INTRAPAIR RELATEDNESS AND RETRIEVAL PROCESSES IN VERBAL DISCRIMINATION LEARNING

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ABSTRACT

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by

Robert Lawrence Mack

In this study a model of verbal discrimination (VD) learning is tested. The model hypothesizes two levels of processing in VD performance. In minimal retrieval subjects can directly access the correct/incorrect encoding of an item, independently of the other item of the pair. If minimal retrieval is inadequate, subjects can retrieve the other constituent of a study pair during testing. This retrieval check increases the probability of a proper discrimination of a correct or incorrect item.

Retrieval checks are only hypothesized for test conditions that re-pair study VD pairs on the test trial. Intrapair relatedness in VD learning allows for retrieval checks as compensatory processing when minimal retrieval is inadequate.

The VD task used aural presentation in a study-test procedure. Intrapair relatedness was manipulated by using compound words and unrelated words as VD pairs. The likelihood of a retrieval check was varied through fast and slow study rates of presentation. It was predicted that the benefit for related over unrelated pairs would only occur for the re-pairing test condition. This difference would be greater for fast study rate where retrieval checks were hypothesized as more likely. No difference was predicted for pair type in a constant study-test pairing condition.

The results did not support the predictions of the model. The only significant result was that related pairs were superior to unrelated pairs in all test and rate conditions. There were no predicted interactions of this difference with either test or rate conditions. Secondary predictions, involving correlations between measures of intrapair relatedness and VD performance, were also not supported.

A potential confounding of the compound word relation with intrapair association is also discussed. It was concluded that the superiority of related pairs (or compound words), compared to unrelated word pairs, must be regarded as a tentative result until the potential confounding of the effect with associative relatedness is assessed more completely.

In the General Discussion, three possible explanations are considered for the failure of the model. It was concluded that further tests of the model developed in this study will require more control over possible strategies subjects can use in the VD task. Finally, we consider the significance of the relatedness effect for current theories of VD learning.

Approved A. M. Barch
Committee Chairman

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by

Robert Lawrence Mack

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INTRODUCTION

Theoretical Issues

This study is concerned with a hypothesis specifying the role of intrapair relatedness in verbal discrimination (VD) learning. In VD learning a list of word pairs is presented in which one word in each pair is arbitrarily designated a correct (C) word. The subjects must learn which word in each pair is the C word. According to the frequency theory of VD learning proposed by Ekstrand, Wallace, and Underwood (1966) this discrimination is based on frequency of occurrence cues that are assumed to accrue each time a word is perceived, both in terms of a representational response and/or in terms of the rehearsal of an item, or pronounciation response. Rehearsal of the correct response provides the differential frequency of occurrence cues that distinguish C and incorrect (I) words in a pair.

For example, consider a word pair like TABLE BEAUTIFUL where TABLE is designated the C word. According to the frequency theory each item in the pair acquires a single frequency of occurrence increment when perceived by the subject. If the subject rehearses an item, further frequency cues accrue to the internal representation of the item. It is hypothesized that the C word will be rehearsed more often than the I word, resulting in a higher frequency of occurrence count than for the I word. The original frequency theory has been modified to account for discrepancies between the nominal frequency of occurrence and the actual (or functional) accrual of frequency cues (see especially Wallace, 1972; Howell, 1973). However, the essential discrimination in VD learning is still regarded as based on differential accrual of frequency of occurrence cues for the C and I word in a pair.

Associative relations between C and I words also influences the rate of frequency cue accruals. Associatively related pairs are pairs containing words with a high degree of intrapair associative strength measured in terms of free association task (normally where one item is the primary response to the other item when the latter is given as a stimulus word). Frequency theory predicts that implicit associative responses from one member of an associated pair to the other will prevent or impair the differential accrual of frequency of occurrence cues. Associatively related pairs should be harder to learn in a VD task than unrelated pairs because the cues distinguishing C and I words are more difficult to establish. This prediction holds for both intra- and inter-pair associations. Although the frequency theory has been successful in accounting for a wide range of phenomena (see, e.g., Wallace, 1972; Kausler, 1974a, 1974b; Eckert & Kanak, 1974), one conspicuous failure of the theory has been the lack of this predicted decrement in VD performance for pairs consisting of associated words, that is, for intrapair associations.

Barch and Whalen (1970), Eberlein and Raskin (1968), and Fulkerson and Kausler (1969) have all shown that associatively related pairs are no more difficult than unrelated pairs for college students, and associated pairs may be easier than unrelated pairs under some circumstances (Barch, Lippman, & Whalen, 1967, for children). This lack of a difference in performance, or null effect, appears to be an established result.

The problem for the frequency theory is compounded by a further examination of the Barch and Whalen (1970) results for college students. The null effect was obtained when test pairs were identical to the study pairs (i.e., in a constant study-constant test pairing or CC condition). However, in a condition where study pairs were re-paired on the test trials (i.e., in a constant study-varied test pairing or CV condition), the associated pairs showed a significantly higher level of learning than the unrelated pairs.

Barch, Lippman, and Whalen (1967) had proposed an alternative to the frequency theory in which associatively related pairs would be benefited by the fact that they would impose less of a memory load on the subjects than the unrelated pairs. They offered a "chunking hypothesis" which assumed that subjects tagged or encoded one item of a given pair (whose constituents are contiguous) as the C word, and then collapsed the whole pair with its encoded information as an intact unit, effectively reducing memory load. This "tag-and-collapse" process was hypothesized to be easier for associated pairs than unrelated pairs. Barch et al. further proposed that the conditions of storage of a pair were all important. In the CV test condition, where re-pairing study pairs might be hypothesized to increase memory demand (compared to the constant pairing CC test), the associated pairs should undergo less impairment as a result of the re-pairing because their original storage is more adequate than for the unrelated pairs.

Further evidence for the higher level of learning for word pairs containing intrapair relatedness comes from unpublished studies using compound words as VD pairs (e.g., APPLESAUCE or TREETOP). The constituents of such words are often not exhibited at high levels of strength in free association norms. In one such study college students were presented with a mixed list of 16 compound words and 16 unrelated pairs in two alternating study-test trial sequences (study rate 4 seconds). Eighty subjects were divided equally between CC and CV test pairing conditions.

The results were essentially identical to those for associated pairs. The proportion correct was higher for related than unrelated pairs, $F(1, 234) = 29.10$, $p < .01$. This difference was significant for the CV condition but not the CC condition. The Pair Type x Test Type interaction was significant, $F(1, 234) = 18.38$, $p < .01$. A Newman-Kuels analysis shown in Table 1 indicates that related pairs in the CC condition did not differ from unrelated pairs in the CC condition, while both of these groups were superior to unrelated pairs in the CV condition. Figure 1 shows proportion correct for related (R) and unrelated (U) pairs in the CC and CV test pairing conditions for the two test trials. There was no main effect for CC and CV Test Type. Of particular interest is that related pairs in the CV condition were superior to related pairs in the CC condition.

These results suggest that whatever benefit derives from intrapair relatedness for college students only occurs when memory demand is presumably increased in VD testing (i.e., under the CV study-test pairing condition). There was no difference between related and unrelated pairs when test conditions were essentially identical to the study conditions (i.e., under the CC study-test pairing condition). It should be appreciated that the intrapair position of items was varied systematically for the CV test pairs (relative to the study position), but that the intrapair sequence was not varied for the CC test pairs or either CC or CV study pairs. Normally, intrapair sequence of items is varied for VD pairs on both study and test trials, even in constant study-constant test pairing conditions (see, e.g., Underwood, 1969).

Compound words pose a problem because the order of constituents is part of the meaning of the compound word. Therefore, the order of

Table 1 Newman-Kuels Analysis of Pair Type (R and U) x Test Type (CC and CV) Interaction.

U-CV	U-CC	R-CC	R-CV
11.38	12.33	12.54	13.24

Note: Mean correct pairs. Maximum score = 16. Any means not on the same line are significantly different at $p < .01$.

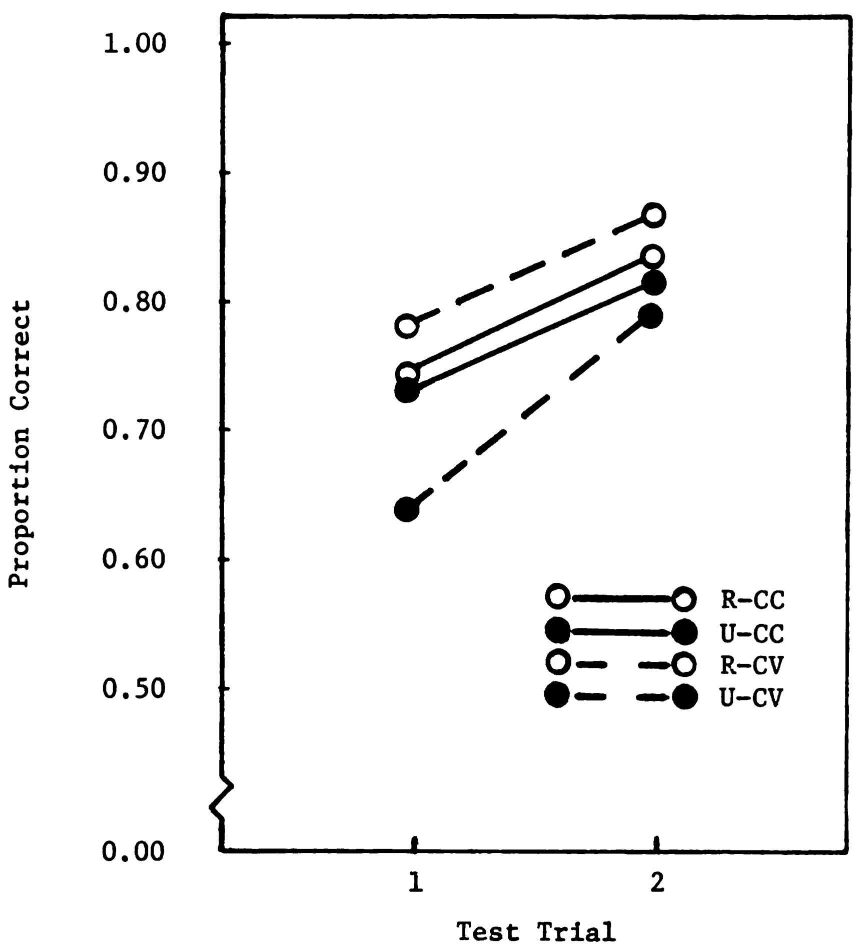

Figure 1 Proportion Correct over Two Trials for Auditory Presentation of VD Pairs in Related (R) and Unrelated (U) Pair Type, and Constant (CC) and Re-Pairing (CV) Test Type.

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constituents was held constant. However, this constancy could be expected to benefit CC pairs. In fact, as already noted above, related pairs in the CV condition were actually superior to related pairs in the CC condition. The same effect was suggested at a non-significant level with associatively related pairs (Barch & Whalen, 1970).

Summarizing, it would appear that a task which presumably increases memory demand on testing appears easier (in some circumstances) than a task with a lower memory demand. But this only occurs when intrapair relatedness holds.

These results also suggest that intrapair relatedness is more general than that of associative relatedness _per se_. This conclusion is tentative until the possible role of associative relatedness in the compound words used above is assessed more carefully. However, we have found it convenient to regard relatedness in more neutral terms, and for this purpose have adopted the notion of redintegrative memory (RM) from Horowitz and Prytulak (1969)[1]. RM properties refer to the extent to which a complex stimulus such as a word pair is retrieved as a whole, given that any part of it is retrieved. For word pairs, an index of RM can be computed from free recall protocols as the ratio of total words recalled in pairs to the total number of words recalled singly or in pairs. RM values range from perfect redintegration (1.0) to no redintegration (0.00).

The potential usefulness of this measure is suggested by recall data obtained immediately after the VD task in the pilot study described above. Subjects were asked to recall all the study pairs they could, including single words if they could not remember pairs. RM values were computed for the original pairs. These RM values were then correlated with the proportion correct for each pair in both constant and re-pairing test conditions, as shown in Table 2. The results are only suggestive but the significant correlations for related (R) pairs (test trial 2 and summed over trials), and those computed over both related and unrelated (U) pairs, are consistent with the hypothesis that intrapair relatedness plays a role in VD learning.

The data clearly implicates intrapair relatedness in VD learning, but it is not clear to what extent the tag-and-collapse model is generally applicable beyond tasks that increase memory demand in testing. What about intrapair relatedness in general terms?

Table 2 Correlations Between RM Values and Proportion Correct[a] for Related (R) and Unrelated (U) Pairs and Collapsed over Pair Type, Constant (CC) and Re-Pairing (CV) Test Type[b], and Test Trials 1, 2, and Summed over Test Trials.

	Pair Type		
	R	U	Overall
	Constant Study-Test Pairing (CC) Condition		
Test Trial			
1	.344	.146	.320 *
2	.822 ***	.262	.263
Overall	.714 ***	.250	.337 *
	Constant Study-Re-Pairing (CV) Test Condition		
Test Trial			
1	.040	.310	.360 *
2	.640 **	.180	.524 ***
Overall	.340 *	.266	.512 ***

a. Proportion correct summed over 30 Ss for each condition.
b. RM value for CV test pair corresponds to pair whose correct word occurs in the pair.

