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A MODEL FOR FREE AND CUED RECALL

by

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Abstract

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A number of studies employing compound items, specifically word pairs, have recently been performed in the contexts of redintegrative memory, "imagery", and retrieval processes in memory. Although these studies differ in theoretical orientation and detail, the basic paradigms are quite similar, and the theoretical developments appear to be converging upon the notion that, at least under certain conditions, what is stored in, and retrieved from, memory is some trace of the whole event rather than of the parts. These studies then, suggested the development of a simple quantitative model for the free and cued recall of word pairs, incorporating a notion of whole storage and retrieval.

In terms of storage, for both free and cued recall, the model assumes that during presentation some words are stored as pairs and others as single words. Pair storage may be considered a function of some constructive process such as the formation of images or narratives. Furthermore, it is assumed that the subject uses one member of a pair as a conceptual peg for the other pair member. This notion is similar to Paivio's conceptual peg hypothesis of paired associate learning.

During retrieval in the free recall situation, 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 assumed to be 0. In the cued recall situation, it is assumed that the presentation of the cue words at testing facilitates the retrieval of cue words that are peg word members of stored pairs.

These assumptions are formalized in probability terms and the appropriate estimation procedures are specified to allow a test of the model. Experiments 1 and 2 provide a test of the model with items that are rated high in terms of imagery-concreteness. Experiment 3 tests the model with items that are rated low on imagery-concreteness. For free recall, the results of all three experiments, separately and combined, show strong correspondence between the observed values and the values predicted by the model for the number of words recalled in correct pairs, the number of words recalled not in correct pairs, and the number of words not recalled. For cued recall, the observed results also correspond quite closely to the values predicted by the model for the number of correct cued recalls.

Studies in the areas of redintegrative memory, "imagery", and retrieval processes in memory are discussed in the context of the current model.

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A number of studies employing compound items, specifically word pairs, have recently been performed in the contexts of redintegrative memory (Horowitz & Prytulak, 1969; Karchmer, 1974), "imagery" (Begg, 1972; Paivio, 1971), and retrieval processes in memory (Watkins & Tulving, 1975, which presents a summary of the work by Tulving and his associates). A review of these studies suggests that they differ in theoretical orientation and detail, but the basic paradigms are quite similar, and the theoretical developments appear to be converging upon the notion that, at least under certain conditions, what is stored in, and retrieved from, memory is some trace of the whole event rather than of the parts. Consequently, an attempt is made here to develop a simple quantitative memory model for word pairs, incorporating a notion of whole storage and retrieval, that may serve as a more precise basis not only for integrating these apparently independently evolving areas of research, but also for the investigation of compound memory events in general.

A notion of redintegration was introduced by Hollingsworth (1928). He proposed that mental processes, as natural phenomena, can be viewed as sequential, consisting of antecedents and consequents in which the antecedent of one sequence is often the consequent of a prior sequence. Furthermore, the unifying factor in all mental activity is the principle of redintegrative sequence. "The word 'redintegrative' will commonly be used instead of the word 'mental'. By a mental process or a redintegrative sequence, then, we shall mean a series of changes in which a partial antecedent functions appropriately or adequately for a former antecedent of greater complexity." (Hollingsworth, 1928, p. 6). That is, "In the case of a mental process or sequence the original antecedent (or its very like) is not required to produce a given consequent (or its very like). Instead, some detail or fragment is adequate to touch off a consequent of the type formerly evoked by a more complex antecedent. Of this antecedent the instigating fragment (or its very like) was formerly but a part." (Hollingsworth, 1928, p. 5). In terms of memory, "The essential point is then that the memory of an object or event . . . is some present event which, as a cue or instigating detail, functions redintegratively for the original context." (Hollingsworth, 1928, p. 259). As an example, he discusses the recall of 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).

Horowitz and Prytulak (1969) discuss redintegration as one kind of memory process. In an attempt to operationalize the notion, they specify a criterion for determining when a situation can be characterized as redintegrative. They conceptualize the problem as deciding whether a part of a display is eliciting the whole display or another part of the display. "Suppose S studies 'AB' and then is shown the stimulus A. And suppose he responds B. Two alternative interpretations are possible. Part A might be viewed as eliciting Part B, or Part A might be eliciting the entire AB, which then yields S's overt response B." (Horowitz & Prytulak, 1969, p. 519). In a free recall situation, each pair can be denoted W_i with the component words A_i and B_i. $P(A_i)$ is the probability of recall of A_i, and $P(B_i)$ is the probability of recall of B_i. $P(W_i)$ is the probability of recall of the pair W_i. They define memory as redintegrative when the conditional probabilities $P(W_i|A_i)$ and $P(W_i|B_i)$ are very high. Pairs for which memory is redintegrative by their criterion appear to show a consistent relationship between free and cued recall. This relationship, or principle of redintegrative power, as they label it, asserts that the member of a pair that is better remembered in a free recall of pairs task will be the better cue in a cued recall task. As a demonstration of this principle, Horowitz and Prytulak (1969) did an experiment using noun-adjective and adjective-noun phrases previously used by Lockhart (1969). Lockhart had found for these items that the noun was the better cue in cued recall. The subjects were given the phrases and then asked to recall as many phrases as they could. If they could only remember a single word they were to write down that single word. Analysis of the results of the experiment showed that the conditional probabilities P(whole|noun) and P(whole|adjective) were high and there was a significant superiority of noun over adjective recall. These findings, of course, are consistent with the principle of redintegrative power.

Karchmer (1974) developed a "proportion of unitization" based on Horowitz and Prytulak's (1969) index. He symbolized a word pair as W_i and each member of the pair as M_i. The conditional probability $P(W|M)$ is the proportion of unitization and is said to be an index of the degree of redintegration, the degree to which pair members occur together at testing. Furthermore, it is argued that if words are recalled together because they were in some way associated in memory, then this index can be considered a measure of the degree of association, or unitization, of elements in storage. Consequently, cued recall should be a direct function of this index. When the index is low, cued recall should be relatively low. When it is high, cued recall should also be relatively high. To test the hypothesis, Karchmer (1974) carried out two experiments in which, using word pairs, he varied the rated imagery-concreteness value of the members of the word pairs and the instructional set in an attempt to obtain different values of the proportion of unitization. As hypothesized, the results of both experiments indicated that there was a direct relationship between the value of the proportion of unitization based on noncued, or free, recall and the cued recall level.

