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RECOGNITION AND CUED RECALL OF RELATED AND UNRELATED WORD PAIRS

by

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A dissertation submitted to the Graduate Faculty in Psychology in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York

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ABSTRACT

RECOGNITION AND CUED RECALL OF RELATED
AND UNRELATED WORD PAIRS

by

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Two experiments were performed to explore the phenomenon of the "recognition failure of recallable words" (Tulving & Thomson, 1973); namely, the finding in some paired-associates learning situations that to-be-remembered words which are not recognized are subsequently retrieved on a cued recall test. Tulving and his colleagues have interpreted this surprising finding in terms of the "encoding specificity principle" which assumes that the specific context in which storage occurs determines what cues are effective in retrieval.

The first experiment tested the hypothesis that subjects are learning word pairs in the Tulving and Thomson paradigm. According to Olson's (1976) modification of the Tulving and Thomson procedure, subjects were presented with a list of 24 associatively related cue-target word pairs. The word pairs were composed of nouns having differential forward and backward associative probabilities. Subjects were instructed to try to remember the target word in each cue-target pair and also to pay attention to cue words. Following presentation of the word pairs, subjects were tested for recognition and cued recall. Group 1 subjects were given the standard cued recall test in

which they responded with the appropriate target word for each cue word presented. The subjects in Group 2 were given a recognition test and asked to identify the target words embedded in a list of distractor items. Following the recognition test, subjects were required to write the appropriate cue word next to each recognized target word. Group 3 was presented with the list of target words and asked to write the appropriate cue word corresponding to each target word. Subjects in Group 4 were given the same tests as Group 2 except that both tasks, recognition and writing the cue word, were performed together rather than separately. The results supported the hypothesis that subjects are learning word pairs in the Tulving and Thomson paradigm. Appropriate cue words were generated for approximately 90% of the recognized target words. Furthermore, performance in Group 3, which required the retrieval of word pairs, did not differ significantly from that of Groups 2 and 4. This result indicated that the same process is occurring in both recognition and cued recall and provided additional support for the hypothesis that subjects are learning word pairs.

The first experiment also replicated Olson's finding that superior cued recall or recognition performance was a function of the direction of the asymmetry in the cue-target word pairs. A greater forward than backward associative probability resulted in better cued recall than recognition. Asymmetry in the opposite direction produced superior recognition compared to cued recall.

Wiseman and Tulving (1976) have found that when unrelated word pairs are substituted for related pairs in the Tulving and Thomson paradigm, the traditional result of cued recall superiority is reversed and overall recognition performance is better than cued recall.

The second experiment tested the hypothesis that superior recognition performance is caused by the high rate of single word storage that occurs with unrelated word pairs. If this hypothesis is correct, appropriate cue words should be written next to a relatively small proportion of recognized target words for unrelated pairs. The results supported the hypothesis. The proportion of cue words recalled for unrelated word pairs was 35%, less than half of that for related pairs.

The results of both experiments were discussed in terms of DeVito's (1976) model of free and cued recall. The model interprets the recognition failure of recallable words as a function of "peg word storage." It was suggested that DeVito's model provides a more detailed and comprehensive explanation of the phenomenon than does Tulving's notion of encoding specificity.

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In a series of experiments (Tulving & Thomson, 1973; Watkins & Tulving, 1975) Tulving and his colleagues have repeatedly observed the curious phenomenon of "recognition failure of recallable words" in which subjects failed to recognize words on a recognition test that they were subsequently able to recall on a cued recall test. In Tulving and Thomson's (1973) basic paradigm, subjects were presented with a list of weakly associated word pairs. The first word in each pair was the "cue word" and was studied with the expectation that it would serve as an aid for the recall of the second word in the pair known as the "target word." The relation between the word pairs used by Tulving and Thomson was such that the to-be-remembered (TBR) target word was a free associate of the cue word. Following visual presentation of the word pairs, subjects were presented with a list of extralist cue words which were strong associates of the target words. Subjects were instructed to generate as many free associates as they could to each of the extralist cues. After completing this task, subjects were told to examine the words they had just generated and circle any they recognized as being TBR target words. Immediately following the recognition task, a cued recall test was administered. A list of the original cue words was presented and subjects were asked to recall as many target words as possible. Typically, subjects failed to recognize words which they were later able to recall on the cued recall test. Furthermore, the proportion of recalled words not recognized was larger than the proportion of recognized words not recalled.

These findings have been interpreted in terms of Tulving's "encoding specificity principle" which assumes that "specific encoding operations performed on what is perceived determine what is stored, and what is stored determines what retrieval cues are effective in providing access to what is stored." (Tulving & Thomson, 1973, p. 369). The assumptions of storage and retrieval implicit in encoding specificity are expanded and devoloped by Tulving and his associates in their conceptualization of "episodic memory." Regarding the storage or retention of verbal information, the theory "assumes that what is retained of our sample event is a unique trace of the psychological episode given by the person's perception . . . The trace is created as a consequence of the perception, and its nature is dictated directly by what is encoded of the encounter." (Watkins & Tulving, 1975, p. 6).

Tulving emphasizes the temporal relations of a specific event, especially the event's temporal relations to other experienced events. "Since the trace is of a unique episode--the person's encounter with a particular item in a particular context at a particular time--its properties are only indirectly related to the person's knowledge about the item, and hence this knowledge will not completely determine the nature of the trace." (Watkins & Tulving, 1975, p. 6).

In its formulation of the retrieval process, episodic theory assumes that "remembering an event requires that information in the trace sufficiently match the information in the retrieval environment. The retrieval environment may be manipulated experimentally through the presentation of specific retrieval cues." (Watkins & Tulving, 1975, p. 6). Although the retrieval cue in a recognition test is the target word, it may not contain information sufficiently similar to that in the original trace. "The finding of recognition failure means that, for certain items, information in the list cue at recall successfully matches the information in the encoded trace, while the information in the copy cue at recognition does not. Thus, although the TBR item is identical with the nominal copy in the recognition test, the specifically encoded trace of that item may be sufficiently different from the copy cue to preclude recognition." (Wiseman & Tulving, 1976, p. 350).

Olson (1976) has examined the results of the Tulving and Thomson research and strongly suggests the presence of an artifact in their procedure. Olson found evidence indicating that recognition failure of recallable words in the Tulving and Thomson data was primarily restricted to a specific kind of word pair, a noun cue word and an adjective target word. Citing Loftus' (1972) suggestion that the long term memory store is primarily organized into noun categories, Olson hypothesized that the built-in asymmetries in Tulving's noun-adjective pairs could reasonably account for recognition failure. "Thus, if a pair such as 'butter-smooth' was presented to a subject, and in cued recall, 'butter' was presented, the word 'smooth' could be generated with reasonable probability, since smooth is a property of butter. On the other hand, if 'smooth' is presented as the cueing word, the subject's task would involve a difficult search, since many objects have the property smooth." (Olson, 1976, p. 23).

Olson tested his hypothesis in a series of experiments using a modified version of the basic Tulving and Thomson paradigm. He constructed cue-target word pairs consisting of nouns having differential forward and backward associative probabilities and found that superior cued recall or recognition performance was a function of the direction of the asymmetry. A greater forward than backward associative probability resulted in better cued recall than recognition performance. If the reverse were true, recognition was superior to cued recall. In the case where forward and backward associative probabilities were similar, there were no differences between cued recall and recognition.

In his discussion of the storage and retrieval processes involved in Tulving's procedure, Olson proposes that "the subject's task in the Tulving and Thomson paradigm may be conceptualized to be one of learning or memorizing a pair of words under both the cued recall and recognition procedures. Under both procedures, the subject must recreate the original stimulus pair. In cued recall it may be assumed that the subject generates associates to the cue and stops when he generates the second member of the original pair and recognizes the pair as the one presented. In recognition from a list of alternatives containing the target, it may be assumed that the subject generates associates to each of the alternatives and stops when he recognizes the pair as the one presented. In this view, at least for pairs, the processes involved for cued recall and recognition memory are essentially the same." (Olson, 1976, pp. 23-24). Consequently, any asymmetry in the cue-target pairs could predispose the subjects to either better cued recall or recognition performance.

Consistent with Olson's results, Bartling and Thompson (1977) have demonstrated that word pairs having differential forward and backward associations produce retrieval asymmetries within a modified Tulving and

Thomson paradigm. The four types of word pairs used by Bartling and Thompson were: noun-adjective, noun-noun, adjective-adjective, and adjective-noun. Their results showed that the degree of recognition failure of recallable words varied systematically as a function of the type of word pair. Recognition failure was greatest for noun-adjective pairs and least for adjective-noun pairs. "All the data reported in this article are consistent with the hypothesis that recognition failure of recallable words is attributable, at least in part, to retrieval asymmetry. More specifically, the data suggest that the conditions for recognition failure are met when the episodic memory trace for a pair of words is not as accessible through the nominal target word (i.e., in recognition) as through the nominal cue (i.e., in cued recall)." (Bartling & Thompson, 1977, pp. 698-699).

DeVito (1975) has investigated the notion of encoding specificity as a function of the degree of integration within word pairs. Specifically, he proposed that a pair of concrete words would have a greater chance of being encoded as an integrated unit compared to a pair of non-concrete words. According to his hypothesis, word pairs having a relatively high degree of integration should favor cued recall over recognition in a Tulving and Thomson paradigm whereas less integrated pairs should favor recognition. It is worthwhile noting that the quality of concreteness of the word pairs has special significance in this context. DeVito's examination of the noun-adjective word pairs used by Tulving and Thomson led him to conclude that they were all concrete-concrete items.

