrected data (Table 7) produced significant main effects of List (F, 1,30 = 18.07, $p < .001$), Imagery (F, 1,30 = 31.86, $p < .001$), and Trials (F, 3,90 = 40.12, $p < .001$). The List X Trials interaction (F 3,90 = 2.92, $p < .05$) was also significant. The interaction is the result of a sharper increase in correct responses over trials for the SW group. No other significant effects were obtained; in particular, the List X Imagery interaction was clearly nonsignificant ($F < 1$). The mean number correct for each

TABLE 7
MEAN NUMBER CORRECT IN VDL FOR EACH EXPERIMENTAL CONDITION AS A FUNCTION OF TRIALS (EXP IV)

Trials	SR High-I	SR Low-I	SW High-I	SW Low-I
1	11.25	6.25	3.00	1.00
	(4.31)	(3.92)	(5.47)	(5.98)
2	12.25	9.50	7.88	4.63
	(3.42)	(4.10)	(5.48)	(5.60)
3	13.88	9.75	9.88	5.75
	(2.63)	(4.84)	(4.07)	(5.26)
4	14.88	11.75	10.63	8.75
	(2.48)	(4.73)	(4.40)	(4.73)

Note:- The figures in brackets are the standard deviations.

condition was nonetheless plotted (Figure 5) to facilitate comparison with the preceding two experiments. The absence of an interaction between List and Imagery is apparent from the graphical presentation, and this was confirmed by a second analysis of variance ($F < 1$). The main effects of List (F, 1,30 = 17.40, $p < .001$) and Imagery (F, 1,30 = 33.36, $p < .001$) were of course significant. Tukey's test showed that the data were additive (F, 1,30 = 1.41, $p > .10$), and calculation of ω^2 showed that List accounted for 49 percent of the total variance with Imagery accounting for 26 percent.

Subjective report data. The subjective report data are summarized in Figure 6, the Other (12.5 percent of responses) and None (16.6 percent) alternatives having been excluded. An analysis of variance of the mean number of pairs for which imagery and repetition were reported yielded significant main effects of Strategy (F, 1,30 = 5.75, $p < .05$) and Imagery (F, 1,30 = 44.53, $p < .001$) and a significant Strategy X Imagery interaction (F, 1,30 = 16.96, $p < .001$). Figure 6 shows clearly that the interaction is due to the fact that imagery was reported for a greater number of High-*I* than Low-*I* pairs (t, 30 = 7.38, $p < .001$) while repetition was about equal for both ($t < 1$).

Relationship between reported strategies and learning. A correlational analysis of the performance scores with each strategy was again carried out (Table 8). Only one significant relationship was found: for reported Imagery with