In the area of "imagery" research, Begg (1972), expanding upon the work of Paivio (see Paivio, 1971, for a review) and Epstein, Rock, and Zuckerman (1960), assumed that images aroused by members of a word pair could be combined into an integrated image which would be treated as a unit by the memory system. Using the examples of the concrete word pair "white horse" and the abstract word pair "basic theory", this assumption leads to two hypotheses. "If it takes a certain amount of memory capacity to retain horse, it would not increase the load if the horse were white, so that two 'words' might become one 'image'. On the other hand, if a theory were basic, the storage requirements would be increased. Second, if the S, for whatever reason, retrieved horse, then white would probably be retrieved as well. Thus, cueing recall should help with concrete phrases. With abstract phrases, however, . . . a similar facilitation would not be expected." (Begg, 1972, pp. 431-432).

As a test of the first hypothesis, one group of subjects received 40 adjective-noun phrases composed of 10 concrete adjective-concrete noun (CC) phrases, 10 abstract-abstract (AA) phrases, 10 abstract-concrete (AC) phrases, and 10 concrete-abstract (CA) phrases. Another group was given just the 40 adjectives from the phrases, and another group the 40 nouns. After list presentation, each subject was asked to recall. The strong form of the prediction for this experiment was " . . . proportionate recall of words in abstract phrases will be half as high as for the words alone, while there will be no difference between the two conditions in concrete phrases." (Begg, 1972, p. 432). Comparing word and phrase recall for CC phrases, the number of nouns recalled in the noun group was not significantly different from the number of nouns recalled in the phrase group. The same was true for the adjectives. "The prediction that free and whole recall of concrete words would not differ was thus strongly supported." (Begg, 1972, p. 433). For AA phrases, approximately half as many adjectives and nouns were recalled in the phrase group as compared with the adjective and noun groups.

To test the hypothesis that cueing should help only for CC phrases, two groups of subjects were given the same phrases as in the prior experiment. The first group of subjects was instructed to recall only nouns. The second group was given the adjectives to cue noun recall. The prediction that cued recall would exceed free recall only for the CC phrases was supported by the data.

In the context of retrieval processes in memory, Tulving and his associates have developed what has been labeled episodic theory. 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). Furthermore, as suggested earlier by Olson (1975), " . . . the unit of memory in our experiments might best be thought of as the episode defined by the subject's encounter with the successive word pairs, rather than with the individual words." (Watkins & Tulving, 1975, p. 27). In terms of the retrieval process, "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, although the assumption that remembering requires an interaction between trace and retrieval information also holds for those situations designated as free recall." (Watkins & Tulving, 1975, p. 6).

This theory is consistent with the somewhat surprising finding of recognition failure of recallable words. (Tulving & Thomson, 1973; Watkins & Tulving, 1975). Their subjects were presented with word pairs composed of "cue" words and weakly associated "target" words and then given a recognition and cued recall test for the target words. It was found that fewer target words were recognized than recalled and the proportion of recalled words that were not recognized was much larger than the proportion of recognized words not recalled. Episodic theory is consistent with this finding in that "the retrieval cue in a recognition test consists of a nominal copy of the . . . 'target' item. . . . recognition can fail because the retrieval cue, although nominally identical with the focal element of the target episode, does not contain information sufficiently similar to that in the target trace." (Watkins & Tulving, 1975, pp. 6-7).

These studies then, suggested the development of a simple quantitative memory model for word pairs, incorporating a notion of whole storage and retrieval. Specifically, a model is presented which generates quantitative predictions for the experimental situations of free and cued recall of word pairs. The strategy adopted was to develop the model for the free recall situation and then specialize it for cued recall.

The theoretical problem can be decomposed into specification of the memory representation at the time of testing and the retrieval process.

Consider the free recall of pairs experimental situation. The subject is told that he will be presented pairs of words and later will be asked to write down as many as he can remember. He is presented the items, then at test time told to write down as many pairs as he can, or single words from pairs if he can't remember pairs. The protocol will exhibit correct pairs, and other words. Given the protocol and the overall experimental situation, one of the simplest assumptions concerning storage is that some words are stored as whole pairs and others as single words. Pair storage may be considered a function of some constructive process such as the formation of images or narratives. Furthermore, for the types of materials considered here, it is assumed that the subject uses one member of a pair as a conceptual peg for the other pair member. This notion is similar to Paivio's conceptual peg hypothesis of paired associate learning insofar as one member of a pair " . . . functions as a 'peg' to which . . . " the other pair member " . . . is hooked during learning . . . " and " . . . from which it can be retrieved . . . " during recall. (Paivio, 1971, p. 248). 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. It may not be precisely 0 since guessing may occur, which is assumed to be the source of the incorrectly matched pairs that appear in the protocol, but the difference from 0 is assumed to be negligible. In any case, the estimation procedures to be described later are assumed to account for guessing.

These assumptions may be formalized in probability terms as follows: P(RL) = the probability of retrieval; P(PEG) = the probability of a stored peg word; P(SGL) = the probability that a word was stored as a single word. The expressions for the probability of a correct pair recall, P(P); recall of a word in an incorrect pair or as a single word, P(S); and word nonrecall, P(0); would take the following forms.

$$P(RL)P(PEG) = P(P) \qquad (1)$$

$$P(RL)P(SGL) = P(S) \qquad (2)$$

$$1-P(P)-P(S) = P(0) \qquad (3)$$

To obtain an estimate of P(RL), a group of subjects can be given the words used in the pair recall situation in a free recall of words situation. The mean proportion of words correctly recalled may be considered to be an estimate of P(RL). Since Begg (1972), in comparing word with phrase recall, presented the words and the phrases at the same rate, it was decided that the per item presentation rate for this estimation task group would be the same as for the word pair group. Furthermore, to insure that the overall cognitive load of this estimation task would be comparable to the load for the pairs task, the same number of words was given to the estimation group.