* $p < .05$
** $p < .01$
*** $p < .005$

The Generality of Intrapair Relatedness in Verbal Discrimination

It appears generally acknowledged that there are so-called "boundary conditions" (after Wallace, 1972, page 308) for the applicability of frequency theory beyond which attributes other than frequency of occurrence cues must be exploited (see also Underwood & Freund, 1970, page 285). Intrapair associations have been regarded as providing compensatory cues when frequency information is not adequate for discriminating correct and incorrect words. This role is exemplified in the double-function paradigm.

Kausler and Boka (1968) presented double-function pairs in which words appeared in two different pairs and with reversed (C or I) function. In a mixed list containing single-function and double-function pairs, the latter were more difficult to learn, as expected. However, frequency theory predicts that such pairs should be impossible to learn, because frequency differentials could not be established. Kausler et al. argued that associations formed during the task provided cues distinguishing pairs containing the same words in different functions. Evidence was presented indicating a positive covariation of VD performance with performance on a subsequent associative (cued) recall task.

The associations involved in this task were acquired during the VD task. Other studies have reported evidence of pairwise associations formed during VD learning but have regarded them as incidental to VD learning (e.g., Zechmeister & Underwood, 1969). Wallace (1972) has argued that correlational evidence of this kind does not prove that intrapair associations have a general role in VD learning except for cases where it is clear that frequency cues are inadequate.

From a complex series of studies involving pre-experimental associations, Zimmerman, Shaughnessy, and Underwood (1972) have also concluded that whatever role intrapair associations have in VD learning, frequency discriminations are the primary determinants of VD performance. Their studies were based on constant study and test pairing corresponding to the CC condition described earlier so that the conclusions do not apply to the effect of relatedness found for the re-pairing test condition. Nevertheless, it might be argued that intrapair relatedness as an explanatory concept also has "boundary conditions." That is, intrapair relatedness may not play a role in VD learning except under certain circumstances such as the re-pairing test condition.[2]

Kausler (1974a, 1974b) has attempted to clarify the role of intrapair relatedness in VD learning and to relate VD performance to processes underlying recognition memory in general. Kausler assimilates frequency theory to a feature analytic concept of word structure in which frequency of occurrence information can accrue to features of words rather than words as units. It is further hypothesized that this process is under the "cognitive control" of subjects. The lack of a decrement for intrapair associations in VD learning follows from this model by assuming that subjects can distinguish within pairs overlapping and non-overlapping features, and process or tag the distinctive features of the C word as the basis for discrimination.

Kausler also argues that the constituents of a VD pair can form a functional unit in a non-associative "Gestalt" whole. He cites the unitization hypothesis of Winograd, Karchmer, and Russell (1971) as an example of such a unit. Winograd et al. proposed an imaginally based unitization. The implication that intrapair relatedness is more general than associative is entirely consistent with the redintegrative concept described earlier. With respect to retrieval, Winograd et al.

hypothesize that,

> ... what is stored is a single or unitary representation rather than two elements and a link between them. However, the subject is considered as being able to decode or extract information from this image which, to the experimenter, pertains to single components or analytic elements [Winograd, Karchmer, & Russell, 1971, page 204].

The authors are discussing recognition memory here, but the parallel with the tag-and-collapse model should be obvious. Kausler argued that if feature tagging and unitization are involved in VD learning, then research in recognition memory concerning context and retrieval effects might be equally relevant to verbal discrimination. The discussion which follows is based on this parallel.

Retrieval Processes in Recognition Memory

Recent characterizations of recognition memory (e.g., Kintsch, 1970; Mandler, 1972; McCormick, 1972; Tulving & Thompson, 1973) have differed about the actuality of retrieval processes and whether organization facilitates retrieval, if it exists. It has been argued, for example, that recall, but not recognition, involves retrieval (e.g., Kintsch, 1970). In recognition subjects are hypothesized to have direct access, through the stimulus available at recognition, to an internal representation of the stimulus, and the information encoded with it regarding familiarity or situational frequency of occurrence. This internal representation is assumed to be independent of other items, and therefore list organization should be irrelevant to accessing the representation. This position has been termed "minimal retrieval" by McCormack (1972).

In contrast to minimal retrieval, more complex retrieval processes have been hypothesized in recognition. Examples include the encoding specificity hypothesis (Tulving & Thompson, 1973), the related demonstration of context effects in recognition of homograph nouns (Light &

Carter-Sobel, 1971), the effects of list organization in recognition and the notion of "retrieval check" argued for by Mandler (1972; Mandler & Boeck, 1974), and the memory search processes in recognition memory for which Atkinson, Herrman, and Wescourt (1974) provide evidence.

The above mentioned concepts of memory search and retrieval check are of particular interest. It is argued that there are two levels of recognition memory. If information distinguishing old (list) and new (distractor) items is directly available (e.g., inspection of familiarity "tags") recognition involves minimal retrieval. However, if this information does not permit a simple discrimination, processes of extended retrieval are hypothesized. List organization is effective only in extended retrieval. List organization facilitates retrieval of information such as list membership or presence of an item in an acquisition set. This information compensates for equivocal information derived from minimal retrieval and increases the probability of correct recognition.

Retrieval Processes in Verbal Discrimination

The extension of these ideas to VD learning seems straightforward. The correct/incorrect coding translates into a discrimination based on differential frequency of occurrence information. The I words can be assigned a role analogous to distractor items. In the original frequency theory this discrimination would correspond to minimal retrieval. To the extent that frequency of occurrence information accrues to features of words or varies from the nominal input conditions, one might consider more complex encoding and retrieval processes, in terms, for example, proposed by Kausler (1974b).

In more general terms, it is proposed that there are two levels of processing in the decisions underlying verbal discrimination:

(1) minimal retrieval involving the matching of a test encoding of an item with the stored trace of that item in memory, and the extraction of information relevant to identifying the item as a C or I word, and (2) extended retrieval or retrieval check in which a test item provides access to compensatory information relevant to the VD encoding of an item when minimal retrieval for that item is inadequate.

It is hypothesized that (2) involves the literal retrieval or recall of one or more study pair constituents in terms of which the C or I encoding of a given item can be inferred with a probability greater than that if no other encoding information could be accessed. This process will be referred to as redintegration after Horowitz and Prytulak (1969). Variables which affect the availability of a retrieval check refer to manipulations of RM values for the word pair.

The tag-and-collapse model emphasized storage processes without specifying in detail the retrieval processes that were hypothesized to occur in testing. The argument above is that the concept of retrieval check can clarify the retrieval stage of the tag-and-collapse model, if a retrieval check is identified with the process of "searching for" and "unfolding and inspecting" the stored unit described in the tag-and-collapse model (Barch et al., 1970).

We hypothesize that retrieval checks are only necessary when minimal retrieval provides inadequate information, and only relevant in test conditions where study pairs are re-paired. That is, retrieval checks are only relevant in the CV re-pairing test condition, and <u>not</u> relevant in the constant study and test pairing, or CC, condition.

If intrapair relatedness is only relevant for facilitating extended retrieval, and irrelevant for minimal retrieval, then it follows that there should be no difference between related (R) and unrelated (U) pairs in the CC condition. This assumes that intrapair relatedness does not influence minimal retrieval or the initial study encoding of VD pairs. On the other hand, there should be an advantage accruing to pairs in the CV test condition to the extent that either or both constituents of the test pair provide for a retrieval check. The probability of a retrieval check depends on the RM properties of VD pairs. These properties should be higher for R pairs than for U pairs. Therefore, R pairs in the CV condition should be learned better than U pairs in the CV condition. Note that one might also predict that R pairs in the CV condition would be superior to R pairs in the CC condition because more information is potentially available in CV test pairs than CC pairs.

These predictions are consistent with the results for the proportion correct measure reported earlier, for both associated word pairs and compound words used as VD pairs (pages 2 and 4). That is, in both studies related pairs (defined associatively or otherwise) were superior to unrelated pairs, but only in the CV test condition, not the CC condition. In addition, R pairs in the CV condition were superior to R pairs in the CC condition, although this result was only statistically significant in the compound word study.[3]

Note, however, that the pattern of results is not entirely consistent with the correlation data shown in Table 2 (for the compound word study). That is, according to the arguments developed above, there should not be any significant correlation of RM with VD performance for the CC test condition. In fact, there are significant correlations in the CC test condition for R pairs, and summed over R and U pairs, although the latter correlations are higher in the CV, compared to CC, test condition. Nevertheless, if this pattern is replicated in the present study, it may pose a problem for the hypothesis proposed here relating intrapair relatedness and VD performance.

It should be noted also that the retrieval check hypothesis is not necessarily incompatible with the frequency theory. No assumption has been made about minimal retrieval except that it does not involve retrieval checks. Frequency of occurrence information may still underly minimal retrieval. Moreover, minimal retrieval may be entirely adequate even for pairs in the CV test condition. Retrieval checks are regarded as optional and may affect only a small subset of CV pairs in a given trial.

This suggests that the benefit for related pairs only derives for pairs that undergo a retrieval check. Performance for CV pairs that do not undergo a retrieval check may be comparable to that of CC pairs. This prediction can be tested if some independent measure could be found for distinguishing pairs that undergo retrieval checks from those that do not. Choice response time might be an appropriate measure sensitive to the immediate processing of VD test pairs, if it is assumed that extended retrieval requires more time than minimal retrieval. The possibility of directly demonstrating retrieval checks is of great interest, and has some precedent from a recognition memory study by Mandler and Boeck (1974). However, a recently completed pilot study using response time measures suggests problems of interpretation.

In the present study, retrieval processes will be inferred from the pattern of results obtained for the proportion correct measure, under manipulations hypothesized to affect the likelihood of a retrieval check occurring in VD performance. In particular, there are at least three conditions relevant to a retrieval check: (1) The relative <u>availability</u> of a retrieval check, determined by the RM properties of a VD pair, (2) the <u>necessity</u> of a retrieval check, or the probability that the initial (study) VD encoding will be inadequate, and minimal retrieval insufficient for deciding whether an item is correct or not, and (3) the probability of completing a retrieval check within the time available.

There are four independent variables that may be hypothesized to affect minimal and extended retrieval in terms of these three conditions: (1) Intrapair relatedness deriving from either (a) pre-experimental relatedness (e.g., compound words or associatively related word pairs versus unrelated pairs of words), or (b) pre-discrimination task familiarization (e.g., memorization of pairs to a criterion of perfect free or cued recall prior to the VD task), (2) test type with test items consisting of test pairs identical to study pairs, test pairs re-paired from study pairs, and/or non-pair (single item) test presentation, (3) rate of presentation for either or both study and test pairs (with rates defined, e.g., as 4:4-sec, 2:4-sec, 4:2-sec, and 2:2-sec, for study and test trials, respectively), where it is necessary to assume that (a) decreasing study time will increase the probability that the C and I encoding of items will be degraded and induce retrieval checks at testing, and (b) decreasing the test (decision) time should decrease the probability of being able to complete a retrieval check even if it is necessary and available, and (4) retention interval between study and test presentation, where it is hypothesized that increasing the retention interval will diminish the adequacy of the initial (study) encoding of items (or diminish the adequacy of minimal retrieval) and induce retrieval checks.

A complete factorial design incorporating all the variables described with all levels would constitute a design of fairly sizable proportions. Such a study does not seem appropriate until the robustness of the effects reported earlier (page 4) has been determined with a fully counterbalanced design.

Justification of Design Limitations

The present study is regarded as essentially a replication of the pilot study described above (page 4) with one additional manipulation. The study rate of presentation is varied from 4 seconds to 2 seconds. It is hypothesized that the faster rate will diminish the encoding of correct and incorrect words and therefore increase the necessity of a retrieval check. If retrieval checks facilitate VD performance, then the difference between related and unrelated pairs in the CV condition should be greater for the fast study presentation than for the slow presentation. For pairs in the CC condition no difference is predicted between related and unrelated pairs.

Rate of presentation for test pairs is not manipulated. Pilot studies indicate that further work is needed to determine what levels of test rate of presentation will be effective.

It is assumed that compound words and unrelated word pairs will provide high and low levels of RM, respectively. However, there are two methodological problems relating to level of RM for VD pairs and the study rate manipulation.

First, the recognition of relatedness in word pairs by the subjects may be affected by rate of study presentation. Therefore, it seemed desirable to provide adequate exposure for recognizing relatedness or non-relatedness of all pairs prior to the VD task. A familiarization task was considered adequate. The task will also serve to ensure that all pairs can be recognized and/or adequately perceived in the subsequent task.

The second difficulty is more serious. This is the possibility of confounding study rate of presentation and the level of intrapair relatedness (or RM). That is, one could argue that the slow rate of study would provide for a greater degree of intrapair relatedness in unrelated pairs than that which would be established for the same unrelated word pairs in the fast study condition. This confounding could produce the Pair Type x Test Type x Rate interaction predicted, rather than the interaction resulting from a greater benefit for related pairs over unrelated pairs in the re-pairing condition for fast compared to slow presentation.