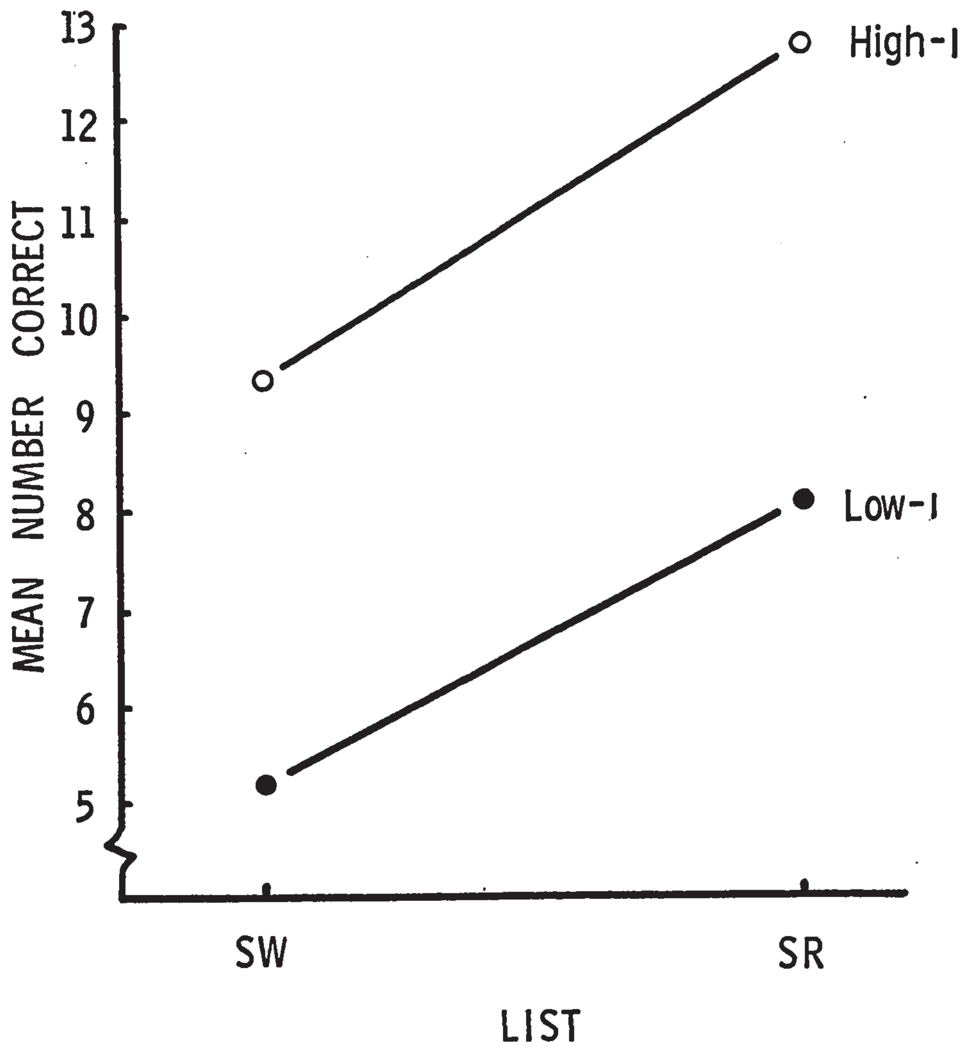

Figure 5. Mean number correct in VDL as a function of imagery value of pairs and type of list (Exp. IV).

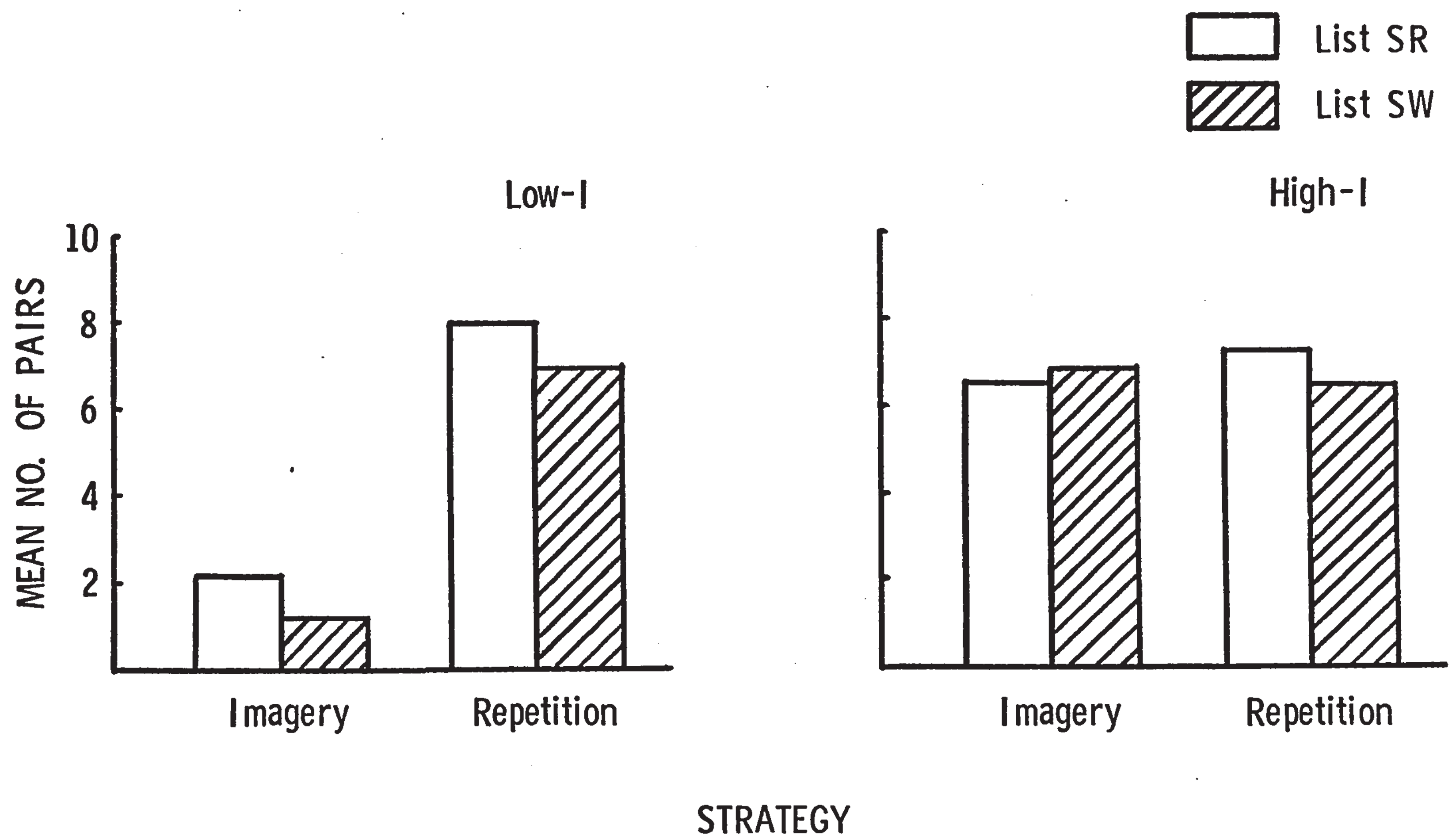

Figure 6. Mean number of pairs for which imagery and repetition strategies were reported as a function of pair type and type of list (Exp. IV).