DeVito tested his hypothesis with four types of noun-adjective word pairs varying in concreteness value. The four types of word pairs were: concrete-concrete, concrete-abstract, abstract-concrete, and abstract-abstract. In general, the results supported the hypothesis. Cued recall was superior to recognition for concrete-concrete pairs. For abstract-concrete and abstract-abstract pairs, recognition was better than cued recall. There was no difference between cued recall and recognition for concrete-abstract pairs. These results tend to suggest that the degree of integration between the members of a word pair, that is, the extent to which a pair of words is stored and retrieved as a unit, is a contributing factor to the differences between cued recall and recognition found by Tulving and Thomson.

Salzberg (1976) has also suggested that subjects are learning word pairs in the Tulving and Thomson paradigm. "Presumably, the cue-target pair is encoded together into some sort of unit. Since they were perceived together the encoding process may well mirror this contiguity." (Salzberg, 1976, p. 594). Consistent with the encoding specificity principle that the target word is encoded with respect to the cue word, Salzberg proposes that "access into the 'encoded unit' is required for recall or recognition of the target word; the target cannot be remembered independent of the unit it was stored in. Thus, the problem of explaining encoding specificity, as was also noted by Tulving and Thomson (1973), reduces to one of explaining the asymmetry between cue and target words in providing access to the encoded unit." (Salzberg, 1976, p. 594).

In a modified Tulving and Thomson paradigm, Salzberg manipulated the concreteness of encoding (input) cues and found that access to a word pair (encoded unit) in memory was dependent upon the relative concreteness of both members of the pair. Specifically, the more concrete, or salient, member of the pair, compared to the more abstract member, was the more effective cue in providing access to the pair. "When the relatively abstract target words were paired with concrete (root noun) cues a retrieval asymmetry was observed; access to the encoded unit, and thus the target word, was better when the 'cue' word was the retrieval cue than when the 'target' word was the retrieval cue. In contrast, when both words were relatively equivalent in concreteness, or biased toward the target side, either both words were equally effective retrieval cues or the target word was more effective." (Salzberg, 1976, p. 594).

Salzberg suggests that the image evoked by a successful cue word is the critical aspect of the memory trace. "If the encoded representation of the cue-target pair includes a unified image incorporating both cue and target words, then reinstatement of that unified image may be a necessary condition for access to the encoded representation. . . . The word that is the most salient part of the image should provide the most reliable access to it." (Salzberg, 1976, pp. 594-595). Salzberg also suggests that "saliency" is the determining factor in the magnitude and direction of cued recall and recognition differences in the Tulving and Thomson paradigm.

In a broad sense, these studies represent a return to unitization hypotheses of the type suggested by the Gestalt psychologists. In recent years, several other investigations in the area of paired-associates learning have produced evidence suggesting that word pairs are often stored and retrieved as organized wholes or as single integrated units (Begg, 1972; DeVito, 1976; Horowitz & Prytulak, 1969; Karchmer, 1974).

The theoretical notion that complex memories are stored as wholes was proposed by Hollingsworth (1928) and referred to as "redintegration." Hollingsworth assumed that all mental processes were a series of antecedent-consequent relationships in which the original antecedent was not necessary to produce its associated consequent. "Instead, some detail or fragment (of the original) is adequate to touch off a consequent of the type formerly evoked by a more complex antecedent." (Hollingsworth, 1928, p. 5). For example, in remembering a former pet, "I speak or imagine his name, and this detail, as a surrogate for the animal that he was, evokes an array of feelings, images, postures, gestures, and further words, descriptive or appreciative." (Hollingsworth, 1928, p. 258).

Begg (1972) specifically assumes that each member of certain types of word pairs produces an image which can then combine to form a unified, integrated image which is processed in memory as a single unit. According to Begg, a concrete word pair such as "white horse" arouses a single, unified image and therefore requires no more memory capacity than it does to remember "horse" alone. Abstract pairs such as "basic-theory" are not so easily integrated however, and may yield images which integrate no more successfully than do two abstract single words. Begg presumably found confirmation for what he termed the "strong form" of the unitization hypothesis; namely, for concrete-concrete pairs his subjects retained almost as many pairs as subjects, getting lists of adjectives or of nouns, learned single words. Similarly, subjects given abstract-abstract pairs retained roughly half the number of pairs as the single word list subjects retained words.

A theoretical and predictive model for the free and cued recall of word pairs has been proposed by DeVito (1976). In his model, assumptions concerning the storage and retrieval of word pairs are extended and developed into a theoretical framework which may further clarify and explain the findings reported by Tulving and his colleagues. In addition, DeVito's theory serves as a basis for the integration of other studies using the Tulving and Thomson paradigm including those of Olson and Salzberg. DeVito found that his model successfully predicted free and cued recall using both high imagery, high concrete and low imagery, low concrete word pairs. In contrast to Begg, he suggests the possibility that both types of items may be processed similarly in memory.

In his discussion of the storage process, DeVito makes the simple assumption that when presented with a list of word pairs, the subject stores some of the words as whole pairs and some of the words as single words. The storage process is considered to be a function of some construction process such as the formation of images or narratives. The model assumes that the subject uses one member of the word pair as a conceptual peg for the other pair member. The concept of "peg words," introduced by Paivio (1971), is a central notion in DeVito's theory. The peg word provides a "hook" for the other pair member during storage, and during retrieval, access to the pair is specifically and only through the peg word and not through the other pair member.

DeVito's notion of peg words is taken from Paivio's "conceptual peg hypothesis" of paired-associates learning in which one member of a word pair " . . . functions as a 'peg' to which . . . " the other word in the pair " . . . is hooked during learning . . . " and " . . . from which it can be retrieved . . . " during recall. (Paivio, 1971, p. 248). The differences between the assumptions made by Paivio and DeVito concern retrieval. In Paivio's formulation of peg word function, the other pair member "can" be retrieved from the peg word, whereas DeVito assumes that retrieval of the word pair occurs "only" through the peg word.

"During retrieval, it is assumed that the subject can retrieve either a peg word member of a stored pair, or a word which was stored as a single word. If the subject retrieves a word which is a peg member of a stored pair, the probability of retrieving the other pair member is 1.0. If the subject retrieves a word which is stored as a single word, the probability of retrieving the other member of the originally presented pair is effectively 0." (DeVito, 1976, p. 8).

According to the model, access to a peg word in a cued recall situation can occur either directly or through free recall. In the direct access process, if one of the cue words on the cued recall test is a peg word member of a stored pair, the subject will retrieve the other pair member. In the free recall process, however, the subject will attempt to retrieve peg words that are not on the test sheet and in that way retrieve word pairs. Thus, in cued recall, one would expect a greater degree of retrieval if the cue word rather than the target word has been selected as the peg, because in the former case, the direct access to peg words provided by the cue eliminates the additional retrieval step required in the free recall of peg words.

The Tulving and Thomson finding of recognition failure of recallable words can be understood in terms of DeVito's model. "As Olson (1976) suggests, the Tulving and Thomson situation may direct the subject toward attempting to store word pairs. . . . This suggests that in the Tulving and Thomson paradigm, the recognition task is similar to a cued recall task with the to-be-remembered (TBR) word as the cue. Furthermore, the word pairs used by Tulving and Thomson were constructed so that the TBR word was a free associate of the cue word. This may have so biased the subjects' selection of peg words, that they selected the cue word much more often. The phenomenon of recognition failure of recallable words then reduces to that of asymmetrical cued recall, which may be analyzed in the context of the current model." (DeVito, 1976, p. 44).

More precisely, in accounting for the Tulving and Thomson results, DeVito's model interprets the phenomenon of recognition failure of recallable words as a function of peg word storage. The prediction is that storage with the cue word as peg will lead to successful cued recall and to recognition failure, whereas storage with the target word as peg will result in recognition superiority and possible cued recall failure.

A similar explanation can account for Olson's results. Olson found that superior cued recall or recognition performance was a function of the differential associative probabilities in his cue-target word pairs. It may be assumed, as an approximation, that the peg word for each of Olson's word pairs was determined by the direction of the asymmetry relating the pair. Thus, the word in a cue-target pair having the higher directional associability would have a correspondingly high probability of being used as the peg word in a pair. For example, a word pair with higher forward than backward associative probability would probably result in the selection of the cue word as the peg, and according to DeVito's model, superior cued recall over recognition would be expected. In the case where the word pair has higher backward than forward associative probability, the target word would probably be selected as the peg and superior recognition over cued recall would result.

In Salzberg's experiments, it may be assumed that subjects selected the more "salient" members of the cue-target pairs as peg words. This would account for the finding that the more concrete or salient member of a cue-target pair provided better access to the entire pair.

The purpose of the following experiments was to continue the process of explanation and clarification initiated by Olson in his analysis of the Tulving and Thomson findings, but within the context of DeVito's theoretical framework. The first experiment was designed to provide a direct test of Olson's hypothesis that subjects are learning word pairs in the Tulving and Thomson paradigm. Although DeVito and Salzberg have also assumed that subjects are learning pairs of words in Tulving's procedure, a direct test has not been made.

In Experiment 1 subjects were presented with Olson's modification of the Tulving and Thomson procedure. Now, however, subjects were asked to write the appropriate cue word next to each recognized target word on the recognition test. If Olson's hypothesis is correct, then appropriate cue words should be written next to a very high proportion of recognized target words. Recognition of a target word on the recognition test implies that the word pair is available and it is expected that the subject will generate the cue word to each recognized target word; that is, it is assumed that the recognized word is either a peg word or not. If it is a peg word the content of storage will be available. If it is not a peg word, then the only way it could have been recognized was for the subject to recall the peg word and generate its corresponding storage word. The exception to this expectation would be recognized words that had been stored as single words and it is surmised that the number of such words would be relatively small for "related" word pairs. The above procedure was intended as a direct test of Olson's hypothesis.

In addition, some subjects were given the target words as cues in a cued recall procedure with the expectation that their performance would be comparable to that of subjects who were performing the recognition task. Again, except for single word storage, cued recall should occur for all words stored as pairs. Use of this procedure was intended to provide an indirect test of Olson's hypothesis.