Therefore, a third rate condition was defined that separated time to encode correct/incorrect information (i.e., which word is correct in a pair) from exposure to the pair *per se*. In this *mixed rate* condition a two second interval was interposed between the presentation of the VD pair and the designation of the correct word. There was no study time following the designation of the correct word. Thus, each pair was exposed for the same time as pairs in the slow (4 second) rate, while the (VD) encoding time was equivalent to that for pairs in the fast (2 second) rate.

This mixed rate condition was hypothesized to indicate, at least for test trial one, whether exposure to the VD pairs affects performance for unrelated pairs independently of the difference in encoding time between fast and slow rates. On subsequent study trials subjects might be expected to rehearse the correct word in the two second interval if they can remember the correct word for a given pair. Nevertheless, the first test trial was expected to be most sensitive to any differences in VD performance due to differences in exposure time during the study trial.

Retention interval was not manipulated. Predictions are similar to those for manipulating study rate, and it appeared inefficient to undertake the laborious research needed to manipulate retention interval if the effect of study rate had not been demonstrated.

Summarizing, this study considered the effect of slow, fast, and mixed study rates of presentation on VD pairs in CC and CV study-test pairing conditions. Test rate of presentation was constant at 4 seconds. The VD pairs had high or low RM properties manipulated by pre-experimental relatedness. The study was concerned with manipulating the availability of hypothesized retrieval checks (in terms of intrapair relatedness) and the probability that such extended retrieval would be necessary in the decision process underlying verbal discrimination.

METHOD

Subjects

A total of 185 Ss participated. The Ss were college age students enrolled in introductory psychology courses. Of these Ss data from 120 Ss was used. Twenty-five Ss were randomly rejected to obtain equal cell sizes. Another 10 Ss were rejected for performing at chance (i.e., obtaining a score of 16 out of 32 on the last test trial). A third group of 30 Ss was used to replace Ss who had been run in conditions for which a counterbalancing error in stimulus presentation had been made. All Ss were tested in small groups of one to six Ss in laboratory setting.

Design

The design was a 2 x 3 x 3 x 2 x 2 x 2 factorial with study Pair Type (R and U) and study-test trials (1, 2, and 3) within-subject variables. Between-subject variables included study Rate (2 and 4 second, and mixed rate), Test Type (CC and CV), Key (standard and reverse), and List (1 and 2).

The VD list contained 32 pairs of words in a mixed list design with 16 unrelated (U) pairs and 16 related (R) pairs (compound words). A pool of 32 compound words was generated by E and selected so that in most (but not all) cases either the compound or its parts were medium (A) or high (AA) frequency on the Thorndike-Lorge (1948) count. Level of possible associative relatedness was not systematically controlled in this list of compounds, except where published norms (e.g., Postman & Keppel, 1970; Palermo & Jenkins, 1964) indicated a high association (defined as greater than 10%) for one constituent given as a response to the other when it appeared as a stimulus item.

The 16 compound words selected as R pairs from the pool included bagpipe, bathtub, checkbook, eardrum, farmland, goldfish, grapefruit, headstone, lifeguard, matchbox, photograph, rosebush, shoehorn, toothbrush, treetop, whalebone.

The 16 U pairs were constructed from the remaining 16 compound words by breaking them up and re-pairing. Re-pairing items were scanned to ensure that no new compounds or obvious relations resulted.

The U pairs were constructed in this way to control for possible effects of the stimulus materials used here. That is, it is possible that words which make up compound words have special properties even taken singly and/or outside the meaningful compound word combination. Therefore, it appeared necessary to represent these potential properties.

The U pairs included bank coat, cloth rain, cross bell, dust night, egg fire, house sand, lamp wood, milk storm, neck apple, plant wind, road sauce, shade mill, smoke post, snow gown, tie door, weed card.

These 32 pairs make up List 1. List 2 pairs correspond to the compound words used to make up List 1 U pairs. These include applesauce, crossroad, doorbell, dustcloth, eggplant, firewood, lampshade, milkweed, necktie, nightgown, postcard, raincoat, sandstorm, smokehouse, snowbank, windmill.

List 2 U pairs were constructed from List 1 R pairs by re-pairing in the same way that List 1 U pairs were constructed. List 2 U pairs include bag brush, box head, bush life, book fruit, check grape, drum fish, ear tub, farm bone, graph horn, land guard, match stone, photo shoe, pipe tooth, rose whale, top gold, tree bath.

Correct words were chosen unsytematically but scanned to ensure that word length or number of syllables could not be used systematically as a cue by subjects.

The VD list has an alternatively keyed version in which all correct words in the standard key are incorrect words in the reverse key and vice versa.

Six different serial orders of pairs were constructed so that no pair occupies the same serial position and/or no pair is followed or preceded by the same pair. Three of the serial orders are used for the study trials and three for the test trials. For any given combination of counterbalancing variables (i.e., List 1 or 2, Key A or B) and Test Type (CC or CV) assignment, it was necessary to rearrange the serial order of some pairs. Therefore, in effect, there are 48 different serial orders of pairs. But the variations are generated from six basic orders constructed systematically.

The serial orders are constructed so that approximately half the pairs in each (R and U) condition in each half of the list for a given study or test trial appear in the opposite half of the list for the subsequent study or test trial. The intrapair order of C and I words does not vary for the study pairs or the CC test pairs. Intrapair sequence of words for compound words is part of the meaning of the compound, and therefore cannot be varied on study trials. Constant pairing on the test (i.e., CC condition) also requires constant intrapair sequence of words for the compounds. Intrapair sequence does vary systematically for the CV test pairs.

For the CV test condition the VD study pairs are re-paired. R pair words are re-paired with other R pair words and U pair words with other

U pair words. For half the words in the test pairs the intrapair position in the study pair is reversed. For half the pairs intrapair position is left intact. Half the items in first or second position in the test pairs reverse their position between the first and second test trial. The other half reverse their position between the second and third test trials. All re-pairings were scanned to minimize new meaningful combinations, within the constraints of counterbalancing correct/incorrect function and same/different intrapair positions of an item between study and test pairs.

Counterbalancing for CV pairs relative to the main independent variables used the correct word as reference. The incorrect words were assigned to correct words systematically, but are not counterbalanced relative to the other main independent variables. For the reverse key, where incorrect words become correct words, and vice versa, lists are constructed according to counterbalancing constraints within and between study and test lists as defined for pairs in the standard key.

The R and U Pair Type, and first or second position of the correct word in a VD pair have all been balanced over blocks of eight pairs for both study and test lists. An alternating ABBA block counterbalancing has been used for the R and U pairs.

A familiarization list was constructed with all 32 pairs presented in alternating blocks of eight R and U pairs. The pairs were typed in two vertical columns of 16 pairs per column. These pairs were also recorded on a TEAC 1230 tape recorder, at a four second presentation rate. The recorded and typed lists presented pairs in the same serial order.

All pairs on the VD study and test trials were recorded on a TEAC 1230 tape recorder. The related pairs, or compound words, were read with normal intonation. Unrelated words were read as two distinct words. On the test trials the number of every fourth test pair was read prior to reading the pair so that Ss could maintain their place on the answer sheet.

Procedure

The main experiment was preceded by a familiarization experience. E played the recording of the familiarization list and Ss were asked to read each pair on the typed list as they heard it. Ss were instructed that these pairs would be used in the VD task to follow. Ss were informed of the difference between related and unrelated pairs (although the word "compound" was not used). They were asked to try to remember the pairs so that they could recognize them when they appeared later in the main task.

Immediately following the familiarization experience instructions for the main experiment were read (instructions shown in Appendix A).

Next, three alternating study-test trial sequences were presented. Pairs were presented using a Wollensak tape recorder. Pairs in the study trial were read as follows: "TREETOP. TREE is correct."

In the 2 second study rate the interval between the onset of a study pair and the next pair was 2 seconds. In the 4 second rate this interval was 4 seconds. For the mixed rate condition (see page 16) there was about a two second interval between the presentation of the study pair and the designation of the correct word (i.e., between "TREETOP" and the phrase "TREE is correct"). The interval varied slightly depending on the length of the initial pair.

Test pairs were read as follows: "TREETOP." The interval between one test pair and the beginning of the next pair was 4 seconds.

Subjects responded by circling either "1" or "2" on an answer sheet depending on whether the first or second word of the test pair was the correct word.

The intertrial interval was between 10 and 15 seconds during which E identified (on tape) the trial to follow. Before the first test trial E stopped the tape and reminded Ss of the procedure for responding.

Following the third test trial, the Ss were given a free recall task. They were asked to recall all the word pairs they could from the study list. Ss were instructed to write down any words they could remember, but especially the original study pairs. Seven minutes were allotted for this task. Instructions are shown in Appendix B.

Finally, after the recall task, Ss were asked to complete a questionnaire inquiring about strategies they may have used in the main task. The questionnaire specified five strategies for which Ss were to indicate whether or not they used them. The questionnaire is shown in Appendix C. The five basic strategies involved the possibility of: (1) Rehearsing the correct word, (2) making (verbal) associations to the correct word, (3) constructing a compound image of items in a VD pair, (4) constructing a single image of the correct word, and essentially ignoring the incorrect word, and (5) given a CV test pair, retrieving the study pair from a constituent in the CV test pair.

RESULTS AND DISCUSSION

The data consist of (1) number of correct responses in the main VD task, and (2) free recall data following the VD task. The data from the main VD task are analyzed in the first section. Primary and secondary hypotheses relating to VD performance are also discussed in this section. Secondary hypotheses relating VD performance to recall are presented in the second section.

The final three sections analyze and discuss results that are of somewhat less direct interest. The third section discusses the possible confounding of intrapair relatedness, defined in terms of the compound word relation, with intrapair associative relatedness. The fourth section provides a qualitative analysis of the results of the questionnaire given to subjects following the main VD and recall tasks. Finally, the fifth section analyzes recall performance *per se*.

VD Performance

A preliminary analysis of number correct responses was undertaken to assess possible effects of the List and Key counterbalancing variables. The data are analyzed in a five factor Pair Type (R and U) x Test Type (CC and CV) x Rate (slow, fast, and mixed) x List (1 and 2) x Key (standard and reverse) analysis of variance. All factors except Pair Type are between-subject variables. Test Trials are not included in this preliminary analysis, and the data are collapsed over trials 1, 2, and 3. Because the pattern of results for the main factors of interest in this analysis does not differ from the pattern of results for the second analysis, collapsed over List and Key, only the effects relating to the List and Key factors will be reported for this preliminary analysis.

There are no main effects for either List or Key, with $F(1, 96) < 1$ in both cases. The only significant interaction involving either of these variables is the Pair Type x Test Type x List interaction, $F(1, 576) = 7.54$, $p < .01$. A Newman-Kuels analysis, shown in Table 3, indicates that the interaction is primarily due to the significant differerence between R and U pairs for the CC condition in List 1, but not List 2, but the opposite relation for the CV test condition. That is, for the CV condition R pairs are superior to U pairs in List 2, but not List 1. It is not clear what this interaction means, and in the subsequent analysis the data are summed over the List and Key variables.

Table 3 Newman-Kuels Analysis of Pair Type (R and U) x Test Type (CC and CV) x List (1 and 2) Interaction.

U-CC 1	U-CV 2	U-CV 1	U-CC 2	R-CV 1	R-CC 2	R-CV 2	R-CC 1
12.36	12.42	12.57	12.76	12.92	13.30	13.36	13.70

Note: Mean correct pairs. Maximum score = 16. Any two means not on the same line are significantly different at $p < .01$.

Summing over List and Key, Table 4 indicates the mean and proportion correct for the major experimental conditions. Figure 2 plots the proportion correct for Pair and Test Type, by Test Trial, for the three Rate conditions. Overall, it appears that related (R) pairs are superior to unrelated (U) pairs, means 13.13 and 12.53, respectively, in all Rate and Test Type conditions. Descriptively, the data are somewhat difficult to assess for main effects of Test Type and Rate, or interactions, but overall, the re-pairing CV test condition does not appear to differ from the constant pairing CC condition, means 13.03 and 12.82, respectively. An interaction of Test Type with Rate is suggested in Figure 2 because the CC condition appears superior to the CV condition in the slow Rate condition, while the test conditions are comparable for both fast and mixed Rates. With respect to the study Rate manipulation, slow and mixed Rates appear comparable, with means 13.48 and 13.05, respectively, while both appear superior to the fast Rate condition, mean 12.32.

A four factor Pair Type x Test Trial x Test Type x Rate analysis of variance, shown in Table 5, confirms some of these observations. There are main effects for Pair Type, $F(1, 576) = 54.88$, $p < .001$, Test Trail, $F(2, 576) = 240.10$, $p < .001$, and Rate, $F(2, 114) = 6.42$, $p < .05$. There was no main effect of Test Type, $F(1, 114) < 1$, and no interactions.