TABLE 8
CORRELATION OF LEARNING STRATEGIES WITH VDL PERFORMANCE (EXP IV)

	Condition			
	SR		SW	
Strategy	High-I	Low-I	High-I	Low-I
Repetition	.02	.16	-.08	-.04
Imagery	-.03	.09	.15	.71**
Other	.05	-.31	-.02	-.08
None	.13	.02	-.18	-.23

**$p < .01$

Low-*I* pairs in the SW condition. The remaining correlations were generally small and inconsistent across conditions, and are thus largely uninformative.

Discussion

The independence of imagery and frequency factors in VDL, as operationally defined in the present series of experiments, was confirmed in Exp. IV. The difficulty encountered in interpreting the data of the preceding experiment, i.e., the apparent ceiling effect, was not present in these results, which are considered as strong evidence in favor of the independence hypothesis. This conclusion will be discussed more fully in the General Discussion section of the thesis.

As in Exp. III, reports of repetition as a learning strategy reflected primarily the use of repeated items in the list rather than covert rehearsal. The former were reported 2.5 times as often as the latter in both the SR and SW conditions, again suggesting that *S*s can use repeated W items as a cue in discrimination learning. Whether the type of repetition strategy differed for High-*I* and Low-*I* pairs was not determined. The overall results regarding strategy usage as a function of list and imagery factors (Figure 6) are in some respects at variance with those reported in Exp. II and III. Reports of imagery were more frequent for High-*I* than for Low-*I* pairs, as found in Exp. II, but repetition reports were essentially unaffected by the imagery variable. By contrast, in Exp. II, repetition was reported more frequently for Low-I pairs, replicating the finding of Rowe and Paivio (1971b), and in Exp. III, an increase in the use of imagery was accompanied by a reduction in the reported use of repetition. The first difference could be due to the different types of repetition strategies involved, i.e., in Exp. II and the Rowe and Paivio experiment, repetition was defined only as rehearsal (either overt or covert), whereas repetition reports in Exp. IV reflect a strategy based on repeated R and W items. From Ss' reports, it appears that the second of these two is a more dominant strategy than the other when both are available, and it could be that a strategy based on repeated list items is strong enough to be unaffected by the I value of pairs. A strong preference for the use of this type of repetition could also account for the difference between the results shown in Figure 6 and those of Exp. III, i.e., the lack of change in repetition reports with increases in the reported use of imagery.

The fact that the repeated-item strategy was used to the same extent for SW and SR lists suggests that the processes underlying use of this strategy are not the same as those involved in rehearsal. Again, Paul's (1970) acquired equivalence explanation seems to be able to account for the use of repeated items, and might be especially applicable to learning under SW conditions, as was previously pointed out.

GENERAL DISCUSSION

The results of the four experiments will be discussed under three headings: (a) relevance for the explanation of imagery effects in VDL, (b) the independence of imagery and frequency effects, and (c) implications of the results for frequency theory.

Imagery effects in VDL

The results reported above have without exception upheld the conclusion drawn from previous research (Paivio & Rowe, 1970, 1971; Rowe & Paivio, 1971a, b, c) that nonverbal visual imagery, defined in terms of the scaled I value of words (Exp. II and IV) is a highly salient variable in verbal discrimination learning. In addition, the effect of imagery was replicated using a second type of defining operation, i.e. an appropriate instructional set (Exp. I and III).

The comparative ease of learning under Single Image as opposed to Compound Image instructions found in Exp. I suggests that the effect occurs primarily as a result of Ss' imaging to the R words alone in a VDL list. It was pointed out in the discussion of that experiment that an "image frequency" interpretation of the effect seems more appropriate than image tagging. However, further comment on the image-frequency explanation is required. As originally proposed, this type of strategy was conceptualized within the framework of frequency theory, with an imaginal reaction to a R item considered as part of the RR or analogous to the (verbal) IAR and, as such, contributing to the process of differential frequency accumulation. A number of considerations suggest that this interpretation is inappropriate.

In the first place, the RR, or perceptual response to an item, and an imaginal response or reaction may be conceptualized as separate types of responses, occurring at different levels of cognitive processing. Paivio (1971) has proposed three hierarchical levels of processing of, or levels of meaning reactions to, stimulus information: (a) representational, where words or objects as stimuli simply activate the corresponding representational processes within the individual; (b) referential, where object stimuli may evoke their appropriate verbal labels, and verbal stimuli, a corresponding nonverbal image; and (c) associative, characterized by the presence of sequences or structures of associative reactions involving both words and images. Further elaboration of the system is unnecessary to suggest that the RR of frequency theory functions at a representational level of processing, while an imaginal reaction occurs at a higher, referential, level. The analogy between the IAR and an image aroused by a R item in VDL is also strained. Not only is the IAR characterized by the third, associative, level in Paivio's model, but it is also presumed by frequency theory to operate only in specific situations, i.e., where there are associatively-related words within the same VDL list (Ekstrand, et al., 1966). It differs theoretically from an imagery response on both counts.