To obtain an estimate of P(PEG) and P(SGL), the following procedure was conceived. A group of subjects would be presented with the pairs used in the free recall of pairs situation, but at test they would be given the full list of words in a random order and told to write them as they were paired at presentation. The same assumptions as to storage and retrieval used for the free recall of pairs situation are considered to apply here. Consequently, here also, P(RL)P(PEG) = P(P) and P(RL)P(SGL) = P(S). However, it was assumed in this situation, that during testing, as a subject read a word, if that word were stored as a peg word or a single word, the memory representation for that word would be accessed and this would be comparable to retrieving the word. If the "retrieved" word was stored as a peg, then the other member of the presented pair would also be retrieved and the subject would write down the pair. If the word was stored as a single word, then the subject would write it down as a single word or, under the instructional set pair it up with another word by guessing. Now, since all the words are given to the subject, it is assumed that P(RL) = 1.0 in this procedure. Consequently, the expression for P(P) becomes P(PEG) = P(P), and the expression for P(S) becomes P(SGL) = P(S). It is seen then, that the probability of recalling a correct pair, P(P), is equivalent to the probability of a stored peg word, P(PEG). Thus, in this situation, the mean proportion of words in correctly recalled pairs which is equivalent to the mean proportion of correctly recalled pairs may be taken as an estimate of P(PEG). Strictly speaking, this probability estimate includes the probability of a correct guess, but it is assumed to be negligible. In any case, the process is thought to be the same in the free recall of pairs condition. The probability of recalling a single word not in a correct pair, P(S), is equivalent to the probability of a stored single word. In this situation, the mean proportion of recalled words not in correct pairs may be taken as an estimate of P(SGL).

Experiment 1 was designed to provide a test of this model.

EXPERIMENT 1

Method

Subjects

The subjects were 75 introductory psychology students who volunteered to participate in partial fulfillment of their course requirement.

Materials

Two sets of eight words each were selected so as to be equated for mean imagery (I), concreteness (C), meaningfulness (M), according to Paivio, Yuille, and Madigan (1968), and mean frequency (F) according to Kucera and Francis (1967), while keeping within set variability for these variables at a minimum. The words are given in Table 1 and the I, C, M, and F values are given in Table 2. Each word from randomly designated set 1 was randomly paired with a word from set 2 to form eight set 1-set 2 pairs. Each pair was typed with the words separated by a dash in the center of a .10 m x .15 m index card. Also, each of the 16 words from the two sets was typed on an index card to form a set of 16 cards. Five random orders of the 16 words were prepared. Each random order was typed in a column on a separate sheet of paper. Three cued recall sheets containing different random orders of the set 1 (stimulus) items were constructed.

Procedure

Subjects were randomly assigned to one of four conditions: free recall words (FRW), n = 22; association (A), n = 22; free

Table 1

Words for Experiment 1

Stimulus	FRW recall	Response	FRW recall
CHIN	18	MICROSCOPE	7
COLONY	16	POET	13
COMMITTEE	12	STRING	8
DRESS	13	GENTLEMAN	12
DUMMY	16	MACHINE	18
HURDLE	17	POLE	11
SEAT	12	SQUARE	12
VILLAGE	11	ENGINE	14

Table 2

I, C, M, and F Values for the Words in Experiment 1

Words	*I*	*C*	*M*	*F*
Stimulus set 1	6.02	6.57	5.51	52.75
Response set 2	6.13	6.61	5.69	59.00

recall pairs (FRP), n = 23; and cued recall (CR), n = 8. There were only eight subjects in the CR group because this condition was instituted after the experiment had begun. In all conditions subjects were individually tested.

Each subject in the FRW condition was told that he would be shown a set of index cards, each card would have a word on it, and later he would be asked to write down as many words as he could remember in any order. He was then shown the cards at a 4 sec. presentation rate. Each subject had a different random order of presentation. Immediately afterwards the subject was given a 3 min. recall period in which he was asked to write down as many words as he could remember on a yellow lined sheet of paper.

Each subject in the FRP condition was given essentially the same instructions prior to presentation only they were told that they would be presented pairs and would be asked to recall pairs. The presentation was also the same as FRW only they were shown the eight pairs for 4 sec. each. Immediately after presentation, the subject was instructed to write down as many pairs as he could remember. If the subject remembered single words from pairs, then he was to write those down also. The recall period was 3 min.

Each subject in the A condition was told that he would be shown pairs, and that later he would be shown the individual words and asked to pair them as they were paired on the cards. The subject was then presented with the pairs as in the FRP condition. Immediately after presentation, the subject was randomly given one of the five random orderings of the words and told to write the pairs as they were presented on the cards. The subject had 3 min. to do this.

Each subject in the CR condition was told that he would be presented pairs, and that he would later be given a list with one word from each pair and he would have to write the other word from the pair. He was presented the pairs as in the FRP and A conditions. Immediately afterward he was randomly given one of the three CR data sheets and asked to write down the words that went with the words on the sheet. The test period was 3 min. In all conditions, prior to presentation, subjects were told that it was important that they try their best.

Subsequent to testing, all subjects were given an unstructured postexperimental interview probing thought processes during the procedure and a debriefing on certain aspects of the research.

Results and Discussion

At this point the CR data will not be a subject of analysis. The mean number of words recalled in FRW was 9.54. In the A condition, the mean number of words in correct pairs was 10.09, with 4.59 words as incorrect pairs or single words. In the FRP condition, 6.09 words were recalled as correct pairs, 2.26 words as incorrect pairs or single words, and 7.65 words were missed. By dividing the mean FRW value by the number of words (16) the estimate of P(RL) is obtained. By doing the same to the mean number of words in correct pairs and the mean number of words not in correct pairs in the A task, estimates of P(PEG) and P(SGL), respectively, are obtained. These values are: $P(RL) = .596$; $P(PEG) = .631$; and $P(SGL) = .287$. Applying these values to Equations 1, 2, and 3, we obtain: $P(P) = .596(.631) = .376$; $P(S) = .596(.287) = .171$; and $P(O) = 1 - .376 - .171 = .453$; respectively. Multiplying these values by 16 gives the predicted number of words in each of the partitions of the FRP data. Table 3 gives the observed (OBS) and predicted (PD) values and the differences (D) between them for the number of words in correct pairs (P), the number of correct words written as single words or in incorrect pairs (S), and the number of words not recalled (O).