Thus, as expected, related pairs were superior to unrelated pairs. Moreover, a Newman-Kuels analysis of the Rate condition indicates that the slow and mixed Rates do not differ, but both are superior to the fast Rate condition. However, the interaction of Test Type and Rate suggested in Figure 2 was not significant, with $F(2, 114) = 2.75$. Note that a separate analysis of this data comparing only the slow and fast Rates, and excluding the mixed Rate condition, also indicates no significant main effect of Test Type, and no interactions involving Rate.

Table 4 Mean Number and Proportion Correct[a] VD Performance for Related (R) and Unrelated (U) Pairs, Constant (CC) and Re-Pairing (CV) Test Type, Three Rates of Study Presentation, and Three Trials.

	Rate Study Presentation					
	Slow (4 sec)		Mixed[b]		Fast (2 sec)	
Pair Type	R	U	R	U	R	U
	Constant Study-Test Pairing (CC) Condition					
Test Trial						
1	13.00 (0.81)	11.80 (0.74)	11.70 (0.73)	10.45 (0.65)	11.15 (0.70)	9.85 (0.62)
2	15.40 (0.96)	13.95 (0.87)	13.25 (0.83)	12.60 (0.79)	12.95 (0.81)	11.65 (0.73)
3	15.45 (0.97)	14.80 (0.93)	14.90 (0.93)	14.35 (0.90)	13.70 (0.86)	13.55 (0.85)
Overall	14.62 (0.91)	13.52 (0.85)	13.28 (0.83)	12.47 (0.78)	12.60 (0.79)	11.68 (0.73)
	Constant Study-Re-Pairing Test (CV) Condition					
Test Trial						
1	11.75 (0.73)	11.35 (0.71)	12.15 (0.76)	11.20 (0.70)	11.10 (0.69)	11.00 (0.69)
2	13.60 (0.85)	12.35 (0.77)	13.75 (0.86)	13.20 (0.83)	13.05 (0.82)	12.30 (0.77)
3	14.55 (0.91)	13.80 (0.86)	14.50 (0.91)	14.55 (0.91)	13.80 (0.86)	12.70 (0.79)
Overall	13.30 (0.83)	12.50 (0.78)	13.47 (0.84)	12.98 (0.81)	12.65 (0.79)	12.00 (0.75)

Note: Maximum score = 16. Each entry represents observations for 20 Ss.
a. Proportion correct in parentheses.
b. See procedure (page 16).

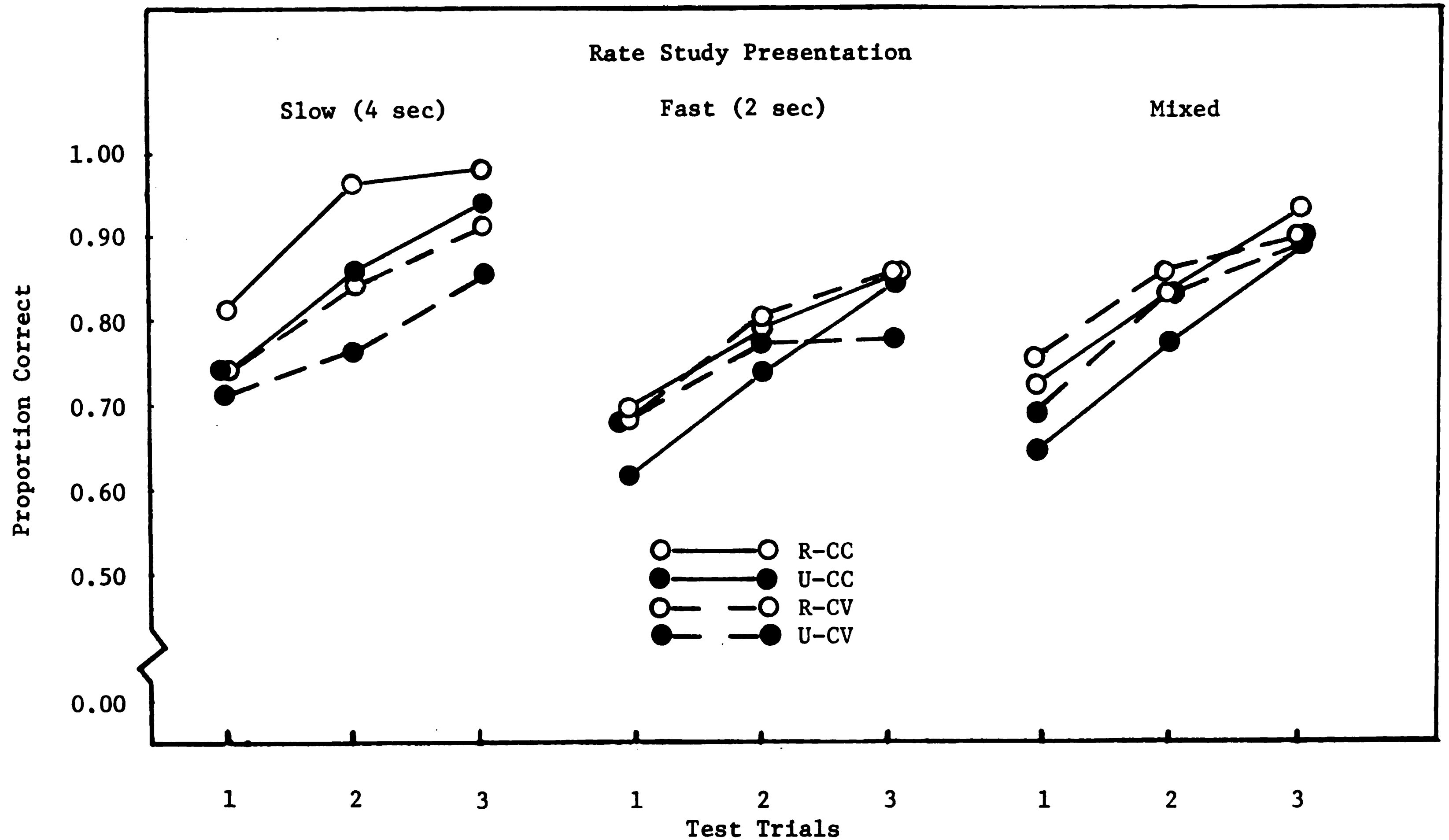

Figure 2 Proportion Correct VD Performance Over Three Trials for Related (R) and Unrelated (U) Pairs, Constant (CC) and Re-Pairing (CV) Test Type, and Three Rates of Study Presentation.

Table 5 Analysis of Variance for VD Performance.

Source	d.f.	SS	MS	F
Total	719	4359.64		
Between-Subject	119	2001.97		
Test Type (M)	1	8.02	8.02	0.53
Rate (R)	2	193.37	96.69	6.42 *
RM	2	83.02	41.51	2.75
Error Between	114	1717.56	15.07	
Within-Subject	600	2357.67		
Pair Type (P)	1	113.60	113.60	54.88 ***
Test Trial (T)	2	994.10	497.05	240.12 ***
PT	2	7.01	3.51	1.69
PM	1	4.05	4.05	1.96
PR	2	2.72	1.37	< 1
PMR	2	0.03	0.02	< 1
TM	2	10.12	5.06	2.44
TR	4	9.75	2.44	< 1
TMR	4	14.26	3.57	< 1
PTM	2	6.31	3.16	< 1
PTR	4	6.99	1.75	< 1
PTMR	4	8.64	2.16	< 1
Error Within	570	1180.09	2.07	

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

Summarizing, the compound words used as VD pairs were learned better than unrelated word pairs. Re-pairing study pairs on the test did not produce a decrement in performance, compared to the constant pairing test condition. Overall performance is reduced in the fast (2 second) presentation compared to both the slow (4 second) and mixed Rate conditions, which do not differ. How do these results relate to the primary and secondary hypotheses of this study?

Primary Predictions The model of VD performance developed in the introduction provided at least two primary predictions which were tested in the present study. First, it was predicted that R and U pairs would not differ in performance in test conditions where test pairs were not re-paired (i.e., the CC condition), but would differ when study pairs were re-paired on the test (i.e., the CV condition). That is, a Pair Type x Test Type interaction was predicted. This result would also amount to a replication of the pilot study (see page 4) on which the present study was based.

Further, it was assumed that the mediation of VD performance by extended retrieval (as hypothesized for the CV condition in the model) would be increased by degrading the encoding of correct/incorrect information during study. We predicted that increasing the study Rate of presentation would impair encoding, and would increase the likelihood of retrieval checks (facilitating performance) for fast as compared to slow Rate of study presentation. This prediction implies that the pair and test type interaction above would be greater for fast compared to slow study presentation. That is, a Pair Type x Test Type x Rate interaction was predicted, in which there would be a greater difference between R and U pairs (in the CV condition) for fast compared to slow study Rate.

No difference between R and U pairs was predicted in the CC test condition for either Rate.

The results reported are not consistent with either of these predictions. There were no interactions of the major independent variables, and therefore neither a replication of the earlier pilot results, nor a validation of the predicted triple interaction specific to this study. Apart from trials, the only significant main effects found were for Pair Type and Rate. Nothing in the results supports the primary hypotheses proposed in this study. What does emerge is that compound words used as VD pairs are easier to learn than pairs of unrelated words.

Secondary Predictions In order to interpret the predicted triple interaction of Pair and Test Type with Rate, it was necessary to determine whether the Rate manipulation would only affect VD encoding, and not the degree of relatedness for pairs that might arise from sheer exposure in the study and test trial presentations. Otherwise, one might argue that a greater difference between R and U pairs in the fast Rate was simply the result of the decreased exposure to pairs, between fast and slow Rates, affecting U pairs more than R pairs.

For this purpose, a third mixed (study) rate was introduced in which the correct word was designated about two seconds after the pair was presented. Thus, overall exposure was identical to the slow Rate (i.e., 4 seconds), while the "encoding time" was comparable to that of the fast rate. It was predicted that, for the first trial at least, performance in the mixed Rate would be no different from that of the fast Rate.

This prediction was also not supported. As already noted, mixed Rate was not different from the slow Rate, while both were superior to the fast Rate. There was no interaction of Rate with Test Trial. Thus we must conclude that simply presenting VD pairs facilitates performance even when the actual time to encode correct/incorrect information of items is comparable to that of the fast Rate, which does diminish performance. This result would have cast doubt on any explanation of the predicted triple interaction involving Pair and Test Type with Rate, but this point is moot. The result does suggest that some other means of inducing retrieval checks must be found, if the hypothesis merits further tests.

VD Performance and Redintegrative Memory

The next secondary hypothesis made in this study was that intrapair relatedness might be reflected in terms of the redintegrative properties of VD pairs, particularly as these properties might also provide a basis for the retrieval processes hypothesized to underly VD performance in some conditions. That is, the availability of retrieval checks in extended retrieval might be related to the extent to which VD pairs are recalled as wholes, or redintegrated, given any part (see page 6).

In order to assess the possibility that VD performance is related to the redintegrative (RM) properties of pairs, measures of RM are computed for each pair. These measures are then correlated with proportion correct performance for these pairs in the VD task.

The RM computation follows the definition of RM proposed by Horowitz and Manelis (1972). The RM value of a given pair is computed as the ratio of total number of words recalled in pairs (i.e., number of pairs x 2) to the total number of words recalled both singly and in pairs (i.e., number of pairs x 2 + number of single items). This proportion is intended to index the degree to which a given pair is recalled given that either constituent is recalled.

In order to obtain enough recall data, pair and item recall are collapsed over Key and Rate, but not Test Type or List. Thus, for each pair, RM measures are composed of recall data from 30 Ss. In addition, a third category of recall is included in this analysis. The actual recall of Ss consisted of pairs, single items, and pairs which contained items from different study pairs and/or intrusions from outside the VD list. Items in the latter pairs are regarded as additional single item recall data. This seems reasonable by the definition of redintegrative memory because the items in such pairs clearly did not provide retrieval of the original study pair, even though such items may have retrieved an item from some other pair.

Proportion correct for each pair is computed, summing across Ss in both the Key and Test Trial conditions. The maximum possible correct for a pair is therefore 30, and the score is averaged across the 10 Ss in the two Key conditions.

Correlations of the RM measure and average proportion correct are shown in Table 6 for Pair Type, Test Type, Rate, and List. For CV test pairs the RM measure used for a test pair was that corresponding to the study pair whose correct item appeared in that CV test pair.

The correlations can be interpreted in somewhat different ways, depending on whether correlations are computed for Pair Type or over all pairs. RM measures are probably a more representative measure of intrapair relatedness than the E defined classification of pairs as related or unrelated. Thus, the most accurate correlations of RM and VD performance involve the 12 overall correlations shown in Table 6, even though

Table 6 Correlations Between RM Measures and Average Number of Correct Responses[a] for Related (R) and Unrelated (U) Pairs, and Collapsed over Pair Type, for Constant (CC) and Re-Pairing (CV) Test Type[b], Three Rates of Study Presentation, and List 1 and 2.