Secondly, the results of Exp. II - IV in the present research strongly suggest that imagery and frequency, as operationally-defined factors, and by inference as underlying psychological processes in VDL, have independent effects. This will be discussed more fully in the following section; suffice it to say here that this finding also argues against the interpretation of the effect of imagery in terms of frequency theory as originally proposed in the image-frequency explanation.[7]

How, then, is the operation of imaginal encoding as it serves a discriminatory function in VDL to be conceptualized? It is proposed that Ss can discriminate between a pair of items on the basis of a differential encoding response (DER) which occurs at a referential or associative level of processing. That is, if one member of a pair is encoded via a verbal or imaginal "associate" and the other

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[7]It should be noted that an imagery reaction to a particular set of items within a given list is a sufficient condition for the establishment of an equivalence class (Paul, 1970; Paul & Paul, 1968). At the present time, however, an interpretation of the imagery effect within this framework seems to offer little in the way of providing a better understanding of the underlying processes involved. This is not to deny that such an interpretation may eventually prove useful, but the demonstration of the utility of the acquired equivalence explanation independent of frequency theory is a necessary prerequisite to a valid application of the concept to the imagery effect. The extension of acquired equivalence to the research on selection strategies (e.g. Kausler, et al., 1970), as outlined previously, would be an important step in this direction.

is not, the possible grounds for a correct discrimination have been established. Thus an imagery reaction to only the R items of a pair (Exp. I) provides an effective cue for discrimination, and conversely, emitting a verbal label to only the R items in a list of picture pairs is a highly effective strategy (Carmean & Weir, 1967). On the other hand, imaging to both words of a pair (Exp. I) or labelling both items of a picture pair (Carmean & Weir, 1967) does not affect the level of performance relative to uninstructed control conditions. Here the occurrence of a DER has presumably been obviated by the instructional set.

At the associative level, responding with a verbal associate to the R word of a verbal pair, or producing a related image to the R member of a picture pair might be expected to enhance performance as well. The effect in this case, however, would probably not be as pronounced as in either the word-image or picture-label situation, because of the likelihood of interference from other items in the list which are similar to the S-produced associate for a given pair. This is clearly a matter for further research, since evidence is scant on the effects of verbal-associative and imaginal-associative strategies in VDL. However, it might be noted that in a recent experiment (Wike & Wike, 1970) where Ss were provided with a meaningful word corresponding to each R item in a list of CVC pairs, significant facilitation resulted.

What is the effect of repeated presentations of a VDL list on a DER? In the absence of relevant data, comments here must again be speculative, but it seems reasonable to postulate that repeated presentations act to "strengthen" a DER, making it more available as an alternate coding of a particular item. This is seen as different from a frequency interpretation such as was offered as part of the image-frequency explanation. A frequency interpretation would demand only that a DER be affected in a quantitative sense through repeated elicitations, which would accumulate and allow S to judge, for example, which word of a pair had produced an image more often. Increasing the "strength" of an image implies in addition the occurrence of qualitative differences in the imaginal response as a function of the number of presentations. Thus, the image may become more vivid, with more detail being added, the imaged object may be placed in a specific context, and so on. Similarly, a verbal labelling response to a repeatedly-presented picture may initially consist of one word, e.g. "dog", but may be elaborated into "large dog", then "large dog facing left", etc., rather than a simple frequency increment of the label "dog" alone. In short, a strength interpretation of DER's with repeated presentations implicates the operation of higher levels of cognitive activity in reactions to stimuli than does a frequency interpretation.

One final point should be made concerning the proposed operation of DER's. If a discrimination were possible strictly in terms of a <u>differential</u> reaction to R and W items, it should make no difference whether the DER occurs to the R or the W member of a pair. For example, instructing <u>S</u>s to image to only the W item should have the same effect as the Single Image instruction of Exp. I. The fact that discrimination learning of pairs of words where the R item is High-<u>I</u> and the other Low-<u>I</u> is not different from the reversed condition (Paivio & Rowe, 1971) provides some support for this position, but additional verification, preferably using instructional sets, is required. It should be noted as well that labelling only the W item of a picture pair does not facilitate performance, as labelling the R item does (Carmean & Weir, 1967). The resolution of this inconsistency is not possible without additional research.

The independence of imagery and frequency

Apart from an attempt at a further understanding of the imagery effect in VDL, the primary impetus behind the present series of experiments was a comparison of imagery and frequency factors, both having been consistently effective in a number of prior experiments. Comparing the two in several additional experiments constituted an attempt to determine the relationship between them, particularly with a view to ascertaining whether the effect of either variable depended in any way upon, or could be interpreted in terms of, the other.

As mentioned several times above, the results of Exp. II, III and IV showed that the two variables, as herein defined, exert independent effects on VDL. It will be recalled that the examination of the relative strength of effects of imagery and frequency by the ω^2 statistic consistently showed frequency to be the stronger of the two. This means that, when the two variables are compared within the same experiment using the present defining operations, performance can be predicted with a greater degree of certainty given knowledge of the level of frequency involved than can be done given the same information regarding imagery. Admittedly, the absolute differences in proportion of variance accounted for by imagery and frequency are not large, especially in Exp. III, but the consistency involved does suggest that frequency manipulations produce a stronger effect. As pointed out previously, however, this finding does not affect the conclusion that the effects are independent. Rather, the relevant values here are ω^2 results for the interaction effects in the three experiments. The interaction accounted for less than one percent of the variance in each case.