EXPERIMENT 1

Method

Subjects

One hundred Brooklyn College undergraduates volunteered to participate in the experiment. They were members of an introductory psychology class and participated in order to fulfill a course requirement.

Materials and Apparatus

The materials were the same as those used by Olson (1976). There were three study lists composed of 24 noun pairs. Each pair consisted of a cue word in small letters and a to-be-remembered target word in capital letters. A slide of each pair was prepared so that a cue word was typed above its target word. The purpose of presenting the first two lists was to establish a set in which the subject would encode the target word with respect to, or in the context of, the cue word. The third, or critical, list was made up of noun pairs that had asymmetric forward and backward associative probabilities taken from the word association norms of Bilodeau and Howell, 1965; Riegel, 1965; and Palermo and Jenkins, 1964. Eight noun pairs had high forward (mean of 25%) and low backward association value (mean of 1%): infant-BABY, crown-KING, stomach-FOOD, kid-BOY, street-CAR, memory-MIND, hand-FOOT, moon-NIGHT. Eight pairs had low forward (mean of 1.5%) and high backward association value (mean of 25%): woman-LADY, flower-PLANT, arm-SHOULDER, water-SEA, window-DOOR, soldier-AMERICAN, sky-GROUND, noise-MUSIC. The last eight pairs had low forward (mean of 1.5%) and low backward association value (mean of 1%): gun-CITY, box-PAPER, bed-TABLE, hair-DOGS, bible-NUMBERS, health-COLOR, doctor-FRIEND, river-TRAIN. All of the target words in the critical list were high frequency nouns (Kucera & Francis, 1971) with a mean frequency value of approximately 205 per million words of printed American English text. The mean frequency value for all of the cue words was approximately 123 per million.

A test for cued recall of the target words on the first two lists consisted of a random ordering of the 24 corresponding cue words. Cued recall for the critical list was similarly tested with one of three different random orders of either cue words (Group 1) or target words (Group 3). A test for recognition of the target words on the critical list consisted of one of three random orders of 96 nouns of which 24 were the target words and 72 were distractor items.

The experiment was conducted in a small room which measured 4.26 x 3.65 x 2.85-m and had diffuse overhead lighting. A Kodak Carousel 800H programmable projector encased within a 1.10 x .51 x .41-m Plexiglas box projected the study lists on an opaque illuminated screen. The subject's chair was placed approximately .61-m in front of the screen.

<u>Procedure</u>

Twenty-five subjects were randomly assigned to each of four groups and tested individually. Before the study lists were presented, each subject was instructed to try to remember the capitalized target word on each slide and to pay attention to the cue word in small letters because "it may help to remember" the target word. Each slide of a cue-target pair was presented individually in a random sequence for each subject at a 2-sec rate.

Immediately after the presentation of List 1, subjects were allowed 3 min for a cued recall test. The same procedure was followed for List 2. Following the presentation of the critical third list, subjects in each of the four groups were tested differently for retention. The subjects in Group 1 were given the standard cued recall test in which they had to write down the appropriate target word corresponding to each of the 24 cue words presented. The subjects in Group 2 were given an initial recognition test followed by a cued recall procedure. They were given the list of 96 target and distractor items and were told to circle each target word they recognized. Following this task, they were instructed to write the appropriate cue word next to each encircled target word. Groups 1 and 2 were comparable to the Tulving and Thomson groups used to test for cued recall and for recognition. Group 3 was given a cued recall procedure which was the reverse of that given to Group 1. The subjects were presented with a list of the 24 target words and asked to write down the appropriate cue word next to each corresponding target word. Group 4 was given the same task as Group 2 except that both recognition and cued recall tasks were performed together instead of separately. That is, subjects tried to write down the appropriate cue word next to each corresponding target word as soon as they recognized it. The subjects in each group, with the exception of Group 2, were permitted 3 min for the completion of the retention tasks. Group 2 subjects were given 3 min for the recognition test and an additional 3 min for the recall test.

Results and Discussion

Table 1 presents the mean number of correct responses on the cued recall and recognition tests for the critical third list for each of the four groups as a function of direction of association of cue-target pairs. The results of a two-factor analysis of variance with repeated measures on one factor is presented in Table 2. It revealed a significant main effect of direction of association, $F(2, 192) = 24.25$, $p < .05$. The main effect of retention task was not significant but there was a significant interaction between direction of assocaition and retention task, $F(6, 192) = 3.02$, $p < .05$. It will be recalled that Groups 1 and 2 were similar to the Tulving and Thomson procedures of cued recall and recognition. Consequently, independent t-tests were computed comparing performance on cued recall (Group 1) and recognition (Group 2) for each type of cue-target pair. The results of these comparisons indicated that the differences between cued recall and recognition were significant for word pairs having high forward and low backward association, $t(48) = 2.45$, $p < .05$, and for pairs with low forward and high backward associations, $t(48) = 2.13$, $p < .05$. There was no significant difference between cued recall and recognition for word pairs with low forward and low backward associations, $t(48) = 1.14$. As shown in both Table 1 and in Figure 1, cued recall was better than recognition for word pairs with high forward and low backward associations. However, for word pairs with low forward and high backward associations, the effect was reversed. The magnitude of the difference between cued recall and recognition in both asymmetric associative

Table 1

Mean Number of Correct Responses for Cued Recall and Recognition as a Function of Direction of Association of Cue-Target Pairs

	Cued Recall		Recognition	
	Group 1	Group 3	Group 2	Group 4
High Forward-Low Backward	5.48	5.04	4.44	5.12
Low Forward-High Backward	4.36	5.68	5.32	5.72
Low Forward-Low Backward	3.44	4.16	4.00	4.32

Table 2

Two-Factor Analysis of Variance on Number of Correct Responses for Cued Recall and Recognition for Differential Association Direction

Source of Variation	Sums of Squares	df	Mean Square	F
Between Ss	426.57	99		
Task (T)	20.04	3	6.68	1.58
Subjects within Groups	406.53	96	4.23	
Within Ss	498.67	200		
Association (A)	93.61	2	46.80	24.25*
T x A	34.95	6	5.82	3.02*
A x Ss within Groups	370.11	192	1.93	
Total	1850.48	598		

* $p < .05$

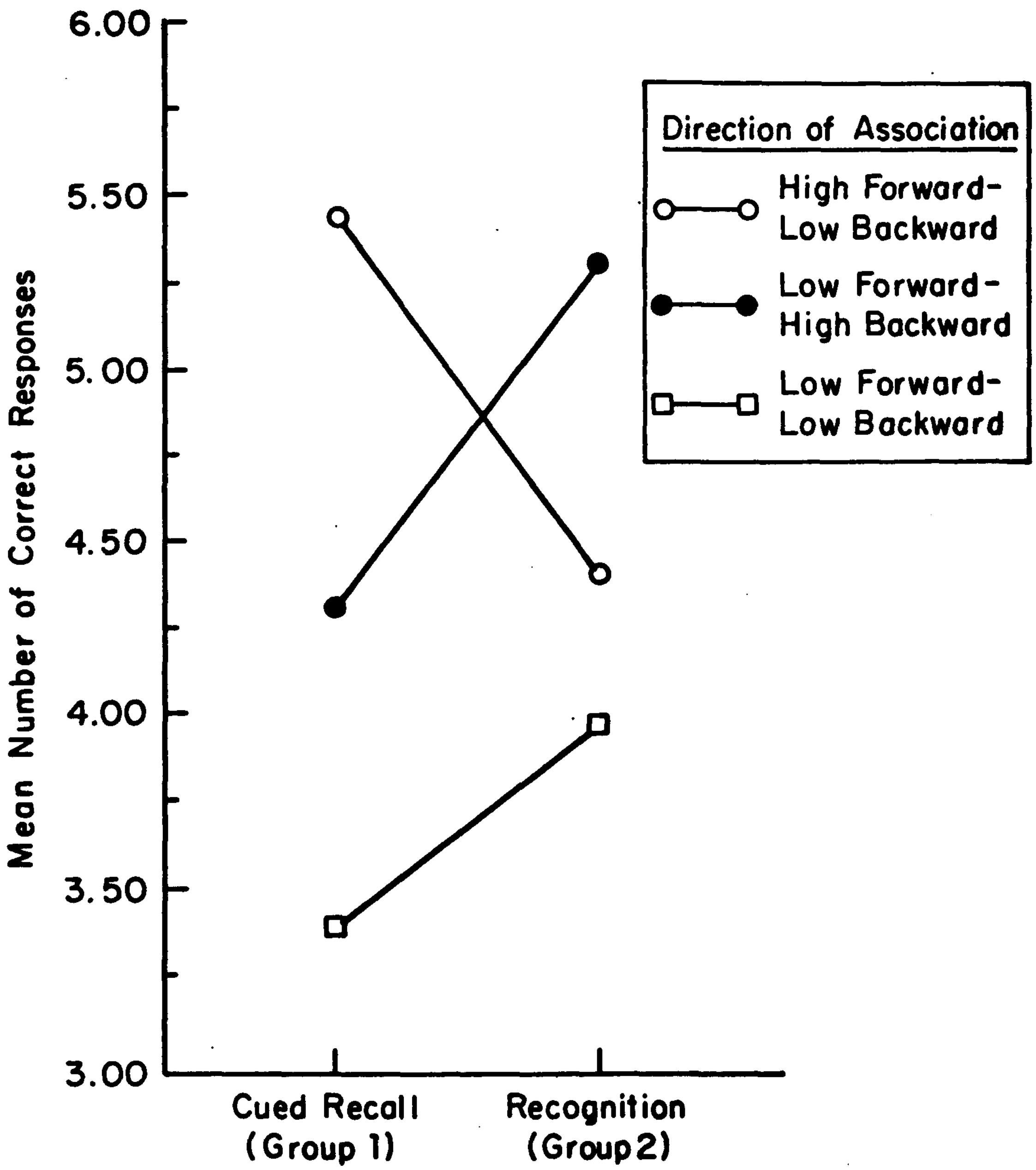

Figure 1. Mean Number of Correct Responses for Cued Recall and Recognition as a Function of Direction of Association of Cue-Target Pairs.

directions was approximately one word. The data indicate that performance on cued recall and recognition was a function of the direction of the associative probabilities in the cue-target word pairs. In addition, for cued recall (Group 1), a correlated t-test revealed a significant difference between word pairs having high forward and low backward associations and pairs with low forward and high backward associations, $t(24) = 3.41$, $p < .05$. A similar comparison for recognition (Group 2) yielded $t(24) = 2.01$, which was close to the critical value of 2.06 needed for significance at the .05 level.