	Rate Study Presentation					
	Slow (4 sec)		Mixed[c]		Fast (2 sec)	
Test Type	CC	CV	CC	CV	CC	CV
			List 1			
Pair Type						
R	.031	.201	.142	.124	.260	.070
U	- .277	.196	.018	.257	- .074	- .062
Overall	.487 ***	.227	.353 *	.261	.346 *	.053
			List 2			
Pair Type						
R	.251	.645 ***	.160	.349	.161	.523 *
U	.161	.420	.405	- .241	.357	.115
Overall	.300 *	.617 ***	.374 *	.139	.329 *	.498 ***

a. Proportion correct averaged over three trials and standard and reverse Key (range 0.00 to 3.0).
b. RM values used correspond to VD pair whose correct word was in the CV test pair.
c. See procedure (page 16).
* $p < .05$
** $p < .01$
*** $p < .005$

correlations broken down by Pair Type are also shown.

Correlations significant at the .05 level or better occur for pairs in the CC condition for all rates of study presentation, in both List 1 and 2. For pairs in the CV test conditions, correlations are only significant for the slow and fast study Rates in List 2, with no significant correlations for List 1.

It is clear that significant correlations of VD performance and RM properties can be found for both CC and CV test conditions, in all rates of study presentation. Significant correlations occur more consistently for CC pairs than CV pairs, although the two correlations for the CV pairs are larger (and more significant) than those for the CC pairs, with one exception (i.e., the List 1 CC pairs in the slow Rate).

Unfortunately, some of the correlations of RM properties and proportion correct are spurious is one takes into account the covariation of the RM measure with pair recall. In the present study, only the correlation of RM and proportion correct for the CC condition in List 1 (collapsed over Rate conditions) remains significant ($p < .005$) when covariation with pair recall is partialled out. In contrast, for the pilot data, (overall) correlations of RM and proportion correct remain significant for both CC and CV test conditions ($p < .05$) when covariation with pair recall is partialled out.

The partial correlations obviously weaken the hypothesis that the present, theoretically motivated, redintegrative measure is an independent, or superior, index of intrapair relatedness. However, it could still be argued that VD performance is related to intrapair relatedness if the latter is assumed to be also indexed by the probability of recalling VD pairs.

It had been predicted that the RM measures would produce a pattern of correlations with correct scores for those pairs, that would reflect the degree of mediation of VD performance by retrieval processes. The predictions were roughly that significant correlations would be found only for the CV conditions, and these would be most likely (or larger) for the fast Rate condition. The results reported, however, show no pattern of significant correlations consistent with the predictions.

The retrieval check hypothesis was intended to specify the role of intrapair relatedness in VD learning. The results of the correlation data, like the data for number correct, do not support this hypothesis because it does not predict a relation between RM properties and VD performance for pairs in the CC condition.

On the other hand, the correlations could have significance outside the perspective of the retrieval check hypothesis. The presence of significant correlations for both CC and CV test conditions, computed over all pairs, does suggest that intrapair relatedness has some relation to VD performance. It may be that there is another sense of retrieval, appropriate for both constant and re-pairing test conditions, that also involves intrapair relatedness of VD pairs. Alternatively, intrapair relatedness, reflected in RM properties--or availability in memory as indexed by likelihood of recall--may facilitate storage or encoding of VD information during study, and thus affect VD performance independently of testing conditions. These possibilities are developed further in the General Discussion.

Finally, it should be appreciated that for the correlations that remain significant when the effect of pair recall is partialled out, the RM measure does not necessarily reflect the overall availability of pairs in memory. Rather, the RM measure reflects the extent to which pairs are recalled as a whole given that either constituent is recalled. It is possible for pairs to differ in absolute level of recall while having identical RM values, although the high correlations of RM and pair recall suggest that this independence is not necessarily the case for the present data. Thus, the partial correlations suggest that redintegrative properties of words (related or unrelated by other criteria) are involved (to some extent) in VD performance, and not simply the sheer recallability (or availability) of pairs.

Intrapair Relatedness and Associative Relations

A third hypothesis of this study was that the relatedness effect predicted is the result of the compound word relation in R pairs, and not a result of intrapair associations. The general hypothesis that intrapair relatedness is more general than associative would be strengthened if no associations existed between constituents of the compound words used. In fact, associations do exist between the constituents of the compounds used in this study.

The model of VD performance proposed is neutral to the kind of intrapair relatedness, of course, but given the failure of the model, the relatedness effect remains the only interesting result of this study. The result would be of much less interest if the relatedness effect was simply the result of associative relatedness, because other studies have shown that associatively related word pairs are learned as well as, if not better than (in some conditions) unrelated word pairs (e.g., Barch & Whalen, 1970; Eberlein & Raskin, 1969; Kanak & Jones, 1974).

Apart from questioning the generality of the relatedness effect, the presence of intrapair associations in the compound words poses a serious problem for interpreting the relatedness effect. The difficulty can be seen by examining the way in which the VD list is constructed. The unrelated word pairs consisted of re-paired compound words. If intrapair associations exist for compound words, then the U pairs would correspond to a list consisting of an interpair manipulation of associatively related items. That is, the items in the VD pairs would have associations with items in other VD pairs of the list. There is some evidence that a VD list with interpair associations is harder to learn than one containing unrelated pairs with no intra- or interpair associations (e.g., Eberlein & Raskin, 1968; Fulkerson & Kausler, 1969), although the decrement has not always been found, for entirely comparable paradigms (e.g., Zimmerman, Shaunnessy, & Underwood, 1972; Mueller, Kanak, & Flannegan, 1973).

This suggests an alternative explanation for the relatedness effect. That is, the advantage for compound words may actually result from comparing a list of pairs with intrapair associations (i.e., R pairs) to a list of pairs exhibiting interpair associations (i.e., U pairs). It is possible that the former list would not differ from a list of truly unrelated pairs given that both intra- and interpair associations were controlled.

For the pilot study, we were not concerned with this possibility, even though we had not assessed the degree of associative relatedness for the compound word items. This was because the R and U pairs only differed for the CV condition, and not the CC condition. The CC condition appeared most comparable to tasks used to assess the effect of interpair associations (i.e., in maintaining constant study and test VD pairings), and thus the lack of a significant decrement suggested that this potential confounding was not an important factor. Unfortunately, in the present study, there is a consistent difference between R and U pairs across test conditions, and the alternative explanation for the superiority of R pairs cannot be rejected.

The presence of intrapair associations in the compounds was assessed in a free association task administered to 92 Ss from roughly the same population that participated in the VD task. The compound words were broken up and one constituent from each pair was presented in the first half of the list, the other constituent in the second half. Half the items were from the first position in the compound, half from the second. This order of single items was reversed for half the Ss. Standard free association instructions were given (shown in Appendix D).

The results indicated that about half the compound words have associations greater than about 1% (i.e., one response out of 92, when responses to both items are counted). In addition, items in other compounds were given as responses to an item. These would constitute interpair associations for both compound and unrelated word pairs. Multiple interpair associations do exist, often for both items of a VD pair.

The association data is summarized in Table 7, where the total number and proportion of total associations for intra- and interpair associations are shown for each group of R and U pairs, in List 1 and 2. The task may have biased syntagmatic responses similar to the compound word relation. Indeed, some Ss said that they noticed that some items in one part of the list formed meaningful combinations with items in other parts. Thus, the data are counted for only the order in which an item appeared before its compound word counterpart (i.e., in

Table 7 Summary of Association Data Indicating Absolute Number and Proportion of Total Associations[a] of Intra- and Interpair Associations for Related (R) and Unrelated (U) Pairs, and List 1 and 2.

	Pair Type	
	R	U
	List 1	
Associations		
Intrapair	111 (0.075)	0
Interpair	115 (0.078)	148 (0.101)
	List 2	
Associations		
Intrapair	60 (0.041)	0
Interpair	88 (0.060)	226 (0.154)

a. Data obtained from 92 Ss. Pairs in each cell = 16. Total number of possible associations in each cell is 1472 (= 32 stimulus items x 92 Ss x (1/2) non-priming order items).

contrast to a priming order in which the item would occur as a stimulus after its compound word counterpart had occurred as a stimulus). This partitioning of responses does not, of course, eliminate other orders of items that may have biased other kinds of responses to items.

The summary indicates that overall level of intra- and interpair associations for the four conditions was not necessarily high, with the highest proportion for a condition about 15% of the total possible responses. Neither List 1 or 2 pairs have a disportionate share of intra- or interpair associations. The number of interpair associations is greater for U pairs, as might be expected, although it is not clear whether this difference has any consequence for performance.

To interpret the relatedness effect in this study, we must, at the very least, determine whether (1) compounds with high intrapair associations are learned better than compounds without associative relatedness, and (2) pairs with low interpair associations are learned better than pairs with high interpair associations. A post-hoc analysis, provided by examining Table 7 in conjunction with Table 3, will permit some assessment of these comparisons.

Comparison (2) argues that U pairs with high interpair associations would be inferior to those with low associations. This is not consistent with the relative VD performance for these pairs, as indicated in Table 3. List 2 U pairs (with high interpair associations) are not inferior to List 1 U pairs, and, if anything, are actually learned better than List 1 pairs (at a non-significant level).

This comparison suggests that interpair associations are not an obvious factor in VD performance for this task, at least for the range of variation represented. One could argue, however, that the real question is whether the degree of interpair association in U pairs is sufficient to produce a decrement in performance relative to R pairs. The proportion of interpair associations for R pairs, averaged over List 1 and 2, is 0.069. This overall level is about half the 0.128 level for U pairs, averaged over List 1 and 2. Although the average level for R pairs is lower than that for U pairs, the difference between these average levels, or 0.059, is comparable to the difference of 0.053 between List 1 and 2 U pairs. Because this latter difference did not appear to affect VD performance (for U pairs), the comparable difference in level between R and U pairs, indicated in Table 7, may be equally irrelevant in accounting for the superiority of R over U pairs. This assumes that the effect of interpair associations is independent of the level of intrapair associations.

Comparison (1), involving the possible effect of intrapair associations for compound words, is harder to assess. One might expect that List 1 R pairs would be superior to List 2 pairs, because the former exhibit about twice the level of intrapair associations. In fact, Table 3 indicates that R pairs do not differ significantly between List or Test Type conditions. At a non-significant level, List 1 pairs are superior to List 2 pairs, but only for the CC test condition, not the CV condition.

There is little that can be said beyond this rough post-hoc analysis. Further analysis, defining, for example, intra- and interpair association as within-subject variables in an analysis of variance, would only make sense for pairs in the CC condition. In the CV condition, items from different pairs are paired, and there is no control over whether items come from pairs with comparable levels of intra- or interpair association. That is, it would not be possible to consistently classify VD pairs except for pairs in the CC condition. Moreover, even for these CC pairs, the number of associations that would constitute high or low intra- or interpair association vary widely between List and Pair Type. What is required is to define level of intra- and interpair association as independent variables in a more carefully controlled experiment.

Summarizing, there is no obvious evidence that either intra- or interpair associations have influenced VD performance in this study. This conclusion is obviously limited by the qualitative, post-hoc character of our analysis of this possible relation. Until a more carefully controlled experiment is performed, we cannot be entirely certain that the relatedness effect is independent of possible effects of associative relatedness.

Questionnaire

The questionnaire data is only analyzed qualitatively, because the questions asked did not provide for consistent, unambiguous responses (i.e., Ss wrote out responses subject to their own constraints), and the data are somewhat fragmentary (i.e., not all Ss responded to all questions). Rather, we have simply counted the number of Ss who responded to each question with one of five possible response categories, as determined by Es evaluation of their written protocol. These categories included yes, No, Sometimes, No Response, and Uninterpretable, all pertaining to whether or not a S reported using a particular strategy.

Strategies 1 through 4 queried the way Ss studied VD pairs. Summing over Rate and Test Type, and ignoring combinations of strategies, the results indicate that overall, 91% (or 109 Ss) claimed to use a simple rehearsal strategy, 39% (or 47 Ss) claimed to use some kind of verbal association to constituents in VD pairs, 56% (67 Ss) reported producing a compound image involving both constituents of the compound word (of whom 67% or 45 Ss also reported "marking" the C word in some way), and 65% (or 78 Ss) reported producing a single image of the C word, while essentially ignoring the I word.

A somewhat finer analysis can be carried out by examining combinations of strategies. In general, all Ss except one reported using more than one strategy in the study phase of the VD task. Thus, the data can be analyzed in terms of the conditional percentage of Ss using a strategy (or strategies) given that some other strategy was used. Only six of the more salient possible combinations are examined.

For example, summing over Rate and Test Type, 35% (or 42 Ss) reported both rehearsing and producing verbal associations in studying VD pairs. Of these, 4% (or only 5 Ss) combined these two verbal strategies without using imaginal strategies 3 or 4 (with one S not classifiable), while 30% (or 36 Ss) also reported using imaginal strategies.

With respect to imaginal strategies, only a selection of the possible combinations with verbal strategy 1 (i.e., rehearsal) are examined. For example, 30% (or 36 Ss) reported producing compound images (strategy 3) and rehearsing the C word, without also producing single images (strategy 4). In contrast, 29% (or 35 Ss) reported both producing single images of and rehearsing the C word, without making compound images. All three strategies were used by 32% (or 38 Ss), presumably either in combination or for different pairs). Finally, only 3% (or 4 Ss) reported using an imaginal strategy without using a verbal strategy in addition.