The underlying psychological processes presumably activated by these operations involving imagery and frequency are also assumed to be independent, or, more properly, qualitatively distinct. A conceptual framework within which the differences between the two can be viewed was introduced in the preceding section, where it was pointed out that the RR and IAR of frequency theory represent a different type of cognitive process or encoding response than an imagery reaction. Like the RR, a PR and RCR may also be assumed to operate at a verbal representational level, as these responses involve reactions to the items qua items in a list. The IAR is best thought of as functioning at a higher, associative, level, but is by definition a verbal-associative response to a word and is therefore comparable to the other three responses.

Imagery reactions to words, because they involve a transformation from a verbal to a nonverbal system, are characteristic of a referential level of processing (i.e., the image presumably bears a referential relation to its corresponding word) and may be distinguished from the four responses of frequency theory on this basis. This is not to deny the existence of some degree of overlap between the two types of processes. For example, repeated presentations of a word may in some instances enhance the probability of image arousal but note that in such cases frequency is still defined with reference to verbal processes whose operation remains conceptually distinct from the operation of imagery mechanisms.[8]

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[8]Underwood (1969) has classified frequency, nonverbal visual (imaginal) and verbal associative mechanisms as separate attributes of memory. However, his classificatory scheme does not include the concept of levels of processing, and comparisons with the model discussed here are therefore limited.

Implications for frequency theory

The implications of the present results for frequency theory, as viewed within the conceptual framework of frequency, imagery, and verbal associative effects presented above, are straightforward. The results suggest that the theory is applicable to those cases where verbal processes alone, either representational or associative, are presumed to operate. Here the evidence is largely supportive, as pointed out in the literature review. Additional processes not accountable in terms of frequency have been indicated even in these situations, but the theory is able to predict overall performance quite well. The present results and theoretical analysis suggest specifically that the theory cannot account for differences attributable to the effects of nonverbal imaginal processes, either on a theoretical or empirical level. Here alternative interpretations of the mechanisms of discrimination, such as the proposed DER, seem required. Furthermore, modifications of frequency theory such as a liberalization of the counting postulate as recently proposed by Wallace and Nappe (1971) cannot resolve the difficulties associated with the application of the theory to those situations which, according to the present suggestions, lie outside the realm of a frequency interpretation. The proposed restriction of the theory as outlined here is also assumed to apply to recognition memory, where a similar frequency explanation has been invoked

(Underwood & Freund, 1968a, 1970c; Underwood, Zimmerman & Freund, 1971), although separate tests of the effects of imagery and frequency in this paradigm are of course needed.

Thus, to think of frequency as the dominant attribute or response cue in VDL, which is used as the basis for discrimination unless other attributes become dominant (Underwood & Freund, 1970a), is not the best approach to a proper understanding of the processes involved in discriminating between pairs of verbal stimuli. Many attributes apparently operate concurrently in learning a VDL list. Subjects may be primed toward the use of frequency by various manipulations, such as those used in the present experiments, but the role of other attributes is not necessarily eliminated (or, in the case of imagery in Exp. II, not even reduced). Similarly, encouraging the use of imagery does not denigrate the role of frequency cues. This is what is meant by the proposed independence of the two types of operations and their corresponding cognitive processes.

In short, the fact that frequency is a highly effective attribute in VDL where verbal processing is present seems indisputable. According to the results of the present study, however, the presence of referential imaginal encodings of verbal items affects performance in a way that is independent of the effects of frequency, and is therefore not explainable in terms of frequency theory.

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APPENDIX A

THE WORD SAMPLE USED TO CONSTRUCT THE EXPERIMENTAL LISTS

A. HIGH-I WORDS

	I	C	m	F
animal	6.10	6.75	7.00	AA
apple	6.73	7.00	7.67	A
army	6.53	6.55	6.88	AA
avenue	6.07	6.48	6.09	A
baby	6.70	6.90	7.04	AA
blossom	6.67	6.62	7.60	43
body	6.40	6.58	5.61	AA
bottle	6.57	6.94	7.24	A
boulder	6.13	6.96	5.88	A
building	6.40	6.94	5.48	AA
butter	6.57	6.96	6.91	AA
cabin	6.47	6.96	7.20	A
cattle	6.40	6.79	7.56	A
circle	6.23	6.00	4.88	AA
city	6.43	6.41	7.72	AA
clothing	6.17	6.63	7.08	A
coffee	6.73	6.89	7.28	A
college	6.20	6.38	7.28	A
corner	6.13	6.65	5.67	AA
cottage	6.50	6.90	7.76	46
cotton	6.00	6.90	7.13	AA
diamond	6.67	6.94	7.84	A
doctor	6.40	6.62	7.32	AA
dollar	6.50	6.62	6.48	AA

HIGH-I WORDS (cont'd)