In order to assess whether the predicted values are consistent with those observed, 95% confidence intervals were computed about the observed mean values. Table 3 also gives the 95% confidence intervals (CI) about the observed means. It can be observed whether

Table 3

Observed and Predicted Values, their Differences,

and the Confidence Intervals for Experiment 1

Partition	OBS	PD	D	CI
P	6.09	6.02	.07	4.80-7.38
S	2.26	2.74	-.48	1.67-2.85
O	7.65	7.24	.41	6.59-8.71

the predicted values fall inside or outside the appropriate intervals. The use of the 95% confidence interval is equivalent to performing a test at the 5% level of significance. All predicted values are well within the 95% confidence interval. There is extremely close agreement between the predicted and obtained results for the P data for which the difference between the predicted and obtained values is approximately 1% of both the predicted and observed values. There is also close agreement between the predicted and obtained results for the O data. The difference between the predicted and obtained values is approximately 5% of both those values.

In order to determine if the words used were homogeneous, the number of recalls for each word in the FRW condition was computed. These values are shown in Table 1. To test for homogeniety, a chi-square was computed on these values. The computed chi-square value is 29.82, which is significant at the .05 level for 15 degrees of freedom. However, most of the departure can be accounted for by 5 words, while 9 words contribute less than 1 each to the chi-square. Analysis of Table 1 then, indicates the absence of any gross overall departure from homogeniety.

EXPERIMENT 2

Experiment 2 was designed to insure that observed values, for all groups, in Experiment 1 were not biased due to insufficient item sampling. An additional two sets of words were constructed and instead of one random pairing for two sets, there were three pairings.

Method

Subjects

The subjects were 74 students from the same source as Experiment 1.

Materials

In addition to the two sets of words from Experiment 1 an additional two sets of eight words each were selected and equated with each other as in Experiment 1. They were also equated with the sets from Experiment 1. Table 4 gives the words and Table 5 gives the I, C, M, and F values for these two additional sets. For sets 3 and 4 the words were randomly paired as in Experiment 1, but this was done three times so there were three sets of pairs. No pair could appear more than once. This was also done for sets 1 and 2 from Experiment 1. The six sets of pairs were typed on cards as in Experiment 1.

The 16 words from sets 3 and 4 were individually typed on cards, as were the words from sets 1 and 2. Three random orders of the 16 words from sets 1 and 2 and 3 and 4 were typed in a column on separate sheets of paper. Three cued recall sheets each were prepared in the manner of Experiment 1 for set 1 and set 3. For the FRW condition,

Table 4

Words for Experiment 2

Stimulus	FRW recall	Response 1	Response 2	Response 3	FRW recall
CHIN	6	MACHINE	POLE	POET	5
COLONY	4	MICROSCOPE	SQUARE	POLE	6
COMMITTEE	8	POET	GENTLEMAN	ENGINE	3
DRESS	6	SQUARE	MICROSCOPE	GENTLEMAN	4
DUMMY	4	STRING	ENGINE	MICROSCOPE	6
HURDLE	4	GENTLEMAN	MACHINE	STRING	3
SEAT	6	ENGINE	POET	MACHINE	4
VILLAGE	7	POLE	STRING	SQUARE	3
ABDOMEN	5	NEWSPAPER	FLESH	AMBASSADOR	4
BOSS	8	PORTRAIT	NEWSPAPER	SAUCE	7
CIRCLE	4	FLESH	AMBASSADOR	PORTRAIT	3
CORNER	2	OFFICER	SAUCE	FLESH	4
DAYLIGHT	1	SAUCE	BUILDING	NEWSPAPER	3
HOTEL	4	PASSAGEWAY	PORTRAIT	BUILDING	6
MANTLE	9	AMBASSADOR	OFFICER	PASSAGEWAY	5
PROFESSOR	8	BUILDING	PASSAGEWAY	OFFICER	3

Table 5

I, C, M, and F Values for the Words in Sets 3 and 4

Words	I	C	M	F
Stimulus set 3	6.10	6.46	5.52	55.63
Response set 4	6.03	6.58	5.57	55.13

the recall sheet contained 16 numbered lines. For the A and FRP conditions, the test sheet contained 8 numbered lines.

Procedure

The procedure was essentially the procedure of Experiment 1. The n for the FRW condition was 18; for the A condition it was 18; for the FRP condition it was 18; and for the CR condition it was 20.

Results and Discussion

Again, the analysis of the CR data will be postponed. Collapsing across both sets 1 and 2 and 3 and 4, the mean number of words recalled in FRW was 8.61. In the A condition, the mean number of words in correct pairs was 9.22 with 5.28 words as incorrect pairs or single words. In FRP, 5.44 words were recalled as correct pairs, 2.89 words as incorrect pairs or single words, and 7.67 words were missed. Converting to proportions to obtain our estimates: P(RL) = .538; P(PEG) = .576; and P(SGL) = .33. Substituting these values into the model we have: P(P) = .31; P(S) = .177; and P(O) = .512. Multiplying these values by 16 gives the predicted number of words in each of the partitions of the FRP data. Table 6 gives the observed and predicted values and the differences between them. Table 6 also gives the 95% confidence intervals about the observed means. All predicted values are well within the 95% confidence interval.

Again, to assess homogeniety, the number of recalls for each word in the FRW condition was computed. These values are shown in Table 4. A chi-square was computed on these values and it equaled 54.38. This is significant at the .05 level for 31 degrees of freedom. A large portion of the chi-square is due to the departure of 4 words, while 18 words contribute less than 1 each. Analysis of Table 4 then indicates the absence of any gross overall departure from homogeniety.