Strategy 5 is a retrieval strategy corresponding to that hypothesized in this study. The only comparison of interest for this strategy is that for the Test Type conditions. Summing over Rate conditions, 60% (or 36 Ss) in the CV test condition reported using this strategy during the test phase of the VD task, at least to some extent, as compared to only 15% (or 9 Ss) in the CC test condition.

It should be noted that the 60 Ss in the CV condition can be roughly divided into those who used strategy 5, and those who did not report using this strategy. It might be expected that Ss who used the retrieval strategy would exhibit a larger relatedness effect than those who did not. However, a post-hoc analysis of VD performance for these two groups revealed no significant main effect of strategy, and no interactions with Pair Type or Test Trial.

Recall Performance

The results for the free recall data involve recall of VD pairs and single item recall. No specific predictions were made for the recall data, and the following analysis is presented only for completeness.

For pair recall, absolute and mean number of pairs recalled are shown in Table 8. Mean recall for related pairs is superior to that of unrelated pairs, with mean recall of 7.66 and 4.21, respectively, out of a maximum score of 16 pairs in each condition. More pairs are recalled in the CC condition, mean 13.12, than in the CV condition, mean 10.62. With respect to the three Rate conditions, recall in the slow and mixed Rates appears comparable, means 6.55 and 6.11, respectively, while both appear superior to recall in the fast Rate, mean 5.14.

A four factor Pair Type x Test Type x Rate x List analysis of variance, shown in Table 9, was carried out for number of pairs recalled. The only within-subject variable is Pair Type. The Key variable is not included in the analysis of either pair or single item recall.

The analysis of variance essentially confirms the observations above. Main effects are significant for Pair Type, $F(1, 119) = 97.14$, $p < .001$, Test Type, $F(1, 108) = 7.83$, $p < .001$, and Rate, $F(2, 108) = 3.50$, $p < .05$. There is no main effect for List, and no interactions are

Table 8 Number of Pairs and Mean Pair Recall[a] for Related (R) and Unrelated (U) Pairs, Constant (CC) and Re-Pairing (CV) Test Type, and Three Rates of Study Presentation.[b]

	Rate Study Presentation					
	Slow (4 sec)		Mixed[c]		Fast (2 sec)	
Pair Type	R	U	R	U	R	U
Test Type						
CC	175 (8.75)	129 (6.45)	156 (7.80)	99 (4.95)	153 (7.65)	75 (3.75)
CV	151 (7.55)	69 (3.45)	159 (7.95)	75 (3.75)	125 (6.25)	58 (2.90)
Overall	326 (8.15)	198 (4.95)	315 (7.88)	174 (4.35)	278 (6.95)	133 (3.33)

Note: Maximum possible recall = 16 pairs. Each entry represents recall of 20 Ss.
a. Mean pair recall in parentheses.
b. Data collapsed over List (1 and 2) variable.
c. See procedure (page 16).

Table 9 Analysis of Variance for Pair Recall.

Source	d.f.	SS	MS	F
Total	239	3156.93		
Between-Subject	119	1517.93		
Test Type (M)	1	93.75	93.75	7.83 **
Rate (R)	2	83.66	41.83	3.50 *
List (L)	1	5.40	5.40	< 1
MR	2	25.28	12.64	1.06
ML	1	4.82	4.82	< 1
RL	2	2.78	1.39	< 1
MRL	2	9.66	4.83	< 1
Error Between	108	1292.60	11.97	
Within-Subject	131	1639.00		
Pair (P)	1	714.15	714.15	97.14 **
PM	1	11.27	11.27	1.53
PR	2	1.98	0.99	< 1
PL	1	8.82	8.82	1.06
PMR	2	15.56	7.78	1.06
PML	1	2.40	2.40	< 1
PRL	2	5.66	5.66	< 1
PMRL	2	4.57	2.29	< 1
Error Within	119	874.60	7.35	

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

significant. As expected, related pairs are recalled better than unrelated pairs, and overall recall is higher in the constant study and test pairing condition, than in the re-pairing test condition. A Newman-Kuels analysis of the Rate condition, however, indicates that recall in the slow and mixed Rate, and mixed and fast Rate comparisons does not differ, but recall in the slow Rate is superior to that in the fast Rate condition.

The analysis of single item (constituent) recall is more complicated than that for pair recall. First, for single item recall, constituents from study pairs could be classified by VD code (or function) as either correct or incorrect items. Thus, an additional factor is included in the analysis, designated <u>Code</u>.

A further complication derives from the fact that single item recall is not necessarily independent from either pair recall, or recall of constituents in combination with constituents from other pairs, that is, in combination with "intrusions." Rather than analyze simple single item recall, a composite measure of recall was considered more appropriate. This composite measure was computed by summing, for each Pair Type and Code combination, the total number of items recalled singly, in pairs, and paired with "intrusion" items from other study pairs in the list.

Absolute and mean number of composite single items recalled is shown in Table 10. Mean composite recall is 8.60 for related word pairs, which is superior to mean recall of 7.07 for unrelated pairs. Correct words are recalled better than incorrect words, mean recall 8.29 and 7.38, respectively. The effects of Test Type and Rate are somewhat harder to assess, but overall recall appears comparable for the CC and CV test conditions, mean recall 7.82 and 7.85, respectively. Recall in the slow and mixed Rates appears comparable, means 8.38 and 8.01, respectively, while both conditions appear superior to the fast Rate, mean recall 7.12.

Table 10 Total and Mean[a] Number of Composite[b] Single Items Recalled for Correct (C) and Incorrect (I) Items, Related (R) and Unrelated (U) Pairs, Constant (CC) and Re-Pairing (CV) Test Type, and Three Rates of Study Presentation.[c]

	Rate Study Presentation					
	Slow (4 sec)		Mixed[d]		Fast (2 sec)	
Pair Type	R	U	R	U	R	U
Constant Study-Test Pairing (CC) Condition						
VD Code						
C	183 (9.15	182 (9.10)	172 (8.60)	149 (7.45)	162 (8.10)	136 (6.80)
I	178 (8.90)	160 (8.00)	167 (8.35)	124 (6.20)	158 (7.90)	106 (5.30)
Overall	361 (18.06)	342 (17.10)	339 (16.96)	273 (13.66)	320 (16.00)	242 (12.10)
Constant Study-Re-Pairing Test (CV) Condition						
VD Code						
C	181 (9.05)	159 (7.95)	190 (9.50)	167 (8.35)	174 (8.70)	135 (6.75)
I	168 (8.40)	129 (6.45)	178 (8.90)	135 (6.75)	153 (7.65)	115 (5.75)
Overall	349 (17.40)	288 (14.40)	368 (18.40)	302 (15.10)	327 (16.34)	250 (12.50)

Note: Maximum total recall = 640 items. Maximum mean recall = 32 items. Each entry averages recall of 20 Ss.
a. Mean recall in parentheses.
b. See page 49 for a definition of this measure.
c. Data collapsed over the List (1 and 2) variable.
d. See procedure (page 16).

Table 11 Analysis of Variance for Composite Single Item Recall.

Source	d.f.	SS	MS	F
Total	479	3904.00		
Between-Subjects	119	2222.75		
Test Type (M)	1	0.10	0.10	< 1
Rate (R)	2	133.78	66.89	3.58 *
List (L)	1	1.30	1.30	< 1
MR	2	49.56	24.78	1.33
ML	1	3.17	3.17	< 1
RL	2	3.21	1.60	< 1
MRL	2	15.31	7.66	< 1
Error Between	108	2016.33	18.67	
Within-Subjects	360	1681.25		
Pair (P)	1	280.60	280.60	75.19 **
Code (C)	1	99.92	99.92	26.77 **
PC	1	20.42	20.42	5.47 *
PM	1	3.50	3.50	< 1
PR	2	18.46	9.23	2.47
PL	1	0.25	0.25	< 1
PMR	2	7.53	3.76	1.01
PML	1	1.75	1.75	< 1
PRL	2	2.03	1.01	< 1
PMRL	2	2.21	1.10	< 1
CM	1	2.85	2.85	< 1
CR	2	0.09	0.04	< 1
CL	1	0.92	0.92	< 1

Table 11 (Continued)

Source	d.f.	SS	MS	F
CMR	2	0.28	0.14	< 1
CML	1	2.55	2.55	< 1
CRL	2	12.01	6.01	1.61
CMRL	2	6.91	3.45	< 1
PCM	1	1.52	1.52	< 1
PCR	2	0.71	0.36	< 1
PCL	1	0.10	0.10	< 1
PCMR	2	3.04	1.52	< 1
PCML	1	2.00	2.00	< 1
PCRL	2	0.66	0.33	< 1
PCMRL	2	1.78	0.89	< 1
Error Within	324	1209.18	3.73	

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

The composite recall measure was analyzed as a five factor Pair Type x Code x Test Type x Rate x List analysis of variance, shown in Table 11. Pair Type and Code are within-subject variables.

The analysis of variance roughly confirms the observations above. Main effects are significant for Pair Type, $F(1, 324) = 75.19$, $p < .01$, Code, $F(1, 347) = 26.77$, $p < .01$, and Rate, $F(2, 108) = 3.58$, $p < .05$. There is no main effect of Test Type, $F(1, 108) < 1$. The only significant interaction is that of Pair Type and Code, $F(1, 324) = 5.47$, $p < .05$.

Thus, as expected, items from related pairs were recalled better than items from unrelated pairs. There was no difference in recall for the Test Type conditions. However, a Newman-Kuels analysis of the Rate condition indicates that mean recall did not differ for either the slow and mixed Rate, or mixed and fast Rate comparisons, but recall was superior in the slow compared to fast Rate condition.

A Newman-Kuels analysis of the Pair Type and Code interaction, shown in Table 12, indicates that there is a significant difference ($p < .01$) between correct and incorrect item recall for unrelated pairs, means 7.73 and 6.41, respectively, but not for related pairs, means 8.85 and 8.35, respectively. At $p < .05$ all means differ significantly.

Table 12 Newman-Kuels Analysis of Pair Type (R and U) x Code (Correct-C and Incorrect-I) Interaction.

U-I	U-C	R-I	R-C
6.41	7.73	8.35	8.85

Note: Mean composite single item recall. Any two means not on the same line are significantly different at $p < .01$.

These results differ somewhat from an analysis of pair and composite single item recall carried out for the pilot study. A two factor Pair Type x Test Type analysis of variance for the total number of pairs recalled indicates only a main effect for Pair Type, $F(1, 78) = 206.47$, $p < .001$, with related pairs recalled better than unrelated pairs, mean recall 7.94 and 3.36, respectively. Unlike the main experiment, there was no main effect of Test Type on pair recall.

The composite single item recall data for the pilot was analyzed in a three factor Pair Type x Code x Test Type analysis of variance. The analysis indicated significant effects for Pair Type, $F(1, 234) = 151.43$, $p < .001$, Code, $F(1, 234) = 18.74$, $p < .001$, and the Pair Type x Test Type interaction, $F(1, 234) = 3.92$, $p < .05$.

A Newman-Kuels analysis of the interaction indicated that items from related pairs in the CC condition were recalled better than items from related pairs in the CV condition, mean recall 9.19 and 8.60, respectively. Both conditions resulted in superior recall compared to items from unrelated pairs in both CC and CV conditions, 6.30 and 6.51, respectively. The unrelated pairs did not differ according to Test Type.

The main effects for the composite single item recall measure are consistent with the results of the main experiment. However, for the latter, the interaction of Pair and Test Type was <u>not</u> significant, while the interaction of Pair Type and Code was significant. In contrast, for the pilot data, the Pair Type and Code interaction was <u>not</u> significant, while the interaction of Pair and Test Type was significant. It is not clear how to account for this difference between experiments.

GENERAL DISCUSSION

The discussion is divided into two parts. The first part attempts to interpret the failure of the results to support the hypotheses. The second part will discuss the possible significance of the relatedness effect in VD performance.

Interpretation of Results

The major predictions of this study were that compound words would be learned better than unrelated word pairs in test conditions that re-paired study pairs, but not for test conditions where study pairs were not re-paired. This relatedness effect was hypothesized to be greater for a fast study Rate of presentation than for a slow Rate. As already discussed, these predictions were not at all supported by the data.

It is not clear how to account for the complete failure of the major predictions. At the very least, it was expected that the pilot study would be replicated. The effect of the Rate manipulation, and the possible superiority of R pairs in the CV compared to CC test conditions, would have been interesting extensions, but depended on assumptions that may have been less justified than those underlying the interpretation of the Pair and Test Type interaction found in the pilot study. However, this latter result was central to the model of VD performance proposed here. The following discussion is necessarily speculative, but will provide some perspective on the results obtained, and will suggest some concrete directions for future research.

First, one could argue that the pilot results are a product of chance variation, even though the pilot data involving compound words was also consistent with results of the Barch and Whalen (1970) study using associatively related and unrelated word pairs. In this case, we have only shown that compound words are easier to learn in a VD task than unrelated word pairs. This relatedness effect may have some significance, as we will consider in the next section.