The data are in agreement with Olson's (1976) findings. Associative asymmetries in cue-target pairs resulted in differences between cued recall and recognition in the Tulving and Thomson paradigm. These results led Olson to hypothesize that the subject's task in the Tulving and Thomson paradigm is to learn pairs of words both in the cued recall and in the recognition procedure. "Under both procedures, the subject must recreate the original stimulus pair. . . . In this view, at least for pairs, the processes involved for cued recall and recognition memory are essentially the same. Therefore, the inferior recognition performance could be explained by the asymmetrical cued recall for noun-adjective pairs that Tulving and Thomson used in their experiments." (Olson, 1976, pp. 23-24).

The hypothesis that subjects are learning and retrieving word pairs in the Tulving and Thomson paradigm was tested in two ways, both directly and indirectly. In the direct test, subjects were instructed to write the appropriate cue word next to each recognized target word on the recognition test. If subjects are retrieving pairs of words on the recognition test, as in cued recall, appropriate cue words should be written next to a high proportion of recognized target words.

As can be seen in Table 3, the proportions of cue words which were generated to recognized target words by both Groups 2 and 4 were quite large. For the two directional categories, the conditional probabilities that the subject generate the cue word given that he recognize the target word were roughly .9. Thus, Olson's hypothesis received strong qualitative support. Group 2 recalled the cue words following the completion of the recognition test while for Group 4, recognition and cued recall tasks were performed together. This may account for the slightly better recall of cue words by Group 4.

The indirect test of Olson's hypothesis involved a comparison between the performance of Groups 2 and 4 on the recognition tests with Group 3 on the cued recall test. The cued recall test for Group 3 consisted of a list of the 24 target words, instead of cue words as in Group 1. If the performance of Group 3, which required the retrieval of word pairs, did not differ from that of Groups 2 and 4, it would lend support to the hypothesis that the same process is occurring in both cued recall and recognition.

The results gave strong support to the hypothesis. Although there were systematic differences between the three conditions, three one-way analyses of variance indicated there were no significant differences between Groups 2, 3 and 4 for either high forward and low backward, $F(2, 72) = 1.29$, $p > .05$, low forward and high backward, $F(2, 72) = .56$, $p > .05$, or low forward and low backward, $F(2, 72) = .20$, $p > .05$, associatively related cue-target pairs. Furthermore, the tests with

Table 3

Mean Proportion of Cue Words Recalled to Recognized Target Words as a Function of Direction of Association of Cue-Target Pairs

	Group 2	Group 4
High Forward-Low Backward	.87	.90
Low Forward-High Backward	.86	.91
Low Forward-Low Backward	.70	.82

their 72 df in the error term were quite powerful tests.

The results of the first experiment constitute a replication and extension of Olson's primary findings. The data strongly suggest that subjects are storing and retrieving word pairs in the Tulving and Thomson paradigm. This result is theoretically important because it suggests that any explanation of the Tulving and Thomson phenomenon of the recognition failure of recallable words should account for the storage and retrieval of word pairs and not just of single words. In addition, an adequate explanation should also include both storage and retrieval processes because if words are retrieved as pairs, it is logical to assume that they have been stored as pairs. At this point it appears that the theoretical framework proposed by DeVito, involving peg word storage and retrieval of word pairs, provides the best possible interpretation of the Tulving and Thomson results.

The results of Experiment 1 suggest that the degree of the association between the members of a word pair is the critical variable in determining whether the word pair will be stored and retrieved as a unit. The directionality of the association appears to determine which particular member of the pair will better provide access to the whole pair, that is, which of the two becomes the peg word. A comparison of the word pairs having high forward and low backward and pairs with low forward and high backward associative probabilities with those having low forward and low backward associative probabilities suggests that the less highly associated pairs are less likely to be retrieved as pairs in both cued recall and recognition tests. Furthermore, the more successful access to a specific high forward and low backward or low forward and high backward word pair is apparently through the word having the high associative probability.

Assuming that the degree and directionality of the association between the words in a pair are critical factors in the formation of organized units, word pairs having a presumably weak relationship, such as unrelated pairs, should form integrated units less frequently. Therefore, for unrelated, as compared with related, word pairs there should be much more single word storage and, as a consequence, greater superiority of recognition over cued recall. Experiment 2 was designed to explore this possibility.

EXPERIMENT 2

Several experiments conducted by Tulving and his associates have been designed to explore the generality of the recognition failure of recallable words and to determine which aspects of the procedure are essential for producing the phenomenon (Watkins & Tulving, 1975; Wiseman & Tulving, 1976). Recently, Wiseman and Tulving (1976) have studied the relation between recognition and cued recall in the Tulving and Thomson paradigm as a function of the pre-experimental associations between the cue and target words used as stimulus items. Such an investigation seems worthwhile because identical stimulus materials have been used in many of the experiments which have found recognition failure of recallable words (Thomson & Tulving, 1970; Tulving & Thomson, 1973; Watkins & Tulving, 1975; Wiseman & Tulving, 1975). Since all previously published studies dealing with encoding specificity had used associatively related word pairs, Wiseman and Tulving (1976) performed a series of experiments using unrelated word pairs. They constructed unrelated cue-target pairs for both the set-establishing and the critical study lists from the original associatively related stimulus items. Cue words were randomly assigned to target words to yield new word pairs in which the cue-target relationship was now arbitrary. If any of the resulting pairs still appeared to be related, they were once more rearranged.

Their experiments produced two primary findings. Recognition was superior to cued recall. The traditional result of cued recall superiority over recognition obtained with related word pairs was reversed when the cue-target pairs were unrelated. In addition, despite overall recognition superiority, the phenomenon of recognition failure of recallable words was still observed.

In discussing their results, Wiseman and Tulving take a position which is clearly inconsistent with Tulving's earlier formulations of episodic theory. They conclude that "the semantic relation between cues and targets in the study list can determine levels of retrieval performance, and thus recall superiority and recognition failure." (Wiseman & Tulving, 1976, p. 358). Indeed, it had been Olson's contention that the semantic relations between the cue and target words used by Tulving and Thomson were at the heart of their findings.

Previously, Tulving had distinguished between semantic and episodic memory and emphasized that his experimental manipulations reflected retrieval processes in episodic rather than semantic memory. "Semantic memory is the system concerned with storage and utilization of knowledge about words and concepts, their properties and interrelationships. Thus, episodic information about a word refers to information about the event of which the word is the focal element, or one of the focal elements, while semantic information about a word is entirely independent of the word's occurrence in a particular situation or its temporal co-occurrence with some other words." (Tulving & Thomson, 1973, p. 354).

Nevertheless, Wiseman and Tulving make no attempt to account for the recognition superiority found with unrelated word pairs and furthermore, assign it no theoretical importance. "In the paradigm under study, recall superiority can be eliminated by the use of unrelated cue-target study pairs. . . . The important lesson to be learned from the research presented here, however, is that the reversal of recall superiority did not eliminate recognition failure." (Wiseman & Tulving, 1976, p. 360).

Within the context of DeVito's model of free and cued recall however, the observation of recognition superiority over cued recall found with unrelated words can be accounted for. It will be recalled that in his formulation of the storage process, DeVito makes the simple assumption that when presented with a list of word pairs, the subject stores some of the words as whole pairs and some of the words as single words. An implication of this assumption is that the success with which a subject is able to store a word pair rather than a single word will be increased if the word pairs are associatively related rather than unrelated. Experiment 1 demonstrated that word pairs that are more highly associated (high forward and low backward pairs, and low forward and high backward pairs) are retrieved more often as pairs both in recognition and cued recall compared to pairs that are less highly associated (low forward and low backward pairs).

On the other hand, if word pairs are not associatively related, or if the relation between the individual pair members is weak as in unrelated pairs, the implication is that the subject will have greater difficulty storing pairs and will necessarily store more words as single words. Therefore, it is hypothesized that the inflated recognition performance in the Wiseman and Tulving experiments is caused by the high rate of single word storage that occurs when word pairs are unrelated.

The Tulving and Thomson paradigm includes two retention tests, recognition followed by cued recall. Consider what is required of a subject in order to perform successfully on each test. Clearly, a knowledge of word pairs is essential for cued recall performance; a subject must respond with the appropriate target word for each cue word presented. Retrieval of a single word is insufficient. In recognition however, the retrieval of both pairs and single words can lead to successful performance. The subject is not limited to pair or single word storage alone. It follows therefore, that in a Tulving and Thomson paradigm using unrelated word pairs, more single words would probably be stored than if related pairs were used, and more single word storage would lead to greater recognition performance compared to cued recall.

Within the context of DeVito's model, the retrieval processes involved in both recognition and cued recall are more precisely described. The recognition test in the Tulving and Thomson procedure consists of randomly arranged target words and distractor items. The model assumes that there are three ways in which a target word may be successfully retrieved in recognition. First, a subject may recognize a particular target word as a peg word and then retrieve the other pair member (cue word) with a probability of 1.0. Second, a subject may retrieve a peg word member (cue word) of a stored pair through free recall and then retrieve the other pair member (target word) with a probability of 1.0 which he then recognizes. Third, a subject may recognize or retrieve through free recall a word (target word) which was stored as a single word and recognize it as such.