	I	C	m	F
engine	6.33	6.76	6.08	A
factory	6.43	6.87	6.00	A
flower	6.57	6.96	7.13	AA
forehead	6.27	6.93	5.08	41
forest	6.63	6.69	9.12	AA
garden	6.73	6.83	6.36	AA
hospital	6.53	6.80	7.44	A
hotel	6.40	6.80	5.96	A
insect	6.10	6.80	6.32	40
iron	6.07	6.87	6.12	AA
letter	6.37	6.94	5.96	AA
library	6.73	6.87	6.40	A
magazine	6.40	6.80	6.52	A
maiden	6.10	6.52	5.04	45
market	6.13	6.08	7.04	AA
meadow	6.43	6.69	8.00	47
mountain	6.77	7.00	7.58	AA
ocean	6.77	6.90	8.76	AA
officer	6.23	6.32	5.43	AA
palace	6.50	6.73	7.08	A
paper	6.30	6.89	7.68	AA
party	6.27	5.50	7.08	AA
pencil	6.37	6.70	6.48	40
picture	6.20	6.75	7.16	AA

HIGH-I WORDS (cont'd)

	I	C	m	F
potato	6.50	7.00	7.13	A
prison	6.23	6.62	7.21	A
pupil	6.37	6.63	6.24	A
railroad	6.27	6.76	6.60	AA
river	6.63	6.83	7.52	AA
sugar	6.57	6.96	7.00	AA
table	6.50	7.00	7.60	AA
temple	6.13	6.69	6.75	A
ticket	6.20	7.00	7.21	A
tower	6.53	6.96	6.42	A
valley	6.57	6.66	6.56	AA
village	6.50	6.69	5.32	AA
water	6.60	6.96	7.50	AA
window	6.37	7.00	6.76	AA
winter	6.53	5.83	8.32	AA
woman	6.70	6.63	6.40	AA

B. LOW-I WORDS

	I	C	m	F
advice	3.13	2.08	5.39	A
amount	2.73	3.62	5.84	AA
answer	2.77	4.49	6.04	AA
attitude	2.77	1.83	5.60	A
chance	2.50	1.51	5.61	AA

LOW-I WORDS (cont'd)

	I	C	m	F
custom	3.43	2.99	5.33	A
duty	3.17	2.32	5.60	AA
effort	3.33	2.22	5.75	AA
event	2.90	3.72	5.04	A
evidence	3.23	3.45	6.20	A
excuse	2.77	3.05	4.04	A
history	3.47	3.03	6.91	AA
honor	3.50	1.75	5.08	AA
idea	2.20	1.42	4.88	AA
instance	2.00	2.87	4.04	A
interest	3.13	2.20	5.52	AA
justice	3.60	2.18	6.60	A
memory	3.10	1.78	5.00	A
mercy	3.40	1.59	5.20	45
method	2.63	2.20	5.20	AA
moment	2.50	2.52	4.38	AA
moral	3.17	1.39	6.44	A
occasion	2.53	3.22	5.00	A
opinion	3.23	2.29	4.96	AA
origin	2.30	3.25	5.32	48
position	2.97	3.31	6.24	AA
quality	3.10	2.13	5.52	A
quantity	3.47	3.32	4.17	A
spirit	3.43	1.86	5.72	AA

LOW-I WORDS (cont'd)

	I	C	m	F
theory	2.57	1.90	5.88	A
trouble	3.53	2.25	5.08	AA
virtue	3.33	1.46	4.87	A

APPENDIX B

THE EXPERIMENTAL INSTRUCTIONS

1. VERBAL DISCRIMINATION LEARNING

General Orienting Instructions: All Experiments

Inside this apparatus is a roll of paper, and on the paper are printed a number of pairs of words which you'll see one pair at a time through this window. One word of each pair has been arbitrarily designated as correct and the other as incorrect. When you first see each pair of words, the correct word will be underlined. I want you to pronounce each word aloud, reading from left to right, and note to yourself which one is the correct one. When all the pairs have been presented in this way, they will occur again in a different order without the underlining. This time I want you to tell me which word of each pair is the correct one.

Following this, you will again see the pairs of words with the correct ones underlined, then the pairs alone, and so on, with the procedure being repeated a set number of times. Try to get as many right as possible, and guess if you don't know which word of a pair is correct.

Some of the words will occur in more than one pair.[1]

(Instructional set)

To make sure you understand the procedure, we'll first of all do a short practice list of 4 pairs of words, which are printed on these cards. The first time I show you each pair, the correct word will be underlined. Pronounce

[1] This line was read only in Exp. III and IV.

each word aloud (and then use the technique I've just described to help you remember the correct word).[2] I'll then show you the pairs again and this time tell me which word is correct in each case.

(Practice)

Are there any questions? We'll follow the same procedure for the main list except that this time there are more pairs and the procedure will be repeated several times.

INSTRUCTIONAL SETS

Repetition

I want you to try to learn which words are correct in the following way. Each time a pair occurs with the correct word underlined and you have read the words aloud, I want you to read the correct word aloud 3 additional times. This should help you remember which word is correct when you see the pair again without the underlining.

Single Image

I want you to try to learn which words are correct in the following way. Each time a pair occurs with the correct word underlined and you have read the words aloud, I want you to try to form a mental image or picture in your head of the object denoted by the correct word. For example, if the pair is CAT BOY and CAT is underlined, form a picture of a

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[2]The bracketed portion was read only for instruction groups.

cat in your mind. It is important that you form an image or picture for the correct word only. This should help you remember which word is correct when you see the pair again without the underlining.