However, rather than immediately rejecting the model proposed in this study, we might consider possible methodological differences between it and the pilot on which it is based. Both studies were similar in using essentially the same pairs, instructions, and overall procedure. In both cases the VD task was preceded by familiarization, in which all pairs were aurally presented to _Ss_, with R and U pairs blocked, and instructions that emphasized the presence of two types of pairs. The only obvious difference was that in the present study, _Ss_ not only heard pairs, but read them simultaneously from a typed list in the familiarization stage.

Familiarization in both studies was used to insure that all words in the VD pairs could be recognized, and/or that difficulties in hearing words could not be considered a source of impairment for U pairs compared to R pairs (for which the meaningful relation between constituents might aid recognition or perception). The literature on familiarization typically deals with the effect of familiarization in establishing frequency differences between correct and incorrect items prior to the VD task proper. Such manipulations have been motivated by the frequency theory of VD performance, and the data are generally supportive of the theory (e.g., Eckert & Kanak, 1974; page 585). However, neither frequency theory, nor the present study, suggests any particular effect of familiarization on possible, more global strategies in the performance of _Ss_. Nonetheless, one might argue that providing all pairs, both aurally and visually, with blocking and emphasis on the difference between R and U pairs, might have led _Ss_ to treat pairs differently in this study, compared to the original pilot study.

Even granting that this is a plausible argument, data from a follow-up study provides no support for it. This study essentially repeated the main study for the slow Rate condition, and List 1 pairs. The manipulation of interest was the familiarization preceding the main VD task. In a within-subject manipulation, _Ss_ heard half the R and U pairs in a familiarization procedure identical to that of the main experiment, with pairs presented both aurally and typed in a list. The other half of the R and U pairs were not presented prior to the VD task. Seventy-two _Ss_ from the same population as the main experiment were run in small groups in laboratory setting.

The results, with mean and proportion correct shown in Table 13, essentially replicate those of the main study. The analysis of variance for number correct, shown in Table 14, indicates a main effect for Pair Type, $F(1, 773) = 34.28$, $p < .01$, and Familiarization, $F(1, 773) = 5.31$, $p < .05$. There was no main effect for Test Type, $F(1, 70) < 1$. The only significant interaction was that of Test Trial and Familiarization, $F(2, 773) = 3.15$, $p < .05$. A Newman-Kuels analysis, shown in Table 15, indicates that familiarized pairs are only superior to unfamiliarized pairs on the first trial, but that performance does not differ on the second and third trials.

Thus, R pairs were again superior to U pairs. None of the interactions predicted for the main study, involving the Pair Type, Test Type, or Rate variables, were significant, although the Pair Type x Test Type

Table 13 Mean Number and Proportion Correct[a] VD Performance for Related (R) and Unrelated (U) Pairs, Constant (CC) and Re-Pairing (CV) Test Type, Presence (F) and Absence (NF) Familiarization, and Three Trials.

	Familiarization			
	F		NF	
Pair Type	R	U	R	U
	Constant Study-Test Pairing (CC) Condition			
Test Trial				
1	6.19 (0.77)	6.11 (0.76)	5.72 (0.72)	5.47 (0.68)
2	6.94 (0.87)	6.86 (0.86)	7.03 (0.88)	6.56 (0.82)
3	7.39 (0.92)	7.14 (0.89)	7.39 (0.92)	7.03 (0.88)
Overall	6.84 (0.86)	6.70 (0.84)	6.72 (0.84)	6.35 (0.79)
	Constant Study-Re-Pairing (CV) Test Condition			
Test Trial				
1	6.33 (0.79)	5.64 (0.71)	5.94 (0.74)	5.56 (0.69)
2	6.97 (0.87)	6.22 (0.78)	6.83 (0.85)	6.08 (0.76)
3	7.08 (0.89)	6.89 (0.86)	7.28 (0.91)	6.94 (0.87)
Overall	6.80 (0.85)	6.25 (0.78)	6.69 (0.84)	6.19 (0.77)

Note: Maximum score = 8. Each entry represents observations of 36 Ss.
a. Proportion correct in parentheses.

Table 14 Analysis of Variance for Follow-Up Study.

Source	d.f.	SS	MS	F
Total	863	1762.12		
Between-Subjects	71	623.94		
Test Type (M)	1	6.34	6.34	< 1
Error Between	70	617.60	8.82	
Within-Subjects	793	1144.52		
Pair (P)	1	31.90	31.90	29.43 ***
Familiarization (F)	1	5.68	5.68	5.68 *
Trial (T)	2	238.83	119.41	110.16 ***
PF	1	0.37	0.37	< 1
PT	2	1.99	0.99	< 1
FT	2	6.82	3.41	3.15 *
MP	1	3.83	3.83	3.53
MF	1	1.34	1.34	< 1
MT	2	3.54	1.77	< 1
MPF	1	1.11	1.11	< 1
MPT	2	2.75	1.38	< 1
MFT	2	1.10	0.55	< 1
MPFT	2	1.26	0.63	< 1
Error Within	773	837.69	1.08	

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

Table 15 Newman-Kuels Analysis of the Familiarization (F and NF) x Test Trial (1, 2, and 3) Interaction.

NF-1	F-1	NF-2	F-2	F-3	NF-3
5.67	6.07	6.63	6.75	7.13	7.16

Note: Mean correct pairs. Maximum score = 8. Any two means not on the same line are significantly different at $p < .05$.

interaction was marginally significant, $F(1, 773) = 3.53$, $p < .10$. Providing exposure to VD pairs prior to the VD task facilitates performance, at least initially. However, this facilitation affects all pairs, without interacting with Pair or Test Type. Therefore, the failure to replicate the pilot study in the present study cannot be attributed to the particular kind of familiarization used.

An alternative explanation is that emphasizing the difference between R and U pairs in a mixed list led Ss to focus on R pairs more than on U pairs in all test conditions. This is obviously not a strong argument without specifying what "differential focus" might mean, and in light of the lack of evidence for any difference between R and U pairs in the CC condition for the pilot. However, a number of investigators have reported differences in performance for particular manipulations, depending on whether the comparison was between- or within-subject.

For example, Kausler and Boka (1969) found a correlation between the degree of pairwise association acquired by double-function pairs and VD performance in an unmixed list, but not in a mixed list of double- and single-function pairs. Similarly, Bruder and Silverman (1972) found that VD pairs of unrelated words and homophones were superior to pairs of synonyms, in an unmixed list, but the reverse relation in a mixed list design (Experiment III), as well as an interaction of these differences with study rate in mixed, but not unmixed conditions.

Thus, it may not be unreasonable to consider the possibility that a within-subject comparison of R and U pairs in the present study might have increased the likelihood of some kind of differential processing of R and U pairs. This could have obscured the interaction of Pair and Test Type predicted on the basis of the pilot study. The obvious test is to use unmixed lists for the R and U Pair Type comparison.

A related possibility is that the retrieval check strategy is only one of several strategies Ss use. The effect on performance of a specific retrieval check strategy may be diminished if other strategies were used by Ss. Battig (1975) has recently provided evidence and argued for the importance of studying not only differences in strategies used by different Ss in various verbal learning tasks (including VD learning), but also the importance of considering variability of strategies for the same subject within a given task.

Different strategies do not necessarily imply different kinds of performance. However, the retrieval check strategy does predict a specific pattern of performance. The possibility that different strategies may be used by different Ss and/or evolve inconsistently for a given subject through the task, does argue for a study with more control over Ss performance. For example, one could either specify or induce Ss to use a strategy that involved retrieving study pairs from the constituents of (CV) test pairs. Certainly the questionnaire results, however limited their validity, are consistent with Battig's observations regarding variability of strategies, and with the possibility that the effects of a specific retrieval strategy could be obscured in the present data.

For the present, we will have to conclude that if the retrieval check hypothesis is tenable, this study has not been able to establish the conditions conducive to it. The preceding discussion has been useful in suggesting some further experimentation dealing with these questions. We will now discuss the significance of the main result of this study--namely, the superiority of related over unrelated word pairs, or relatedness effect.

Significance of Relatedness Effect and Conclusions

Given that the superiority of compound words over unrelated word pairs is not confounded with associative relatedness, what would be the significance of this relatedness effect? First, it might call into question recent conclusions that intrapair relatedness is essentially irrelevant in VD learning (e.g., Postman, 1975; Zimmerman, et al., 1972), and reinforce theories that hypothesize more complicated processes than frequency discriminations (e.g., Kausler, 1974a, 1974b). Second, any account of the effect would seem to be consistent with recent attempts to theoretically establish continuity of processes in VD learning and recognition memory (e.g., Kausler, 1974b).

With respect to the first issue, we had originally hypothesized that intrapair relatedness (associative or otherwise) would only be relevant to VD performance under certain conditions. In the present study, these referred to test conditions that re-paired study pairs on the test. In the simpler constant pairing CC condition, no difference in performance as a function of intrapair relatedness was predicted.

In the case of associative relatedness, this hypothesis was consistent with a number of studies that have found no decrement or superiority of associatively related versus unrelated word pairs (e.g., Zimmerman, et al., 1972; Barch et al., 1970, for the CC condition). These studies have led several investigators to conclude that intrapair associations have no clear role in VD learning, at least in the typical VD paradigm (i.e., corresponding to the CC study-test condition). That is, in general, one did not need to hypothesize additional components involving intrapair associations in VD learning (e.g., Postman, 1975).

In more complicated tasks, where frequency discriminations are more difficult or unavailable, other mechanisms might become important. Here intrapair associations have been assigned a possible role. The double-function list Kausler and Boka (1969) used is one example of a task where associative relatedness may mediate VD performance when frequency discriminations are inadequate (see page 8). The CV re-pairing test condition in this study (or in Barch et al., 1970) can also be considered another example (if the constant pairing CC condition is regarded as "standard" procedure). That is, the effect of intrapair relatedness has been regarded as a compensatory process that does not necessarily result in performance differences except where simpler frequency discriminations are more difficult to use.

The use of compound words in this study was intended to increase the generality of this relatedness effect. Moreover, the results of the initial pilot reported earlier suggested that the conclusions regarding intrapair associations cited above were equally true for the case of compound word relatedness. Therefore, we essentially concurred with Postman (1975) and Underwood (e.g., Zimmerman, et al., 1972), but hypothesized that their conclusion regarding the irrelevance of intrapair associations in VD learning was limited to typical VD paradigms that did not re-pair study pairs on the test, or which did not otherwise diminish the effectiveness of frequency of occurrence discriminations. In somewhat more complex paradigms, we believed that we had found a role for intrapair relatedness that was consistent with conclusions for the typical study-test conditions, and which would also accomodate forms of relatedness other than associative.

In this context, the present relatedness effect would, at the very least, qualify our previous conclusion about the case of non-associative compound word relatedness (if not also associative relatedness), because related words appear to be learned better than unrelated words, in all test conditions. This would be interesting from the perspective of the frequency theory because it requires some explanation of why frequency discriminations are easier in related as compared to unrelated pairs.

Recall that frequency theory originally predicted a decrement in VD performance for associatively related pairs used as VD pairs, because implicit associative responses (IARs) would interfere with the accrual of a frequency differential between items. The consistent finding of a lack of a decrement for such pairs (compared to unrelated pairs) led to a rejection of the IAR hypothesis in VD learning, but the frequency theory did not propose a facilitating mechanism for associative relatedness. The present relatedness effect (for compound words) would seem to require such a mechanism.

The hypothesis proposed in this study, based on the tag-and-collapse model proposed by Barch et al. (1967, 1970), did provide a specific mechanism, extended retrieval, for the facilitation of VD performance for related word pairs, at least under conditions that might be expected to make frequency discriminations more difficult, and/or processes of extended retrieval available (by the definition of extended retrieval proposed in the model).

It should be noted that in the model proposed earlier, minimal retrieval need not be equivalent for related and unrelated pairs, even in the constant pairing test condition. It is possible that even minimal retrieval is facilitated for related as opposed to unrelated pairs. This hypothesis was not made because it did not seem necessary to complicate the model of VD developed, and the simpler hypothesis was consistent with preliminary pilot data. However, even if the relatedness effect occurs for both CC and CV test conditions, the interaction of Pair and Test Type would still be a prediction deriving from the model.

Given that the relatedness effect for compound words would have to be granted a more general role in theories of VD performance, what kind of explanation is possible for the effect? Recent theories of VD learning, and extensions of frequency theory, are suggestive.

Wallace (1972), for example, has proposed that the accrual of a frequency differential between items in VD pairs may not be a simple function of the nominal presentation or rehearsal of items, but may, in part, be a function of the relatedness of items in pairs. In particular, he has argued that frequency accruals within pairs may be yoked such that the absolute level of frequency accruals may differ across pairs, for the same input conditions. Alternatively, frequency differentials may accrue more rapidly and/or consistently for associatively related compared to unrelated word pairs.

Wallace proposed this extension of frequency theory to account for the decrement observed in VD learning when pairs are re-paired at some point in acquisition (e.g., Kanak & Dean, 1969). Our interest in the extension lies in the suggestion, consistent with the tag-and-collapse model, that the encoding of items in related pairs may be more stable over presentations, providing easier access to frequency information (or "tags" differentiating correct and incorrect words) during testing.