The test for cued recall in the Tulving and Thomson procedure consists of a random ordering of the cue words. According to DeVito's model, the first two ways of retrieving a target word in cued recall are identical to those for recognition. First, a subject may recognize a particular cue word as a peg word and then retrieve the other pair member (target word) with a probability of 1.0. Second, a subject may retrieve a peg word member (target word) of a stored pair through free recall and then retrieve the other pair member (cue word) with a probability of 1.0, which he then recognizes in the list of cue words. The third process of retrieval used in recognition however, is of no value in cued recall. Assuming a subject retrieves a cue word or a target word which was stored as a single word, there is no possibility of pairing it with any of the cue words on the cued recall test. The retrieved word was stored as a single word and not as a member of a pair.

If the retrieval of stored single words can only benefit recognition performance and not cued recall, while the retrieval of stored pairs can benefit both recognition and cued recall, then any experimental manipulation which increases the probability of single word storage, such as the use of unrelated words, would lead to recognition superiority over cued recall.

One purpose of the second experiment was to test the hypothesis that the recognition superiority over cued recall found by Wiseman and Tulving is due to the high rate of single word storage that occurs with unrelated word pairs. If this hypothesis is correct, then appropriate cue words should be written next to a relatively small proportion of recognized target words for unrelated pairs. In addition however, Experiment 2 will provide an assessment of the relation between recognition and cued recall performance and the extent of single word and pair storage for both related and unrelated word pairs.

Since each subject is to be tested successively for recognition and cued recall of the target words on the critical third list, it will be possible to compute the number of items that are: (a) both recognized and recalled, (b) recognized but not recalled, (c) recalled but not recognized, and (d) neither recognized nor recalled. Watkins and Tulving (1975) originally presented their data in this same type of four-fold contingency table showing four mutually exclusive retrieval outcomes. Analysis of the data in the contingency table may provide another test of the hypothesis that superior recognition over cued recall for unrelated word pairs is due to the high rate of single word storage. If the hypothesis is correct, and unrelated word pairs are stored more often as single words than as pairs whereas related words are stored more often as pairs than as single words, then the proportion of target words recognized, as single words, but not recalled should be greater for unrelated compared to related word pairs.

The other major finding reported by Wiseman and Tulving, in addition to recognition superiority, was the observation of the recognition failure of recallable words. Despite overall recognition superiority, a proportion of recallable words were not recognized. As previously stated, DeVito's model interprets the recognition failure of recallable words as a function of peg word storage. We hypothesize that highly associated or related words such as Olson's are stored more often as pairs than as single words, by virtue of peg word storage. The peg word for each word pair is determined by the direction of the asymmetry relating the pair. Unrelated words, on the other hand, are more likely to be stored as single words than as pairs. For unrelated pairs, DeVito makes the assumption that selection of the peg word cannot be specified but that the probability of either word being used is close to .5, although some subjects may show idiosyncratic choices with quite high probability. Since cued recall is assumed to be a function of the degree of pair storage, then the proportion of word pairs recalled but not recognized should be greater for related as compared with unrelated word pairs.

One further purpose of the second experiment was to assess the role of immediate memory in learning word pairs. The results of Experiment 1 demonstrated that relatively large proportions of cue and target words were retrieved as word pairs and not as single words. Nevertheless, a small proportion of single words were retrieved, indicating that the storage and retrieval of word pairs was not perfect. One possible mechanism which may help to account for the failure to retrieve word pairs is the storage of single words in immediate memory. If this hypothesis is correct, one would expect to retrieve more single words from the end of the presentation order than at any other point.

Method

Subjects

One hundred subjects from the same source as Experiment 1 participated in the experiment.

Materials

The same three lists of associatively related word pairs used in Experiment 1 were used in Experiment 2. In addition, three new study lists of unrelated word pairs were constructed. Following the procedure used by Wiseman and Tulving (1976), the unrelated lists were composed of the same related word pairs randomly arranged into new cue-target pairs. The 24 noun pairs on the critical third list for unrelated pairs were: noise-SHOULDER, flower-SEA, crown-NIGHT, woman-PAPER, health-AMERICAN, hand-TRAIN, river-LADY, gun-FOOD, sky-BOY, box-FRIEND, water-KING, stomach-CITY, memory-DOGS, soldier-DOOR, doctor-GROUND, kid-NUMBERS, bed-MIND, infant-COLOR, hair-CAR, street-BABY, bible-PLANT, moon-TABLE, window-FOOT, arm-MUSIC. The tests for cued recall and recognition were the same as those used in Groups 1 and 2 of Experiment 1.

Procedure

Twenty-five subjects were randomly assigned to each of four groups and tested individually. The four groups were arranged in a 2 x 2 factorial design. One of the variables was the degree of relationship between the two words of a pair and the other variable was whether the subjects were asked to write the cue word belonging to each recognized target word. Thus, Group 1 was given related word pairs and was asked to write the cue word for each recognized target word, while Group 2 was given related word pairs but did not write down the cue word. Similarly, Groups 3 and 4 both were given unrelated word pairs with Group 3 writing down and Group 4 not writing down the cue word corresponding to recognized target words. The procedure of not writing cue words to recognized targets was employed as a relatively minor control device for a subsequent cued recall test. Therefore, we shall refer to Groups 1 and 3 as experimental and Groups 2 and 4 as control groups.

All three study lists were presented to each subject and the same instructions were administered as in Experiment 1. Following the presentation of List 1, all subjects were given 3 min for a cued recall test. The same procedure was followed for List 2. Immediately after presentation of the critical third list, all subjects were allowed 3 min for a recognition test in which they circled all of the target words they recognized. Upon completion of this task, Groups 1 and 3 were instructed to write the appropriate cue word next to each identified target word on the recognition test. Three minutes were permitted for this task. Groups 2 and 4 were given an additional 3 min for the recognition test. Finally, all subjects were given a 3 min cued recall test. The presentation order of each word pair was recorded in order to permit the construction of serial position curves.

Results and Discussion

Table 4 presents the mean number of correct responses on the recognition and cued recall tests for the critical third list for related and unrelated word pairs. An overall three-factor analysis of variance with repeated measures on one factor revealed significant main effects of degree of relatedness, $F(1, 96) = 72.94$, $p < .05$, and retention task, $F(1, 96) = 181.95$, $p < .05$. See Table 5. The effect of major interest however, was the significant interaction between relatedness and retention task, $F(1, 96) = 116.32$, $p < .05$. As can be seen in Table 4, this interaction stems from the fact that subjects who were given unrelated word pairs performed markedly less well on cued recall compared to subjects who received related word pairs. The main effect of procedures was not significant, thus indicating no differences between the experimental and control groups. This suggests that the procedure of writing the cue word next to each identified target word on the recognition test had no large effect on the cued recall test.

The mean number of correct responses on recognition and cued recall for related word pairs are presented in Table 6. A three-factor analysis of variance with repeated measures on two factors yielded significant main effects of retention task, $F(1, 48) = 4.09$, $p < .05$, and direction of association, $F(2, 96) = 21.55$, $p < .05$, (Table 7). The significant interaction between retention task and direction of association, $F(2, 96) = 11.72$, $p < .05$, indicates that performance on recognition and cued recall was a function of the direction of the

Table 4

Mean Number of Correct Responses on Recognition and Cued Recall for Related and Unrelated Cue-Target Pairs for Experimental and Control Procedures

	Recognition		Cued Recall	
	Experimental	Control	Experimental	Control
Related Pairs	15.80	15.56	14.88	14.68
Unrelated Pairs	13.36	13.76	5.92	5.04

Table 5

Three-Factor Analysis of Variance on Number of Correct Responses for Recognition and Cued Recall for Related and Unrelated Cue-Target Pairs for Experimental and Control Procedures

Source of Variation	Sums of Squares	df	Mean Square	F
Between Ss	3778.38	99		
Relatedness (R)	1630.21	1	1630.21	72.94*
Procedure (P)	2.65	1	2.65	$<$ 1.00
R x P	0	1	0	$<$ 1.00
Error b	2145.52	96	22.35	
Within Ss	2194.50	100		
Task (T)	1008.01	1	1008.01	181.95*
R x T	644.40	1	644.40	116.32*
P x T	4.80	1	4.80	$<$ 1.00
R x P x T	5.45	1	5.45	$<$ 1.00
Error w	531.84	96	5.54	
Total	11,945.76	398		

* $p < .05$

Table 6

Mean Number of Correct Responses on Recognition and Cued Recall for Related Cue-Target Pairs as a Function of Direction of Association for Experimental and Control Procedures

	Recognition		Cued Recall	
	Experimental	Control	Experimental	Control
High Forward-Low Backward	5.20	5.12	5.68	5.92
Low Forward-High Backward	5.76	6.00	5.00	5.44
Low Forward-Low Backward	4.84	4.44	4.20	3.32

Table 7

Three-Factor Analysis of Variance on Number of Correct Responses for Recognition and Cued Recall for Differential Association Direction of Related Cue-Target Pairs for Experimental and Control Procedures

Source of Variation	Sums of Squares	df	Mean Square	F
Between Ss	307.07	49		
Procedure (P)	.41	1	.41	< 1.00
Error P	306.66	48	6.39	
Within Ss	646.17	250		
Task (T)	6.75	1	6.75	4.09*
P x T	0	1	0	< 1.00
Error T	79.42	48	1.65	
Association (A)	115.53	2	57.76	21.55*
P x A	12.88	2	6.44	2.40
Error A	257.26	96	2.68	
T x A	33.74	2	16.87	11.72*
P x T x A	2.33	2	1.17	< 1.00
Error TA	138.26	96	1.44	
Total	1906.48	598		

* $p < .05$

associative probabilities in the cue-target pairs. As shown in Table 6 and in Figure 2, cued recall was better than recognition for word pairs with high forward and low backward associations. For word pairs with low forward and high backward associations however, recognition was better than cued recall. This interaction replicated the results found in Experiment 1 and is consistent with Olson's (1976) major findings. Performance on recognition and cued recall was a function of the differential associative asymmetries in the cue-target pairs. There was no main effect of procedures which indicated there were no differences between the experimental and control groups.