Compound Image

I want you to try to learn which words are correct in the following way. Each time a pair occurs with the correct word underlined and you have read the words aloud, I want you to try to form a mental image or picture in your head of the objects denoted by the pairs of words, making the image for the correct word the larger of the two. For example, if the pair is CAT BOY and CAT is underlined, form a picture of a cat and a boy together in your mind, but making the cat much larger than the boy. It is important that you form an image or picture to both words of the pair, making the correct one the larger. This should help you remember which word is correct when you see the pair again without the underlining.

2. INVESTIGATION OF LEARNING STRATEGIES

General Orienting Instructions

In this part of the experiment, I want to find out what kinds of techniques or strategies you used to learn and remember which word was correct in each pair. I'm going to let you see each of the pairs again. Try to remember the the technique, if any, that you used in each case. You have to limit your responses to four alternatives, which I've listed here on this card.

Experiment II

Instruction group: If you made use of the technique of repeating the correct word aloud in remembering which word was correct, say "repetition".

Control: Repetition means repeating the correct word to yourself after reading both aloud in order to help you remember it. If you used this technique to help you remember the correct word of a pair, say "repetition" for those pairs.

Imagery means forming a mental image or picture in your head for the correct word. By this I don't mean a picture of the printed word, but a picture of an object or scene denoted by the word. For example, picturing a dog in your mind if the correct word is DOG, or picturing a policeman to represent the word LAW. If you used the technique of forming an image to the correct word of a pair as an aid in remembering, say "imagery".

If you used some other technique than these two, say "other", and if you are not aware of using any technique at all to remember the correct word of a pair, say "none".

Do your best to remember the techniques you used, if any, and be honest in giving your answers (that is, even though I told you to use repetition, you might have used other techniques instead to help you learn the task.)[3]

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[3]The bracketed portion was read for the instruction group only.

Tell me the correct word of each pair again before selecting the alternative from the card that best describes the strategy you used for that pair.

<u>Experiment III and IV</u>

Repetition refers to two possible strategies you might have used in learning the correct words. First of all, it refers to the technique of repeating the correct word to yourself after reading both aloud in order to help you remember it. Second, it also refers to any use you might have made of the fact that some words occurred more than once in different pairs. If you used either of these two types of strategies to help you remember the correct word of a pair, say "repetition" for those pairs.

If you made use of the technique of forming an image to the correct word of a pair as an aid in remembering, say "imagery".[4]

Imagery means forming a mental image or picture in your head for the correct word. By this I don't mean a picture of the printed word, but a picture of an object or scene denoted by the word. For example, picturing a dog in your mind to represent the word DOG (or picturing a policeman to represent the word LAW).[5] If you used the technique

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[4]This sentence was read only for the instruction group of Exp. III.

[5]The bracketed portion was read only in Exp. IV.

of forming an image to the correct word of a pair as an aid in remembering, say "imagery".

If you used some other technique than these two, say "other", and if you are not aware of using any technique at all to remember the correct word of a pair, say "none".

Do your best to remember the techniques you used, if any, and be honest in giving your answers (that is, even though I told you to use imagery, you might have used other techniques instead to help you learn the task)[6].

Tell me the correct word of each pair again before selecting the alternative from the card that best describes the strategy you used for that pair.

(Final test trial)

When you said "repetition", were you referring to repeating the correct word to yourself, or the fact that some words occurred more than once in different pairs, as a learning strategy?

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[6]The bracketed portion was read only for the instruction group of Exp. III.

APPENDIX C

ANALYSIS OF VARIANCE SUMMARY TABLES

TABLE C1
SUMMARY OF ANALYSIS OF VARIANCE FOR VERBAL DISCRIMINATION LEARNING (EXP I)

Source	df	MS	F
<u>Between Subjects</u>			
Cue Type (A)	1	84.38	1.79
Instruction (B)	3	418.78	8.86***
AB	3	64.15	1.36
Subj. w. groups	88	47.26	
<u>Within Subjects</u>			
Trials (C)	3	2595.08	232.45***
AC	3	3.57	0.32
BC	9	58.25	5.22***
ABC	9	29.83	2.67**
C X Subj. w. groups	264	11.16	

$^{**}p < .01$

$^{***}p < .001$

TABLE C2
SUMMARY OF ANALYSIS OF VARIANCE FOR VERBAL DISCRIMINATION LEARNING, WITH DATA COLLAPSED ACROSS TRIALS (EXP I)

Source	df	MS	F
Instruction	3	103.77	8.61***
Within Cell	92	12.06	

$^{***}p < .001$

TABLE C3
SUMMARY OF ANALYSIS OF VARIANCE FOR
ASSOCIATIVE RECALL (EXP I)

Source	df	MS	F
Cue Type (A)	1	315.38	6.37*
Instruction (B)	3	344.17	6.95***
AB	3	22.15	0.45
Within Cell	88	49.52	

*p < .05
***p < .001

TABLE C4
SUMMARY OF ANALYSIS OF VARIANCE FOR VERBAL
DISCRIMINATION LEARNING (EXP II)