Kausler (1974b) has also developed an extension of frequency theory that elaborates on this possibility. As already noted (page 8), Kausler proposes that subjects can selectively encode features of words in VD pairs, and that items in VD pairs can form a functional unit which may mediate VD performance. These extensions suggest that the formation of a functional unit provides a relational context for items, which can both determine how information about items is encoded (i.e., what features will accrue frequency cues or be "tagged" as correct or not), and/or facilitate the consistency of this encoding as well as its retrieval during testing.

This account could be consistent with either the results predicted in this study, or with the results actually obtained. With respect to the latter, one would expect that it would be more difficult to consistently encode, hence retrieve, information regarding the correct/incorrect coding of items for unrelated word pairs compared to related word pairs. This would explain the relatedness effect.

Alternatively, one might also expect that this effect would increase for test conditions that re-paired study pairs, because the re-pairing would result in greater disruption of the relational context for unrelated pairs than for related pairs. That is, the Pair and Test Type interaction predicted in this study would also seem to follow from Kausler's account. It is not clear from this prediction why there is not an overall decrement for the CV test condition compared to the CC condition in this study. But without specifying the properties of the functional unit, or how it specifically mediates VD performance, this question may not be resolvable.

It should be noted that the correlation results obtained may also be consistent with the concept of a functional unit, and its facilitation of VD learning. That is, if RM properties (or the availability of pairs in memory, as assessed by free recall) reflects the capacity to form a unit during the study stage of VD learning, and/or the ability to exploit this unit during the test stage, then one would expect a positive covariation between RM properties (or recall) and VD performance. As already noted, this relation holds for both constant and re-pairing test conditions.

Two more points before concluding. First, the discussion above would apply equally well for the original tag-and-collapse model proposed by Barch et al. (1967, 1970). This parallel has been noted before (page 9), and we will not dwell on it further, except to note that the failure of the extension proposed here, involving the concept of retrieval check, does not diminish the tag-and-collapse model. It does, of course, leave open the question of exactly what processes underly the facilitative effect of intrapair relatedness in VD learning.

The last point is that the lack of a decrement for the re-pairing (CV) test, compared to the constant pairing (CC) test, might be considered surprising given that some studies have reported a re-pairing decrement (e.g., Kanak & Dean, 1969; Zimmerman et al., 1972; Wallace, 1972; Wallace & Nappe, 1970; Wallace, Murphy, & Ludwig, 1975). However, these studies differ in methodology from the study-test procedure, and the CV condition we have used, therefore limiting comparisons.

For example, all the studies use the anticipation method (as well as unrelated word pairs). It is possible that this procedure does not facilitate the formation of a functional unit in the same way as the study-test procedure. Also, in most cases re-pairing occurs after some point in acquisition (e.g., Kanak et al., 1969; Wallace, 1972; Wallace et al., 1970, 1975). This manipulation may impose difficulties on the subject that are not found in our CV procedure. Where re-pairing has been carried out throughout trials, the decrement only occurred when Ss were not informed of the re-pairing manipulation (Zimmerman et al., 1972). Finally, not all studies report a re-pairing decrement (e.g., Ullrich, 1972). This discussion suggests that the lack of a re-pairing decrement found in this study does not necessarily imply that it is anomalous in this respect.

Conclusion In general, it would appear that considerations of encoding and retrieval, consistent with those hypothesized in recognition memory performance, may be necessary to account for VD learning. This possibility is certainly developed by Kausler (1974b), and was a major consideration in this study. We hypothesized a continuity of processes between VD learning and recognition memory in terms of current memory search interpretations of retrieval processes in certain recognition memory tasks (e.g., Atkinson et al., 1974; Mandler, 1972), rather than focusing on issues of context effects and encoding specificity in recognition memory. The failure of the hypothesis based on these considerations to be supported in this study casts some doubt on this particular form of potential continuity.[4]

These considerations depend, of course, on establishing the actuality of the relatedness effect. To this end, we have discussed a number of experimental manipulations that might settle the theoretical and methodological questions raised. The results of the study, for both the usual measures of VD performance, and, to some extent, their correlation with the redintegrative properties of VD pairs, strongly suggest that intrapair relatedness is involved in VD learning. The particular theoretical model specifying the role of intrapair relatedness was not supported. In concluding this discussion, we believe that we have, however, provided a coherent framework for investigating the questions we began with, even if we have not provided unqualified answers to them.

APPENDICES

APPENDIX A

APPENDIX A

INSTRUCTIONS FOR VD TASK

This is a memory experiment to test ability to remember word pairs. The words will be presented to you in word pairs. Some of the word pairs contain words that you are likely to hear together. An example of a related pair of words might be STREETCAR. Some of the pairs contain words that you are not likely to hear together. An example of an unrelated pair of words might be TABLE PIN.

Before we start the main experiment, I want you to become acquainted with the word pairs that will appear later. In order to do this you have been given a list of the 32 word pairs. When I say begin turn the blue [green] cover sheet over and begin reading the first pair to yourself.

As you read each pair I am also going to play a tape recording of that pair so that you can hear the pair. The recorded pairs will be read at a four second rate. Say each pair to yourself as you hear it from the tape recorder.

Make sure that you can recognize the words in each tape recorded pair. In the main experiment you will hear these word pairs, and I want to make sure you can recognize the word in the pairs.

Any questions?

The pairs are in groups of four. Each group of four pairs is either all related or all unrelated. Please read the pairs on the list in the order in which you hear them from the tape recorder.

Do not write anything during this presentation. Just read the pairs to yourself and pay attention to how the words sound so you will not have trouble recognizing them later.

Ready.

Turn the cover sheet over and begin with the first pair.

[FAMILIARIZATION]

Now I want to read the instructions for the main experiment. One word in each pair is a correct word. Your task is to learn which word in each pair is the correct word.

First, all the word pairs will be presented in a study trial. On the study trial, after each pair of words is given, the correct word will be repeated and you will be told that it is correct.

For example, you might hear: "STREETCAR. CAR is correct." Or you might hear: "TABLE PIN. TABLE is correct."

Do not write anything during a study trial. Listen to the word pairs and try to remember which is the correct word.

[SLOW STUDY RATE] You will have four seconds to study each pair.

[FAST STUDY RATE] You will have two seconds to study each pair.

[MIXED STUDY RATE] You will have four seconds to study each pair. First the pair will be read, followed by a two second pause, after which the correct word will be named.

After you have heard all the pairs and have been told which word is correct in each pair, you will have a test trial. On the test trial only the pairs will be read. Your task is to decide which word is the correct word and to indicate your choice on the answer sheet.

[FOR THE RE-PAIRING TEST]

The words in the test pairs will be the same as in the study but the particular word combinations will not be the same. We have scrambled the study pairs. For example, if AIRPLANE and STREETCAR had appeared on the study, you might now hear the new combination STREET AIR.

Only one word in each test pair is a correct word. The other word is not correct. You have to decide which is the correct word, and indicate your choice on the answer sheet.

[FOR BOTH CONSTANT AND RE-PAIRING TESTS]

Now look at your answer sheet. There are two columns numbered 1 through 32. After each number there is a number "1" and a number "2".

For each test pair, you decide which word is the correct word. If the first word is correct, circle number "1". If the second word is correct, circle number "2".

In order to help you keep your place on the test sheet the number of every fourth test pair will be read. Make sure that the number of the test pair is the same as the number on the answer sheet.

You will have four seconds for each pair to decide which is the correct word and to circle either number "1" or "2" for that pair.

Do you have any questions?

After the test trial you will have another study trial and another test trial. This will be followed by a third study and third test trial. A correct word is correct on all study and test trials. Likewise, an incorrect word is incorrect on all study and test trials.

On the test make a choice for each word pair.

Do not skip any items--guess if you have to.

Ready for study trial one.

APPENDIX B

APPENDIX B

INSTRUCTIONS FOR FREE RECALL

Turn the answer sheet over to the third blank page. Draw a line about one inch from the left side of the sheet vertically down the page.

When I say begin, and only when I say begin, write down all the pairs you can remember from the study list. Write vertically down the page.

If you can only remember one word of a pair, write it down anyway. If you remember the other word later on, put the two together, but circle the word you remembered later on, so that I know you recalled it later on.

Write words down even if you are not certain about them. I am not interested in whether words are correct or not. I am only interested in how many words you can remember, and how many you can remember in the original study pairs.

Every minute I will say the word line. When I do, draw a line under the last word you wrote down before I said "line." Always draw a line even if you have not written anything since the last time.

Any questions?

Begin.

APPENDIX C

APPENDIX C

QUESTIONNAIRE

This questionnaire will give you a chance to indicate what strategies you may have used to remember the correct words for the pairs in this experiment. Most people claim to have intuitions about how they perform in tasks like these, and if you are one of these people, then I would like to know about your intuitions.

I have described five possible strategies that are sometimes reported. Please indicate for each one listed whether you used it. Feel free to describe other strategies or elaborate on the ones suggested here. If you need more room, use the back of this sheet.

If your memory is really good, you might turn to the last page. There I have listed all the pairs used in this study. Each has a blank after it. In the blank you can indicate how you studied and/or remembered the correct word on the test. Use the numbers for the strategies listed below as a code to minimize writing.

Please feel free to add any general comments about memory strategies if you can formulate them. We really do not have many ideas about how people remember information about words. Any intuitions you have about your performance will be appreciated.

STRATEGY 1

Some people use a rehearsal strategy where they simply repeat the correct word one or more times. Did you repeat the correct word to yourself?

Did you do this for all pairs on all trials, or did this method change for some pairs and/or over trials 1, 2, and 3?

STRATEGY 2

Some people report making (verbal) associations or "connections" of the correct word with other words or ideas (not pictures or images). They say this helps them to emphasize the correct word. Did you do this?

If you did make verbal associations, did you do this along with Strategy 1?

STRATEGY 3

Some people report making images or mental pictures of word pairs. One way is to make a compound image involving both words in a pair. Did you make single images that somehow involved both words in some relation?

If you did this, did you do anything special to the correct word (to single is out as the word to remember as special)?

STRATEGY 4

There is another image strategy where people say they just make a single image to the correct word and essentially ignore the incorrect word. Does this describe what you did to study pairs?

Did you mix these different strategies?

If you did mix strategies, did you nevertheless treat a given pair or set of pairs consistently over trials?

There are also strategies for remembering the correct word when you hear a test pair containing it. In general, can you remember how you knew which word in a test pair was correct?

STRATEGY 5

One particular way of remembering the correct word for a test pair is to remember which word a test item had been paired with on the study. For example, if you heard a scrambled test pair like PLANE STREET, could you remember that PLANE came from the study pair AIRPLANE?

Did this help you to infer which word in the test pair had to be correct if you could not tell this by just looking at them alone?

If you did this strategy, did you do it for all pairs (e.g., related and unrelated)?

Was it easier for some pairs but not others (especially related and unrelated)?

On the second and third study trials, were you able to remember whether you had chosen the correct word on the previous test trials? That is, did you have some memory of prior errors while studying pairs for the second or third time?

Finally, if you can remember how you studied specific pairs, you can turn to the last page which lists these pairs, and indicate for each what you did. Use the number of the strategy given in the questionnaire above in filling in the blank after each pair.

APPENDIX D

APPENDIX D

INSTRUCTIONS FOR FREE ASSOCIATION

This booklet contains 96 single words. Each word has a blank after it. Your task is to look at each word and write down the first word it makes you think of. Write your choice in the blank after the word.

It does not matter what word you think of as long as the word on the paper makes you think of it. There are no correct answers. Do not spend a lot of time thinking about your choice. Write down the first word you think of.

There are 12 pages with 8 words on a page. Work quickly and do not skip any items. Finish with words on one page before going on to the next page.

There is no time limit but work quickly. Every minute I will write down the total time elapsed from the start on the black board. When you are done, please write that time on the last page of the booklet.

Write clearly so that the scorer will be able to understand the word you wrote down.

Try to concentrate on one word at a time.

When you are finished, please sit quietly until everyone else is finished.

Please do not start until any questions have been answered and the experimenter says to begin.

FOOTNOTES

FOOTNOTES

1

It is possible to specify a number of linguistic properties of compound words which may be relevant to their relatedness (e.g., Gleitman & Gleitman, 1970). However, it is not clear to what extent the VD task exploits these properties unique to compound words.

2

We are not considering the transfer literature for VD learning. In this literature intrapair associations have provided a source of explanation contrasting with predictions derived from the frequency theory of VD learning (see, e.g., Wallace, 1972; Eckert & Kanak, 1974).

3

This result only applies for college students, and not for grade school children. For the latter, related pairs in the CC condition are superior to related pairs in the CV condition (see Barch et al., 1967).

4

These alternative accounts of retrieval processes in recognition memory may only involve a matter of emphasis from the perspective of the present model. For example, the concept of retrieval check may be related to Kausler's concept of a functional unit, if one can identify the latter, at least in some tasks, with the literal retrieval of a study pair, as hypothesized in this study. The main difference appears to be that the concept of a functional unit might be somewhat easier to use in accounting for a consistent relatedness effect, not only in CV test conditions, but in CC test conditions, where the notion of literal retrieval is harder to conceive.

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