The mean number of correct responses on recognition and cued recall for unrelated word pairs are given in Table 4. It can be seen that recognition performance was substantially higher than cued recall. A two-factor analysis of variance with repeated measures on one factor revealed a significant main effect of retention task, $F(1, 48) = 266.69$, $p < .05$, thus demonstrating the superiority of recognition over cued recall. See Table 8. This result replicated Wiseman and Tulving's findings of recognition superiority with unrelated word pairs.

It was hypothesized that the recognition superiority found by Wiseman and Tulving was due to the high rate of single word storage occurring with unrelated word pairs. If this hypothesis is correct, then appropriate cue words should be written next to a small proportion of recognized target words in the unrelated condition. Table 9 shows that the proportion of cue words recalled for unrelated pairs was relatively small, approximately half of that for related word pairs,

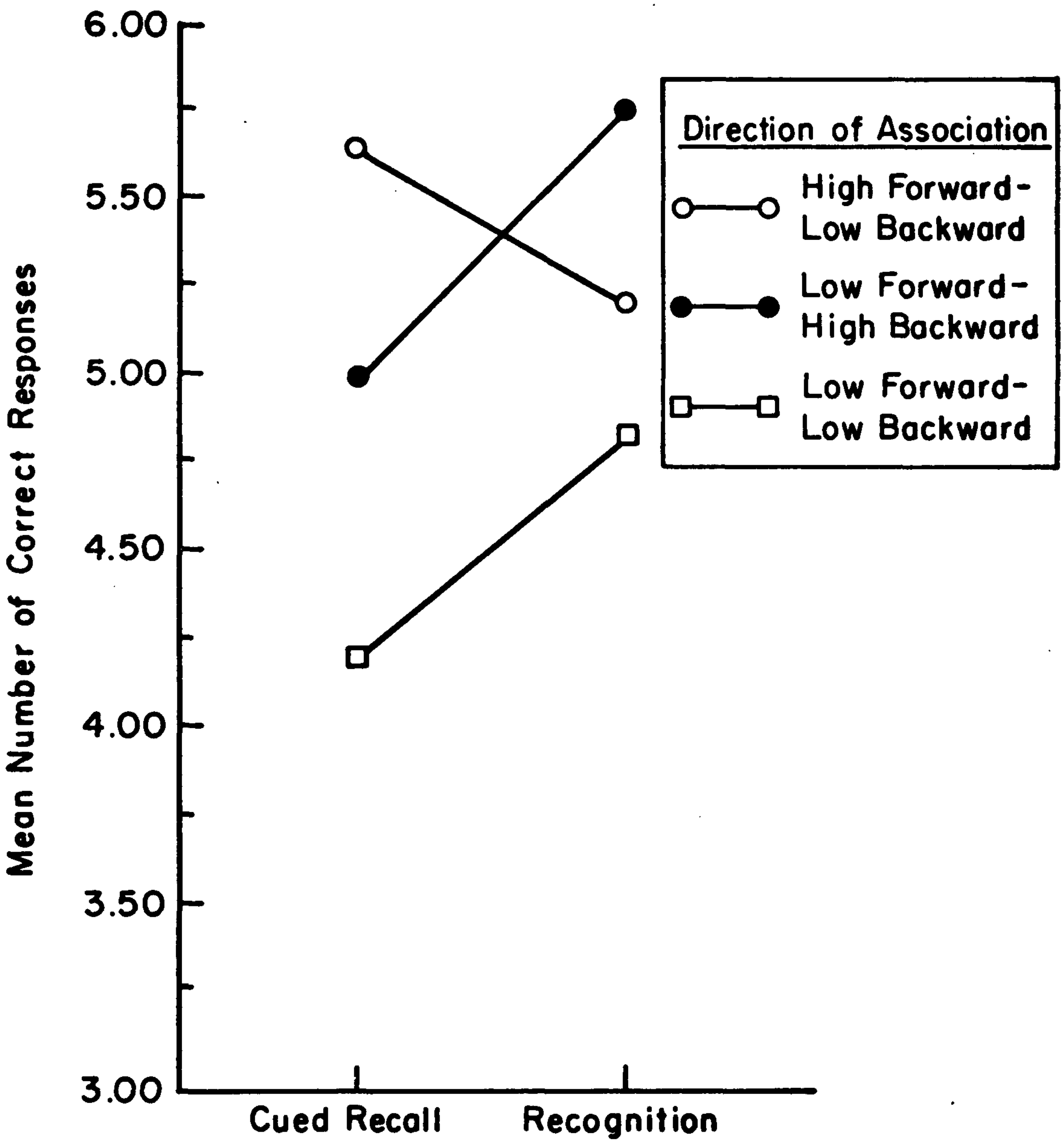

Figure 2. Mean Number of Correct Responses for Cued Recall and Recognition as a Function of Direction of Association of Related Cue-Target Pairs for Group Receiving the Experimental Procedure.

Table 8

Two-Factor Analysis of Variance on Number of Correct Responses for Recognition and Cued Recall of Unrelated Cue-Target Pairs for Experimental and Control Procedures

Source of Variation	Sums of Squares	df	Mean Square	F
Between Ss	1226.96	49		
Procedure (P)	1.44	1	1.44	< 1.00
Error P	1225.52	48	25.53	
Within Ss	1936.00	50		
Task (T)	1632.16	1	1632.16	266.69*
P x T	10.24	1	10.24	1.67
Error w	293.60	48	6.12	
Total	6325.92	198		

* $p < .05$

Table 9

Mean Proportion of Cue Words Recalled to Recognized Target Words for Related and Unrelated Cue-Target Pairs

	Direction of Association			
	High Forward-Low Backward	Low Forward-High Backward	Low Forward-Low Backward	
Related Pairs	.74	.81	.68	
Unrelated Pairs				.35

$t(48) = 10.34$, $p < .05$. As in Experiment 1, relatively large proportions of cue words were generated to recognized target words for related pairs. These results suggest that the words in the unrelated pairs tend to be stored more often as single words than as pairs. If word pairs are related however, the data indicate that the reverse is true and more words are stored as pairs than as single words.

Following the procedure used by Watkins and Tulving (1975), the data were placed in four-fold contingency tables which made it possible to analyze the number of target words that were: (a) both recognized and recalled, (b) recognized but not recalled, (c) recalled but not recognized, and (d) neither recognized nor recalled. Since only the data in the experimental groups allowed consideration of both single word and pair retrieval, only these data were considered. In any case, there were no gross differences in the contingency tables between the experimental and control procedures.

The recognition and cued recall contingency tables for related and unrelated word pairs are presented in Tables 10 and 11, respectively. Analysis of these data provided another test of the hypothesis that superiority of recognition over cued recall is due to the high rate of single word storage with unrelated word pairs. If the hypothesis is correct, the proportion of target words recognized as single words but not recalled should be greater for unrelated compared to related word pairs. The data supported this hypothesis.

There is additional evidence in the data consistent with the assumption that there is more pair than single word storage with related word pairs and more single word storage with unrelated pairs.

Table 10

Number and Proportion of Responses in Recognition and Cued Recall for Related Cue-Target Pairs for Group Receiving the Experimental Procedure

	Recognized	Not Recognized
Recalled	311 (.52) 270 Pairs (.87) 41 Singles (.13)	61 (.10)
Not Recalled	84 (.14) 26 Pairs (.31) 58 Singles (.69)	144 (.24)

Table 11

Number and Proportion of Responses in Recognition and Cued Recall for Unrelated Cue-Target Pairs for Group Receiving the Experimental Procedure

	Recognized	Not Recognized
Recalled	136 (.23) 101 Pairs (.74) 35 Singles (.26)	13 (.02)
Not Recalled	198 (.33) 21 Pairs (.11) 177 Singles (.89)	253 (.42)

The contingency tables show that the proportion of words that are both recognized and recalled is far greater for related words compared to unrelated words. Of those words both recognized and recalled, the proportion of word pairs compared to single words is higher for related than for unrelated words.

Wiseman and Tulving had reported two major results with unrelated word pairs: overall recognition superiority over cued recall and the recognition failure of recallable words. According to DeVito's model, the phenomenon of recognition failure of recallable words can be understood as a function of peg word storage. If cued recall requires the storage of word pairs, and word pairs are stored in terms of peg words, as DeVito's model assumes, then the proportion of word pairs recalled but not recognized should be greater for related compared to unrelated word pairs. The data supported this prediction.

The mean proportion of cue words generated to recognized target words in Experiments 1 and 2 for related words was .81 and .74, respectively. These values represent averages across all three degree of association categories. The mean proportion of cue words generated to recognized target words in Experiment 2 for unrelated words was .35. The results for related cue-target word pairs support the hypothesis that subjects are learning word pairs in the Tulving and Thomson paradigm. When word pairs are unrelated however, the data indicate that more words are stored and retrieved as single words than as pairs. Nevertheless, even for related cue-target words, the storage and retrieval of word pairs is less than perfect. A small proportion of words are retrieved as single words and not as pairs.

One source of single word storage for related pairs of words is the storage of single words in immediate memory. Specifically, certain words which are among the last stimulus items in the presentation order of a study list may be stored in immediate memory even though the peg-storage procedure has not worked. If this hypothesis is correct, one would expect to retrieve a greater number of single words from the end of the list of cue-target pairs than at any other point and we should find a serial position effect.