Table 6

Observed and Predicted Values, their Differences,

and the Confidence Intervals for Experiment 2

Partition	OBS	PD	D	CI
P	5.44	4.96	.48	3.71-7.17
S	2.89	2.84	.05	2.19-3.59
O	7.67	8.20	-.53	6.32-9.02

In both Experiments 1 and 2, the model generates quite accurate predictions, the worst departure being the S data of Experiment 1 in which the observed result is somewhat less than 20% off from the predicted value. However, all other differences are less than 10% and none of the differences are statistically significant.

Experiment 3 was designed as a test of the generality of the model.

EXPERIMENT 3

Experiments 1 and 2 were restricted to what can be characterized as high imagery-concreteness items. Paivio (1971) discusses a large number of studies that show differences between high and low imagery-concreteness items. Experiment 3 was essentially a repetition of Experiment 2 using low imagery-concreteness items.

Method

Subjects

The subjects were 80 students from the same source as in Experiments 1 and 2.

Materials

Four sets of eight words each characterized as low imagery-concreteness items were selected. They were equated with each other on I and C, and with each other and the four sets from Experiment 2 on M and F. Table 7 gives the words. Table 8 gives the I, C, M, and F values for these four sets. Randomly designated sets 5 and 6 and sets 7 and 8 formed the two sets of pairs. Materials were constructed from these sets as described in Experiment 2.

Procedure

The procedure was essentially the procedure of Experiment 2. The number of subjects in all conditions was 20.

Table 7

Words for Experiment 3

Stimulus	FRW recall	Response 1	Response 2	Response 3	FRW recall
CRIME	8	APTITUDE	THEORY	SHOCK	2
DISCIPLINE	5	THEORY	BETRAYAL	PERCEPTION	6
ECONOMY	5	ADVICE	SHOCK	NECESSITY	8
EGO	9	SHOCK	NECESSITY	ADVICE	5
GREED	6	NECESSITY	PERCEPTION	APTITUDE	3
HONOR	9	BETRAYAL	ADVICE	TRUTH	7
KNOWLEDGE	3	PERCEPTION	TRUTH	BETRAYAL	5
MEMORY	5	TRUTH	APTITUDE	THEORY	3
ADVANTAGE	3	ATTITUDE	MORAL	SOUL	7
BOREDOM	7	CONFIDENCE	SOUL	ANIMOSITY	9
CHANCE	7	MORAL	ATTITUDE	GENIUS	4
CHARM	5	EXPRESSION	CONFIDENCE	MORAL	6
DEMOCRACY	7	ANIMOSITY	INTELLECT	CONFIDENCE	2
FREEDOM	8	SOUL	ANIMOSITY	EXPRESSION	2
SENSATION	3	GENIUS	EXPRESSION	INTELLECT	4
SPREE	4	INTELLECT	GENIUS	ATTITUDE	4

Table 8

I, C, M, and F Values for the Words in Experiment 3

Words	I	C	M	F
Stimulus set 5	3.40	2.13	5.80	55.38
Response set 6	3.18	2.17	5.53	51.88
Stimulus set 7	3.46	2.06	5.48	51.38
Response set 8	3.09	2.07	5.62	57.75

Results and Discussion

Again, consideration of the CR data will be postponed. Collapsing across sets, the mean number of words recalled in FRW was 8.55. In the A condition, the mean number of words in correct pairs was 7.8, and the mean number of words in incorrect pairs or written as single words was 5.05. In FRP, 4.2 words were recalled as correct pairs, 3.15 words as incorrect pairs and single words, and 8.65 words were missed. Converting to proportions to get the required estimates we have: $P(RL) = .534$; $P(PEG) = .488$; and $P(SGL) = .316$. Substituting these values into the model we have: $P(P) = .261$; $P(S) = .169$; and $P(O) = .57$. Table 9 gives the observed and predicted mean values, their differences, and the 95% confidence intervals. All predicted values are well within their respective confidence intervals.

Again, to assess homogeniety, the number of recalls for each word in the FRW condition was computed. These values are shown in Table 7. A chi-square was computed on these values and it equaled 58.21. This is significant at the .05 level for 31 degrees of freedom. A large portion of the chi-square is due to the departure of 5 words, while 13 words contribute less than 1 each and 5 words contribute slightly more than 1 each. As in the prior experiments then, analysis of Table 7 indicates the absence of any gross overall departure from homogeniety.

Experiment 3 shows the applicability of the model to a class of items considered distinctly different from the items in Experiments 1 and 2, and consequently extends the generality of the model.

Table 9

Observed and Predicted Values, their Differences, and the Confidence Intervals for Experiment 3

Partition	OBS	PD	D	CI
P	4.20	4.18	.02	2.69-5.71
S	3.15	2.70	.45	2.22-4.08
O	8.65	9.12	-.47	7.68-9.61

General Discussion

In order to decrease the range of the confidence intervals and provide a more rigorous test of the model, the data of all three experiments were combined. For the combined data, the n for the FRW condition was 60; for the A condition it was 60; and for the FRP condition it was 61. The mean number of words recalled in the FRW was 8.93. In the A task, the mean number of words in correct pairs was 9.07, and the mean number of words in incorrect pairs or written as single words was 4.95. In the FRP condition, 5.28 words were recalled as correct pairs; 2.74 as incorrect pairs or single words; and 7.98 words were missed. The estimate for P(RL) = .558; for P(PEG) = .567; and for P(SGL) = .309. Applying the estimates to the model we have: P(P) = .316; P(S) = .172; and P(O) = .511. Table 10 gives the observed and predicted mean values for the combined data, their differences, and the confidence intervals.

Although the ranges of the confidence intervals have been greatly reduced, all predicted values lie well within the 95% confidence intervals. At worst, the difference between predicted and observed (for the P partition) is less than 5% of the observed and the predicted values. It appears clear then, that the goal of developing a quantitatively precise model for the free recall experimental situation has been achieved.

The theoretical context for the current model, to a large extent, evolved independently of any of the theories presented earlier, since close examination of those theories suggested

Table 10

Observed and Predicted Values, their Differences, and the Confidence Intervals for the Combined Data of Experiments 1, 2, and 3

Partition	OBS	PD	D	CI
P	5.28	5.06	.22	4.44-6.11
S	2.74	2.76	-.02	2.33-3.15
O	7.98	8.18	-.20	7.36-8.60

fundamental problems in their development.