Source	df	MS	F
Between Subjects			
Instruction (A)	1	625.00	6.27*
Subj. w. groups	30	99.76	
Within Subjects			
Trials (B)	3	360.54	36.09***
AB	3	2.46	0.25
B X Subj. w. groups	90	9.99	
Imagery (C)	1	400.00	36.61***
AC	1	6.25	0.57
C X Subj. w. groups	30	10.93	
BC	3	14.04	1.87
ABC	3	3.63	0.48
BC X Subj. w. groups	90	7.52	

*p < .05
***p < .001

TABLE C5
SUMMARY OF ANALYSIS OF VARIANCE FOR VERBAL DISCRIMINATION LEARNING, WITH DATA COLLAPSED ACROSS TRIALS (EXP II)

Source	df	MS	F
Between Subjects			
Instruction (A)	1	2450.25	6.10*
Subj. w. groups	30	401.92	
Within Subjects			
Imagery (B)	1	1640.25	37.24***
AB	1	30.25	0.69
B X Subj. w. groups	30	44.05	

*p < .05
***p < .001

TABLE C6
SUMMARY OF ANALYSIS OF VARIANCE FOR REPORTED STRATEGIES (EXP II)

Source	df	MS	F
Between Subjects			
Instruction (A)	1	86.13	9.06**
Subj. w. groups	30	9.51	
Within Subjects			
Strategy (B)	1	0.07	0.01
AB	1	70.51	5.11*
B X Subj. w. groups	30	13.79	
Imagery (C)	1	118.20	33.98***
AC	1	5.70	1.64
C X Subj. w. groups	30	3.48	
BC	1	940.70	116.59***
ABC	1	8.51	1.05
BC X Subj. w. groups	30	8.07	

*p < .05
**p < .01
***p < .001

TABLE C7
SUMMARY OF ANALYSIS OF VARIANCE FOR VERBAL DISCRIMINATION LEARNING (EXP III)

Source	df	MS	F
Between Subjects			
Instruction (A)	1	784.00	8.30**
List (B)	1	930.25	9.84**
AB	1	138.06	1.46
Subj. w. groups	60	94.52	
Within Subjects			
Trials (C)	3	794.69	61.55***
AC	3	181.13	14.03***
BC	3	66.54	5.15**
ABC	3	33.02	2.56
B X Subj. w. groups	180	12.91	

**$p < .01$
***$p < .001$

TABLE C8
SUMMARY OF ANALYSIS OF VARIANCE FOR VERBAL DISCRIMINATION LEARNING, WITH DATA COLLAPSED ACROSS TRIALS (EXP III)

Source	df	MS	F
Instruction (A)	1	204.85	8.36**
List (B)	1	242.19	9.88**
AB	1	38.29	1.56
Within Cell	60	24.50	

**$p < .01$

TABLE C9
SUMMARY OF ANALYSIS OF VARIANCE FOR REPORTED STRATEGIES (EXP. III)

Source	df	MS	F
Between Subjects			
Instruction (A)	1	548.63	18.60***
List (B)	1	89.45	3.03
AB	1	15.82	0.54
Subj. w. groups	60	29.49	
Within Subjects			
Strategy (C)	1	1478.32	16.66***
AC	1	5657.82	63.74***
BC	1	37.20	0.41
ABC	1	0.38	0.00
B X Subj. w. groups	60	88.76	

***$p < .001$

TABLE C10
SUMMARY OF ANALYSIS OF VARIANCE FOR VERBAL DISCRIMINATION LEARNING (EXP IV)

Source	df	MS	F
<u>Between Subjects</u>			
List (A)	1	1444.00	18.07***
Subj. w. groups	30	79.90	
<u>Within Subjects</u>			
Trials (B)	3	428.83	40.12***
AB	3	31.17	2.92*
B X Subj. w. groups	90	10.69	
Imagery (C)	1	689.06	31.86***
AC	1	14.06	0.65
C X Subj. w. groups	30	21.63	
BC	3	7.73	0.70
ABC	3	9.73	0.88
BC X Subj. w. groups	90	11.06	

*$p < .05$
***$p < .001$

TABLE C11
SUMMARY OF ANALYSIS OF VARIANCE FOR VERBAL DISCRIMINATION LEARNING, WITH DATA COLLAPSED ACROSS TRIALS (EXP IV)

Source	df	MS	F
Between Subjects			
List (A)	1	5439.06	17.40***
Subj. w. groups	30	312.65	
Within Subjects			
Imagery (B)	1	2782.56	33.36***
AB	1	33.06	0.40
B X Subj. w. groups	30	83.41	

***$p < .001$

TABLE C12
SUMMARY OF ANALYSIS OF VARIANCE FOR REPORTED STRATEGIES (EXP IV)

Source	df	MS	F
Between Subjects			
List (A)	1	13.78	0.96
Subj. w. groups	30	14.38	
Within Subjects			
Strategy (B)	1	294.03	5.75*
AB	1	2.53	0.05
B X Subj. w. groups	30	51.11	
Imagery (C)	1	175.78	44.53***
AC	1	3.78	0.96
C X Subj. w. groups	30	3.95	
BC	1	258.78	16.96***
ABC	1	2.53	0.17
BC X Subj. w. groups	30	15.26	

*$p < .05$

***$p < .001$