Serial position curves were constructed from the recognition data for both related and unrelated word pairs for the groups receiving the experimental procedure. Figure 3 presents the serial position curves for recognized single target words as a function of related and unrelated cue-target pairs. The data provided no support for the hypothesis that words recognized as single words are more likely to be in the last part of the list.

The results of the second experiment suggest that the recognition superiority over cued recall found by Wiseman and Tulving is due to the high rate of single word storage that occurs with unrelated word pairs. On the other hand, the data indicate that related word pairs are stored more often as pairs than as single words.

The phenomenon of recognition failure of recallable words also reported by Wiseman and Tulving for both related and unrelated word pairs can be understood as a function of the peg word storage of word pairs. The predictions derived from DeVito's model concerning the recognition-recall contingency tables were supported by the data. In this regard, it is important to note that the present data confirmed

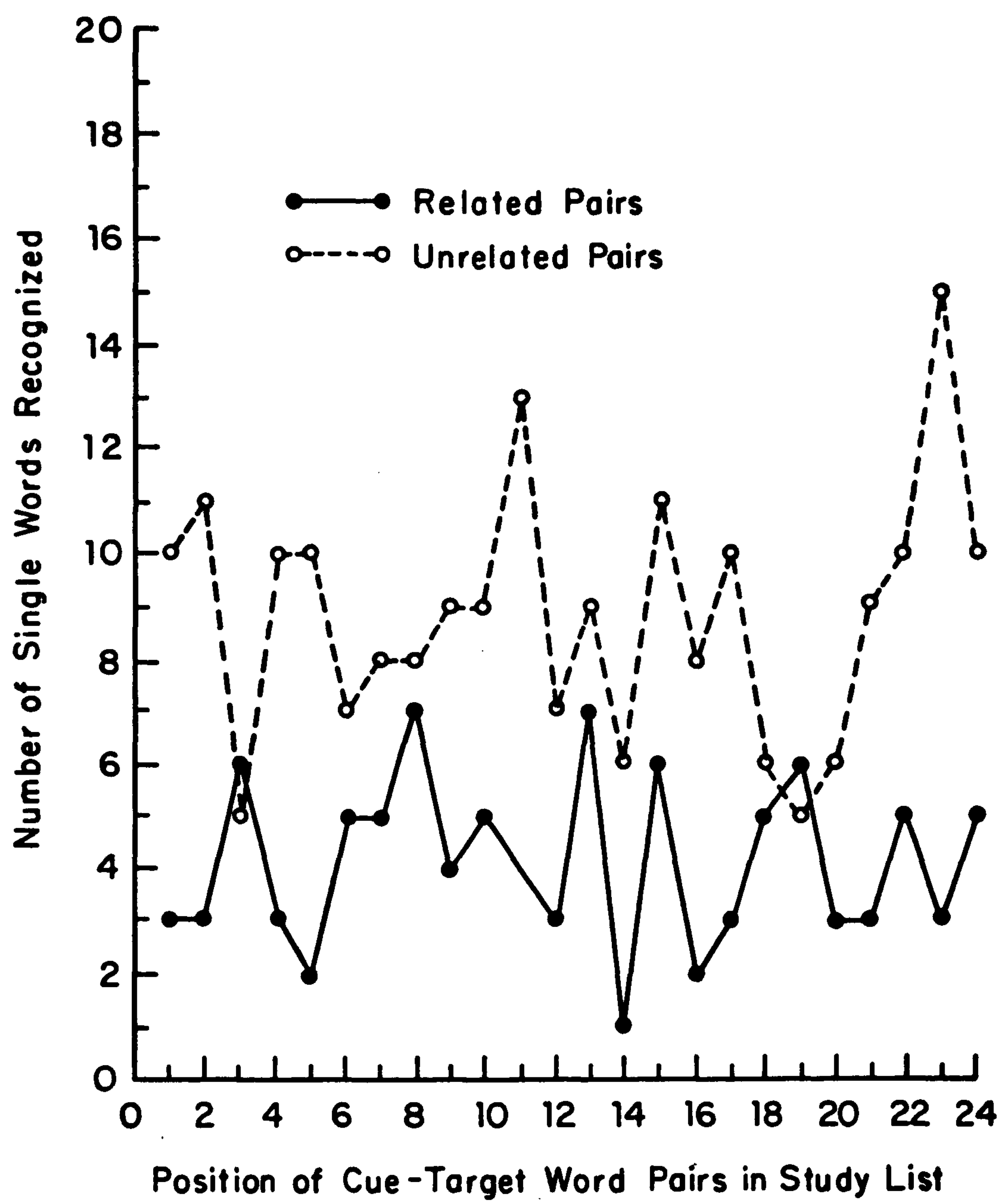

Figure 3. Serial Position Curves Showing Number of Single Words Recognized at Each Position as a Function of Related and Unrelated Cue-Target Pairs.

predictions not only for the recall-not recognize retrieval outcome, but for the recognize and recall, and recognize-not recall contingencies as well. In contrast, Wiseman and Tulving directed their attention exclusively to the recall-not recognize contingency, the basis of their encoding specificity phenomenon and failed to deal with the other retrieval outcomes.

In general, the results of the second experiment suggest that DeVito's model provides a more comprehensive explanation of the recognition failure of recallable words than does episodic theory. The model addresses directly some of the basic problems of storage and retrieval at issue in the data reported by Tulving and his colleagues. For example, Tulving's encoding specificity principle states that "specific encoding operations performed on what is perceived determine what is stored, and what is stored determines what retrieval cues are effective in providing access to what is stored." (Tulving & Thomson, 1973, p. 369). The proposals made by DeVito have the advantage of specifying the nature of the encoding operations (peg word storage of pairs, or single word storage) on what is perceived and identifying the specific retrieval cue (the peg word member of a stored pair, or a single word) that provides access to what is stored.

GENERAL DISCUSSION

Tulving and Thomson (1973) have observed that the experimental and theoretical separation between storage and retrieval processes represents a relatively new approach to the investigation of human memory. Many theorists are now concerning themselves with retrieval processes whereas twenty years ago "memory was still a matter of acquisition, retention, transfer, and interference of associations between stimuli and responses. . . . Today the orienting attitudes clearly include the notion that both recall and recognition are more or less complex retrieval operations or processes." (Tulving & Thomson, 1973, p. 352).

If the retrieval process has not until recently been recognized as a separate entity and if it has been neglected by students of verbal learning in the past, then it is appropriate that it should become a subject for theoretical and experimental investigation. Nevertheless, any theory of human memory should ideally include both storage and retrieval processes, not one or the other. Without considering both operations, any theory would seem incomplete. Since they are the beginning and end points of memory, storage and retrieval mechanisms should be developed with regard to each other, for if they are not intimately related, one suspects minimally that the storage process may influence subsequent retrieval operations and the retrieval process may be dependent in some way upon the storage mechanism.

Tulving and Thomson point out that many of the most widely accepted theories of retrieval used to account for cueing effects, that is, effective retrieval cues of all sorts, are several versions of the generation-recognition models of information processing. These models assume that there are two successive stages of the retrieval process: (a) implicit generation of possible response alternatives and (b) recognition of one of the generated alternatives as the to-be-remembered word. The process of generation of response alternatives can be frequently influenced by the semantic information the subject may have about the cue word. For example, the cue word "dessert" may implicitly generate the response word "cake." The success of the recognition process however, depends upon the availability of relevant episodic information. That is, a particular response word would be recognized as correct if its internal representation carries an appropriate "occurrence tag" (Mandler, 1972) which provides information about the temporal-spatial relations of the word in a particular study list.

According to generation-recognition models, "Effective retrieval cues of all sorts, including extralist cues, facilitate recall . . . because they reduce the probability that the desired information, although available in the memory store, cannot be found. Cued recall, in this view, produces a higher level of retrieval than does noncued recall for the same reason that recognition is higher than recall." (Tulving & Thomson, 1973, p. 357).

Bahrick (1969) states that a cue or a prompt "is likely to produce a hierarchy of responses as a result of past learning. . . . One of these responses is likely to be the training response. S is thus unburdened of the search strategy involved in unaided recall tasks. He continues to produce responses associated with the prompt until he can identify one of them as the response presented during training. This portion of the prompted recall task functionally approximates a recognition task." (Bahrick, 1969, p. 217).

According to Tulving and Thomson, the generation-recognition models offer a reasonable explanation of the "extralist cueing effect," facilitation of recall of list items by nonlist items. However, the theory predicts that a subject will recognize all of the items he can recall and therefore cannot account for Tulving's phenomenon of the recognition failure of recallable words. Tulving argues that "recovery of information through two bottlenecks (generation and recognition) in a recall situation cannot be more effective than that through only one of the two (recognition)." (Tulving & Thomson, 1973, p. 365).

It is in the context of generate-recognize models of cued recall of pairs of words that the Tulving and Thomson finding of superiority of cued recall over recognition of target words takes on its major impact. According to the generate-recognize model, recognition would have to be uniformly superior to recall, even cued recall, and we should not find a recognition failure of recallable words. Thus, even in situations where recognition shows an overall superiority, as in Wiseman and Tulving (1976) and our Experiment 2, the existence of recognition failure for some recallable word pairs is a blow to prior theories.

Tulving and Thomson have taken the position that the nature of the encoding process determines what cues are effective in recognition and in recall in their encoding specificity principle: "Specific encoding operations performed on what is perceived determine what is stored, and what is stored determines what retrieval cues are effective in providing access to what is stored." (Tulving & Thomson, 1973, p. 369). Consequently, it is possible to gain access to a stored word with an appropriate cue even though the stored word is not available or cannot be recognized without the appropriate cue; in short, recognition failure of recallable words. Thus, a general position on the importance of encoding processes on retrieval took on specific experimental content.