There are at least two problems with the theoretical development undertaken by Horowitz and Prytulak (1969). The first they themselves acknowledge. The criterion used to decide when a situation can be considered to be redintegrative is an arbitrary one. Thus, it is not at all certain that they are dealing with redintegrative memory. Consequently, the possibility exists that their principle of redintegrative power may have little to do with redintegrative memory. The second problem appears in their conceptualization of the very notion of redintegrative memory. Hollingsworth (1928), whom they cite as a source of the concept, suggests that all memory involves a redintegrative sequence. For Horowitz and Prytulak, redintegrative memory is but one kind of memory. They fail to specify clearly at a theoretical level how the various kinds of memory can be distinguished from each other. It appears, then, that the theoretical development of Horowitz and Prytulak (1969) is weak in clearly specifying the conceptual notion of redintegrative memory and weak in linking their concept of redintegrative memory to their criterion index and the ensuing empirical relationship between free and cued recall.

In Begg's (1972) work there appears to be a problem with the data used to support the hypothesis that the memory capacity required for a concrete phrase would be the same as for a concrete word, while there would be a greater capacity requirement for an abstract phrase as compared to an abstract word. This hypothesis is based on his fundamental assumption that a concrete phrase would evoke a single integrated image. For the experiment described earlier, the specific prediction was " . . . proportionate recall of words in abstract phrases will be half as high as for the words alone, while there will be no difference between the two conditions in concrete phrases." (Begg, 1972, p. 432). After analyzing the data, he concludes for CC phrases, "The prediction that free and whole recall of concrete words would not differ was thus strongly supported." (Begg, 1972, p. 433), and for the AA phrases, the recall was proportionate as predicted. However, the prediction he confirmed does not appear to be the original prediction he made. For both CC and AA phrases he did not compare the number of nouns in recalled phrases or number of adjectives in recalled phrases with the appropriate word groups, but he compared the number of nouns in phrases plus nouns recalled alone in the phrase group with the number of nouns recalled in the noun group. The same was done for the adjectives. If the appropriate comparisons are made, the mean differences observed suggest that the original prediction was not confirmed for either concrete or abstract items. Consequently, Begg's theoretical assumptions do not clearly find support in these data.

That there are difficulties with the work of Tulving and his associates can be seen most clearly by considering the recent work of Olson (1975). In a series of experiments using the Tulving and Thomson (1973) paradigm, he manipulated the forward and backward associative probabilities between the cue and the to-be-remembered

(TBR) words, and the syntactical relationship between the words of the pair. In general, the results support the notion that the differences between cued recall and recognition are a function of differential forward and backward associative probabilities. "If the forward associative probability is greater than the backward associative probability then one would expect greater cued recall than recognition performance. If the reverse was true, then recognition performance should be better than cued recall performance. If there are no differential associative probabilities then cued recall and recognition should be the same." (Olson, 1975, p. 48). He also found evidence that suggests that type of syntactical pairing, adjective-noun versus noun-adjective, may lead to recall-recognition differences under certain conditions. "Based on the results of these experiments, it would appear that the results reported by Tulving and Thomson (1973) as well as their earlier results . . . are subject to at least one of two confounds: asymmetries caused by adjectival cueing . . . , or asymmetries caused by differential associative probabilities . . . " (Olson, 1975, p. 60). He suggests that recognition failure occurs because in both recall and recognition the subject must recreate the original word pair and the asymmetries present in the Tulving items bias the process in favor of cued recall.

Reder, Anderson, and Bjork (1974) have shown that target word frequency influences recall-recognition differences and suggest a semantic interpretation of the findings in terms of the number of possible "senses" of the target words. DeVito (1975) suggests that one factor that influences recall-recognition differences is the degree of integration of word pairs. He found that recall-recognition differences in a modified Tulving and Thomson paradigm were a function of cue and target word concreteness value. Light, Kimble, and Pellegrino (1975) examine Santa and Lamwers' (1974) criticisms, and present their own arguments against various aspects of the Tulving and Thomson paradigm. They suggest caution in interpreting the generality of recognition failure and also question whether failure of recognition has been clearly demonstrated. They conclude by indicating that the data of Watkins and Tulving (1975) and Tulving and Thomson (1973) are consistent with revised generation-recognition models as well as episodic theory.

Thus the recognition failure found by Tulving and his associates, interpreted as evidence for an episodic theory of memory and against a generation-recognition model of memory, must be viewed as questionable in both its generality and interpretation.

The problems with these theories then led to a decision not to attempt an extension of any one of them to serve as a foundation for the current model. Rather, the current model evolved from an attempt to specify and estimate, as simply as possible, the probabilistic factors operating in a memory task where the subjects are presented word pairs for recall. Pursuing this approach, the extension of the model to cued recall will now be considered. The theoretical development and underlying assumptions will be essentially the same as for the FRP analysis, except for a modification based on the difference in the test situations in CR as compared to FRP.

As in the model for FRP, the probability of a correct pair may be specified as P(RL)P(PEG). P(PEG) may be partitioned into the probability of a stored stimulus peg, P(SPEG), plus the probability of a stored response peg, P(RPEG), that is P(PEG) = P(SPEG) + P(RPEG). P(SPEG) equals the probability of a peg times the conditional probability of a stimulus given a peg, $P(PEG)P(S|PEG)$, and P(RPEG) equals the probability of a peg times the conditional probability of a response given a peg, $P(PEG)P(R|PEG)$. With this partitioning, the probability of a correct pair may be specified as $P(RL)P(PEG)P(S|PEG) + P(RL)P(PEG)P(R|PEG)$, where $P(S|PEG) + P(R|PEG) = 1$. Now, it is assumed that in the current experiments, $P(S|PEG) = P(R|PEG) = .5$, since the pairs used are homogeneous. As a matter of fact, we do not know if the value of $P(S|PEG) = .5$. It may well be somewhat more than .5. We are choosing the simplest assumption which is, in effect, that subjects pick the peg word of a pair idiosyncratically and not on the basis of position under the current set of instructions. With this assumption then, the probability of a correct pair may be specified as P(RL)P(PEG)(.5) + P(RL)P(PEG)(.5). Furthermore, in a cued recall situation, the cue words are given at the time of testing. Following the rationale for the development of the estimation procedure for P(PEG), it is assumed that the probability of retrieval of the stored peg words that are cue words equals 1.0 in this situation. In the current experiments, the presented stimulus was always the cue word, so the expression for the probability of a correct cued recall word pair, P(CR), now becomes P(PEG)(.5) + P(RL)P(PEG)(.5) = P(CR). The estimates of P(RL) and P(PEG) may be taken as before. For Experiment 1, P(RL) = .596 and P(PEG) = .631; for Experiment 2, P(RL) = .538 and P(PEG) = .576; for Experiment 3, P(RL) = .534 and P(PEG) = .488; and averaging across all three experiments, P(RL) = .558 and P(PEG) = .567. Substituting these values into the expression for P(CR) we obtain the probability of a correct cued recall pair for each experiment and the combined data. Table 11 gives the observed and predicted mean values of the numbers of words recalled in correct pairs, their differences, and the number of subjects on which the observed values are based, and the confidence intervals for all three experiments and the combined data. In terms of correctly recalled response words, of course, the observed and predicted values, and their differences would be reduced by a factor of two. All values are well within the 95% confidence intervals supporting the proposed model for cued recall.

Thus, the modified model generated predictions consistent with the observed data not only for free recall of word pairs for both high and low imagery-concreteness items, but also for cued recall. Furthermore, with the specification of the model for free and cued recall, the data of Horowitz and Prytulak, Karchmer, Begg, and Tulving and his associates may now be examined within the context of the model.

Table 11

Observed and Predicted Values for Cued Recall, their Differences, the Number of Subjects upon which the Observed Values are Based, and the Confidence Intervals for all Three Experiments and the Combined Data

Experiment	N	OBS	PD	D	CI
1	8	10.25	8.06	2.19	5.83-14.67
2	20	7.80	7.09	.71	6.26-9.34
3	20	4.80	5.98	-1.18	3.02-6.58
1, 2, 3	48	6.96	7.07	-.11	5.71-8.20

Horowitz and Prytulak's (1969) principle of redintegrative power states that when the conditional probabilities $P(W|A)$ and $P(W|B)$ are high, the word member of a pair that is better remembered in a free recall of pairs task will be the better cue in a cued recall task. It can be shown that the current model, with some elaboration, will predict this relationship.

Consider, as Horowitz and Prytulak (1969) did, an experiment where the items are adjective-noun pairs instead of homogeneous pairs. If in a free recall of pairs procedure there are more nouns than adjectives recalled, then it would be required in the present model that the conditional probability of a noun given a stored single word, $P(N|SGL)$, be greater than the conditional probability of an adjective given a stored single word, $P(A|SGL)$. That is, it is required that more nouns than adjectives are stored as single words. This can be seen if we partition $P(SGL)$ as we did $P(PEG)$. The probability of a stored single word equals the probability of a stored single noun plus the probability of a stored single adjective. That is, $P(SGL) = P(SGL)P(N|SGL) + P(SGL)P(A|SGL)$. Then, the probability of recalling a single word not in a correct pair, $P(S)$, equals $P(RL)P(SGL)P(N|SGL) + P(RL)P(SGL)P(A|SGL)$. If more nouns than adjectives are recalled, then in terms of the model $P(RL)P(SGL)P(N|SGL) > P(RL)P(SGL)P(A|SGL)$, or $P(N|SGL) > P(A|SGL)$. Now, it is assumed that if more nouns than adjectives are stored as single words, then more nouns than adjectives are stored as peg words. That is, if $P(N|SGL) > P(A|SGL)$, then the conditional probability of a noun given a peg, $P(N|PEG)$, is greater than the conditional probability of an adjective given a peg, $P(A|PEG)$. When $P(N|PEG) > P(A|PEG)$, it can be shown that $P(PEG)P(N|PEG) + P(RL)P(PEG)P(A|PEG) > P(RL)P(PEG)P(N|PEG) + P(PEG)P(A|PEG)$. That is, when $P(N|PEG) > P(A|PEG)$ the model predicts cued recall will be better with the noun as the cue than with the adjective as the cue. Thus, when the noun is better recalled in FRP, then cued recall with the noun as the cue will be better than cued recall with the adjective as the cue. Furthermore, it can be shown that this asymmetry in cued recall will increase as P(PEG) increases, assuming other factors equal. So if both P(PEG) and the conditional probabilities of Horowitz and Prytulak are direct functions of the degree of pair storage, then as Horowitz and Prytulak's conditional probabilities increase P(PEG) will increase and the difference between noun and adjective cued recall will increase. Thus, as described, the model predicts the relationship specified by Horowitz and Prytulak (1969).

Karchmer's (1974) proportion of unitization is based on Horowitz and Prytulak's (1969) conditional probabilities and may be taken as a measure of the degree of pair storage. As P(PEG) increases Karchmer's proportion will increase, and in the context of the current model, so will the level of cued recall. Consequently, Karchmer's (1974) observed relationship between the proportion of unitization and cued recall is highly consistent with and predictable from the present model. Furthermore, Karchmer indicates that the notion of unitization is insufficient as an explanation of the asymmetrical cued recall observed with mixed imagery-concreteness (I-C) pairs. "One flaw with the unitization conception as it pertains to cued recall has to do with mixed I-C pairs. In Experiment I, the high I-C word was found to be the better cue than the low I-C word. . . . Such retrieval differences in cued recall cannot be predicted from considerations of unitization alone." (Karchmer, 1974, p. 356). The model can be applied here as it was to Horowitz and Prytulak's (1969) data. If it is assumed that $P(HI\ I\text{-}C|PEG) > P(LO\ I\text{-}C|PEG)$, a not at all unreasonable assumption (see Paivio, 1971), then the asymmetrical cued recall observed by Karchmer is readily predicted from the model.