The work done by Olson (1976) demonstrated that the phenomenon of recognition failure of recallable words found by Tulving and Thomson could be explained as the result of the pre-experimental asymmetries present in their cue-target word pairs. Olson showed specifically that for adjective-noun cue-target pairs recognition was superior to cued recall. Word pairs having the opposite asymmetry produced better cued recall compared to recognition. He then generalized this result to noun-noun pairs with directional asymmetries in their associability, and we have replicated those findings in our Experiments 1 and 2. Therefore, Olson was able to predict either superior recognition or cued recall performance as a function of the directional asymmetries between a particular cue-target word pair. Olson concluded that the experimental results obtained by Tulving and Thomson were based on a procedural artifact, the asymmetries inherent in their cue-target pairs.

In this way, Olson sought possibly to save generate-recognize models of pair learning and retention by criticizing Tulving and Thomson on methodological grounds. In addition, however, he took positive steps to clarify what was being learned in the Tulving and Thomson experimental paradigm and in paired-associates learning more generally. At the same time, DeVito (1976), proceeding along the same lines and Salzberg (1976), working independently, came to the conclusion that the subject's task in the Tulving and Thomson procedure involves the learning of word pairs. Salzberg's experiments indicated that access to a particular word pair was dependent upon the relative concreteness of the cue and target words. He found the greatest amount of "recognition failure of recallable words" with concrete noun cues. Although Salzberg does not present a formal theory to account for Tulving's phenomenon, he discusses the possibility that a cue and target word may be unified in terms of an image.

DeVito has carried the analytic procedure a number of steps forward and has provided a descriptive probabilistic model for paired-associates storage and retrieval. He performed a number of specialized experiments which successfully tested quantitative predictions from the model. At the heart of DeVito's model is the theoretical notion that word pairs are stored through use of a peg word and that if the peg word is recalled, both words in the pair will be recalled, while if it is not, with minor exceptions for related words at least, neither word will be recalled. Thus, DeVito provided a major mechanism for the understanding of memory for pairs of words. The experiments reported above sought to test implications of that mechanism for the Tulving and Thomson experimental paradigm.

The main purpose of the first experiment was to make a direct test of Olson's hypothesis that subjects are learning word pairs in the

Tulving and Thomson paradigm. The results strongly supported the hypothesis. Appropriate cue words were generated for the majority of recognized target words. In addition, an indirect test of this hypothesis was made comparing the results of the two recognition tests with a cued recall procedure in which subjects responded with the appropriate cue word for each target word presented. There were no significant differences in performance between the three tests. The hypothesis that subjects are learning word pairs in the Tulving and Thomson paradigm was once again strongly supported. The demonstration that subjects are learning word pairs is important in several respects.

1. It provides new information which permits a greater understanding of the processes underlying the Tulving and Thomson phenomenon of "recognition failure of recallable words." Although each cue-target item consists of two words, each word pair is apparently processed as a single stimulus unit.

2. It strengthens the notion of peg word storage. If subjects are learning word pairs in the Tulving and Thomson procedure, they may be storing each pair in terms of a peg word. In the present research, once pair learning was demonstrated, it permitted the application of DeVito's model.

3. In the broadest sense, evidence for the learning of word pairs, or compound items, suggests that a number of human memory processes may involve organized structures rather than isolated stimulus items.

Other results in the first experiment were in agreement with Olson's primary findings. Performance on cued recall and recognition was a function of the direction of the associative probabilities in the cue-target word pairs. An explanation of these results in terms of DeVito's model has been presented in the General Introduction. DeVito's model can be adapted to Olson's experimental procedure since the recognition task is similar to a cued recall task with the to-be-remembered word as the cue. Therefore, DeVito's conceptualization provides a framework for understanding Olson's results. The phenomenon of recognition failure of recallable words may be explained by the model as a function of peg word storage.

In addition, the results of the first experiment indicated that the degree and direction of association between the members of a word pair influences the probability of storage and retrieval of the pair. Highly associated pairs were more likely to be retrieved as pairs in both cued recall and recognition. It would seem that a high degree of association between the members of a word pair makes the storage process easier. If, as DeVito's model assumes, the storage mechanism involves some constructive process such as the formation of images or narratives, the process may be facilitated if the word pair is related. Similarly, the selection of a peg word may be easier with related or associated words. Related words have a greater probability of having been associated together in a subject's past experience and consequently, any subsequent experience with them may be facilitated.

The data also indicated that the more successful access to a specific word pair was through the word having the higher associative probability. This result is consistent with peg word selection and storage and justifies the assumptions made concerning the selection of specific peg words in the present experiments. It is reasonable to assume that the word selected as a peg word is in some sense outstanding whereas the other member of the word pair, which is stored in relation to the peg word, is correspondingly subordinate.

Wiseman and Tulving (1976) used unrelated cue-target word pairs within a Tulving and Thomson paradigm and failed to obtain the traditional result of cued recall superiority over recognition found with related word pairs. Instead, recognition was superior to cued recall. The phenomenon of recongition failure of recallable words was still observed, however. Wiseman and Tulving did not account for their result of recognition superiority found with unrelated word pairs. DeVito's model however, can account for this result in terms of single word storage.

The second experiment tested the hypothesis that the inflated recognition performance in the Wiseman and Tulving experiments is due to the high rate of single word storage that occurs with unrelated word pairs. This result is in contrast to related or associated cue-target pairs that are stored more often as pairs than as single words. The hypothesis was supported. Appropriate cue words were written next to a relatively small proportion of recognized target words for unrelated pairs.

It will be recalled that these results were suggested by the data in the first experiment. Related or highly associated word pairs were more likely to be retrieved as word pairs compared to less related or associated pairs. There are some possible reasons for this. In an unrelated word pair, neither cue nor target word may be an obvious candidate for a peg word. Image or narrative construction may therefore be more complicated and require more time.

Although DeVito's notion of single word storage can account for the superiority of recognition over cued recall, it is possible to formulate a model which explains the same results in terms of a different conceptual framework. For example, one may propose a memory model in which related word pairs, for whatever reason, receive multiple representation in the storage mechanism whereas unrelated word pairs, which may be more difficult to store, are given single, or at least fewer representations in storage. During retrieval, the probability of retrieving a word pair would be greater for related word pairs which have multiple representations whereas retrieval failures, in the form of the recall of single words, would be most likely to occur with unrelated word pairs which have fewer representations in memory.

According to DeVito's model, "single word storage" refers to the failure to store a word pair during the storage process. In the multiple representation model however, it is assumed that word pairs are always stored as pairs in greater or lesser numbers and the retrieval of a single word rather than a word pair represents a retrieval failure rather than the failure to store a word pair.

Although both models predict superior recognition over cued recall for unrelated word pairs, they lead to different predictions of recognition performance. The multiple representations model predicts that fewer unrelated target words would be recognized compared to related target words because they have fewer representations in storage.

DeVito's model however, does not predict this difference and the data show that the number of words recognized for related and unrelated word pairs is similar.

Although independent studies will have to be done to determine what is actually being stored in the Tulving and Thomson procedure, the data suggest that DeVito's model may be more appropriate than a model of multiple representation in storage. In addition, the results of the second experiment illustrate the need to consider both storage and retrieval processes in explaining the Tulving and Thomson data.

It should be emphasized that use of the theoretical framework of DeVito's model allows us to state the conditions under which recognition performance will be superior, namely, the learning of single words, whereas Wiseman and Tulving did not. This state of affairs exists to a greater or lesser degree throughout the present research. Use of the notion of peg word storage provides a theoretical account of the results obtained in these experiments whereas Tulving's episodic theory and the encoding specificity principle either fail to do so or do so inadequately. It is of special significance in this regard that the present experiments replicate Tulving's phenomenon of the recognition failure of recallable words. The expectations derived from DeVito's model concerning the data in the recognition-recall contingency tables of Experiment 2 were supported by the data. Three of the four retrieval contingencies were accounted for. Wiseman and Tulving however, dealt exclusively with the result of the recognition failure of recallable words. Thus, DeVito's model was able to account for more data than Wiseman and Tulving.

DeVito (1976) has shown that his model can serve as a basis for the integration of other studies dealing with the storage and retrieval of word pairs. The model has successfully explained or predicted the data reported by Horowitz and Prytulak (1969), Karchmer (1974), and Begg (1972), in addition to those already mentioned.

Although DeVito developed his model for word pairs, he has suggested that it may be extended to multiple compound events such as word triads. It may also be possible that the model is applicable to memory processes of storage and retrieval in general. For example, a series of words or a sentence may be stored in terms of a single word or two which function as peg words. Similarly, several sentences or more may be organized and stored in terms of a few key words or ideas which function as pegs and then elicit the stored information during retrieval.

The experimental evidence for category clustering, the success of mnemonic devices and the notion of chunking all suggest that people characteristically try to impose order and organization on material which is to be learned. Perhaps the processes of storage and retrieval, as they are conceptualized in DeVito's model are at the foundation of these methods for organizing verbal information. For example, students faced with the task of learning large amounts of information often organize their material in an outline form which includes main headings and subordinate subdivisions. These headings and subdivisions may function as pegs for information stored underneath them. Textbooks and review books are organized in this way and they are presumably written for maximum facilitation of learning.

Memory may thus be conceptualized as a kind of index system in which access to information is gained most successfully through specific peg words. Peg word storage and retrieval may help explain why the presentation of specific cues or "reminders" can aid in the recall of information which would otherwise not be remembered.

In a sense we have come full circle. Both DeVito's model and the Tulving and Thomson encoding specificity principle lay heavy emphasis on initial learning in retrieval processes. The problem with encoding specificity is that it is not specific. It does not specify the storage process. DeVito's notion of peg word storage and retrieval may provide the needed details to enable us to develop expectations about experimental outcomes for a number of situations. In a sense then, it is an elaboration of the encoding specificity principle for paired-associates learning.

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