The model applies to the situation used by Begg (1972). Specifically, he assumed that concrete word pairs, as contrasted to abstract word pairs, would be treated as a unit by the memory system since they would arouse integrated images. Based on these assumptions, he predicted that comparison of a word-recall group with a phrase-recall group would lead to a result in which the " . . . proportionate recall of words in abstract phrases will be half as high as for the words alone, while there will be no difference between the conditions in concrete phrases." (Begg, 1972, p. 432). Our analysis of the data suggests that this prediction was not confirmed, contrary to Begg's conclusion in his written report. Consequently, his theoretical assumptions do not clearly find support in these data. As compared with Begg's theory the current model appears to be more successful in making precise predictions for both high and low I-C items.

The model also appears to be applicable to the Tulving and Thomson (1973) finding of recognition failure of recallable words. As Olson (1975) suggests, the Tulving and Thomson situation may direct the subject toward attempting to store word pairs. " . . . the subject's task in the Tulving and Thomson paradigm may be conceptualized to be one of learning or memorizing pairs of words. Under both cued recall and recognition procedures, the subjects must recreate the original stimulus pair." (Olson, 1975, p. 59). 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, as in the discussion of Horowitz and Prytulak's (1969) and Karchmer's (1974) studies.

It is suggested then, that the current model may be reasonably considered a potential basis for the integration of the above described areas of research.

A major problem in applying the model to data is the adequacy of the procedures used to estimate the various probabilities needed to generate predictions. Future research is required to assess fully the adequacy of the current estimation procedure. It is not completely clear at this time if the number of words and the presentation time in the estimation group for P(RL) must be equivalent to the values in the word pair groups. A minor difficluty in the current test of the model is the slight departure of the words from homogeniety despite the fact that the word sets were matched on existing norms. However, for most of the words the departure was very small. The alternative was to do a normative study using a Brooklyn College population. Such an expenditure of research effort did not seem justified given the rapid change in the composition of the Brooklyn College population. Additional research is also required to specify the procedures necessary for the estimation of probabilities of the form $P(S|PEG)$ and $P(R|PEG)$ when they cannot be assumed to be equal.

One of the most intriguing general findings of the present experiments was that the same model applied to both high I-C (Experiments 1 and 2) and low I-C (Experiment 3) items. If as Begg (1972) theorizes, high I-C items are coded primarily in some imaginal form and low I-C items are coded in some verbal form, then the current research suggests that the difference in the encoding does not change the general properties of the memory representation or the retrieval process. With both types of items, the model is quite successful in predicting free and cued recall. The difference between the processing of high and low I-C items appears to be a quantitative one, and not a qualitative one. This runs counter to the notion of distinct visual as opposed to verbal memory representations (Paivio, 1971). Furthermore, the applicability of the model to both high and low I-C items suggests a generality which may make the model appropriate for items other than word pairs, for example for picture-word pairs. The suggestion here is that the model may be appropriate for compound events in general, regardless of their specific form or modality and this implies the possibility that the memory system is highly parsimonious, operating according to the same specific principles, independent of the stimulus form or modality and the form or modality of the encoding. In other words, the implication is that the memory system operates according to the same simple principles, whether the items are words or pictures, and the same principles apply whether a visual mnemonic or a verbal mnemonic or no mnemonic at all is reported.

The success of the current model also suggests an extension to compound events where there are more than two discernible components, for example, word triads. Hopefully, the general form of the model will require no new assumptions, simply a compounding of the old assumptions. Both of these suggestions should be readily open to experimental test.

In sum, the current research developed a quantitatively predictive model for free and cued recall, which may serve as a basis not only for integrating research in the areas of redintegrative memory, "imagery" and retrieval processes, but also for the investigation of compound memory events in general.

References

Begg, I. Recall of meaningful phrases. Journal of Verbal Learning and Verbal Behavior, 1972, 11, 431-439.

DeVito, C. Encoding specificity and integration of word pairs. Bulletin of the Psychonomic Society, 1975, 5(3), 215-216.

Epstein, W., Rock, I., & Zuckerman, C. B. Meaning and familiarity in associative learning. Psychological Monographs, 1960, 74, (4, Whole No. 491).

Hollingsworth, H. L. Psychology: Its facts and principles. New York: Appleton-Century-Crofts, 1928.

Horowitz, L. M. & Prytulak, L. S. Redintegrative memory. Psychological Review, 1969, 76, 519-531.

Karchmer, M. A. Proportion of unitization as an index of cued recall level. Journal of Experimental Psychology, 1974, 103(2), 351-357.

Kucera, H. & Francis, W. N. Computational analysis of present-day american english. Providence: Brown University Press, 1967.

Light, L. L., Kimble, G. A., & Pellegrino, J. W. Comments on episodic memory: When recognition fails, by Watkins and Tulving. Journal of Experimental Psychology: General, 1975, 104(1), 30-36.

Lockhart, R. S. Retrieval asymmetry in the recall of adjectives and nouns. Journal of Experimental Psychology, 1969, 79, 12-17.

Olson, A. M. Encoding specificity: An artifact of paradigm and analysis? Unpublished doctoral dissertation, City University of New York, 1975.

Paivio, A. Imagery and verbal processes. New York: Holt, Rinehart, & Winston, 1971.

Paivio, A., Yuille, J. C., & Madigan, S. A. Concreteness, imagery and meaningfulness values for 925 nouns. Journal of Experimental Psychology Monograph Supplement, 1968, 76(1, Pt. 2).

Reder, L. M., Anderson, J. R., & Bjork, R. A. A semantic interpretation of encoding specificity. Journal of Experimental Psychology, 1974, 102, 648-656.

Santa, J. L., & Lamwers, L. L. Encoding specificity: Fact or artifact? Journal of Verbal Learning and Verbal Behavior, 1974, 13, 412-423.

Tulving, E., & Thomson, D. M. Encoding specificity and retrieval processes in episodic memory. Psychological Review, 1973, 80, 352-373.

Watkins, M. J., & Tulving, E. Episodic memory: When recognition fails. Journal of Experimental Psychology: General, 1975, 104, 5-29.