

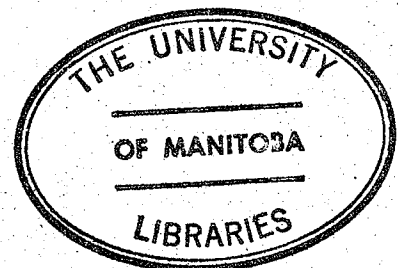
**THE ROLE OF INTERITEM DEPENDENCIES IN
HIGHER ORDER MEMORY UNITS IN FREE RECALL LEARNING**

by

David L. Kearns

A thesis submitted to the Faculty of the
Graduate School of the University of Manitoba
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for the Master of Arts degree.

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General Literature Review

Normative Associative and Cueing Studies

Initial studies during the 1950's which examined the relationships between associative and organizational theories of learning began by inspecting free recall protocols for evidence of clustering of associatively related items. Typically, various indices of associative strength were derived on the basis of "free associations" given by subjects to stimulus words, and then free recall protocols were examined for occurrences of these particular groupings. These studies have indicated that the products of free recall learning and associative learning may be related in some manner.

Jenkins, Mink, & Russell (1958) and Jenkins & Russell (1952) examined the relationship between the Kent-Rosanoff word association list and clustering in free recall experiments. The Kent-Rosanoff word association list is a compilation of the frequency with which each stimulus word elicited a given response when presented to 1008 subjects (Kent & Rosanoff, 1910, as cited in Marshall & Cofer, 1963). The associative strength between a given stimulus and response is indicated by the frequency with which the stimulus elicits that response. Jenkins et al (1958) selected word pairs for four degrees of associative strength, and constructed four separate random word lists which were presented orally to subjects at a one word per second rate. The subjects then free recalled the lists, and the recall protocols were examined for the frequency of occurrence of Kent-Rosanoff associative pairs. It was found that the number of associated pairs recalled together increased monotonically as a function of average associative strength, and that the mean number of words recalled was directly related to their associative strength. Using this same procedure, Jenkins & Russell (1952) found that the mean number of Kent-Rosanoff pairings was significantly greater than idiosyncratic pairings. The free recall protocols faithfully reflected the basic associative pairwise dependencies derived from the frequency with which each Kent-Rosanoff stimulus elicited each response.

In one of his early studies, Bousfield (1953) extended the notion of clustering to experimenter defined categories based upon selected titles or names under which a list of subordinates could be compiled. He also

defined a cluster as "a sequence of associates having an essential relationship between its members." This essential relationship may be specified by the category title so that all the subordinates become direct or indirect associates of the category title (Field, 1969). Such experimenter defined lists often have high degrees of interitem associative strength (I.I.A.S.) which Deese (1959) has defined as the average relative frequency with which all items in a given list of stimuli tend to elicit all other items in the same list as free associates. Bousfield chose animals, people's names, professions, and vegetables as category titles. Fifteen subordinates were chosen as examples of each category and presented orally to subjects at a 3 seconds per word rate. Recall protocols were then examined for occurrences of sequences of two or more words from the same category. The results showed the subjects clustered items at greater than chance levels forming groups of words of size two up to groups containing as many as seven items.

Bousfield & Cohen (1955) replicated Bousfield (1953) while attempting to assess the effects of Thorndike-Lorge frequency of word usage upon degree of clustering. The same procedure was employed except that two levels of Thorndike-Lorge word frequency were used to construct two separate lists of category items. Mean words recalled for the low frequency list were 22.18 while mean word recall for the high frequency list was 25.55. This difference is not large, but is reported as significant. Extent of clustering was significantly above chance levels for both word frequency groups, and while clustering was lower for the low frequency word list, this difference between groups was not large. Bousfield & Cohen (1956) again assessed the extent of clustering based upon experimenter defined categories as a function of the number of categories (NC) per list. Total list length (40 words) was held constant while either 2, 4, or 8 categories were used per list. Thus, the number of items per category (IPC) was either 20, 10, or 5 words for the 2, 4, or 8 category conditions, respectively. Extent of clustering was assessed by the mean ratio of repetition (RR) which is a ratio of the obtained repetitions to the number of repetitions possible for the number of words recalled. A repetition is the contiguous occurrence of two items in a subject's free recall protocol from the same experimenter defined category. It was found that as the number of categories increased (as IPC decreased) the extent of clustering increased when compared with chance

clustering levels. This effect was again confirmed in a second experiment. In general, these early studies of clustering support the hypothesis that chunking in free recall learning is determined by natural language habits based upon indirect associative relationships.

Bousfield, Cohen, & Witmarsh (1958) extended the notion of associative strength from the single S-R relationships established by the Kent-Rosanoff lists to multiple responses given to category names. Subjects were asked to list the first four items that occurred to them when presented with forty-three category names, (taxonomic groups). This normative data provided frequencies of occurrence for the responses elicited by the category names which were used to examine the effects of word frequency upon clustering for various taxonomic groups. Four lists of 40 stimulus items each were constructed comprising two high frequency and two low frequency word lists. Each list contained 10 words from four different categories. Words in each list were presented once at a 2.5 second rate, and a five minute free recall followed immediately. Mean word recall was significantly greater for the high frequency associates of the category names than for the low frequency associates. Also, clustering as assessed by RR was significantly greater for the high frequency associates. Thus, it would appear that both word recall and clustering in free recall learning are related to the associative strength of S-R bonds whether these relationships are assessed on the basis of single responses to a stimulus word or multiple responses to classes of words (category names).

Numerous other measures of associative relatedness have been developed. These measures have been reviewed (Marshall & Cofer, 1963) with the conclusion that both direct and indirect associative indices appear to have considerable power in predicting the clustering of words in free recall. Marshall (1967) examined the index of total association (IIA) and the index of concept cohesiveness (ICC) both of which are associative measures. He found that both IIA and ICC were significantly related to word recall and clustering as assessed by RR. However, while a general consensus exists that associative indices can predict clustering in free recall, it has been found that various associative indices are not always correlated. Some appear to be measuring different correlates of the clustering phenomena.

For example, Pollio & Christy (1964) evaluated the effects of interitem associative strength upon the number of words recalled in a free recall task. Three 22 item lists varying in IIAS (low, medium, high) were constructed employing "filler items" before and after the critical portion of each list to control for primacy and recency effects. Items were presented visually at a 1.2 second rate. Superior recall was obtained for the medium value IIAS list, but recall remained the same for both low or high value IIAS lists. These results differ from those of Jenkins, Mink & Russell (1958) who found that increases in associative strength were positively correlated with increases in word recall. This discrepancy is possibly related to Jenkins, Mink & Russell's (1958) use of the Kent-Rosanoff word association list which applies to single pairs of words, while IIAS is a measure of association among specified groups of words.

Bousfield, Steward & Cowan (1964) also attempted to assess the correspondence between two associative indices - IIAS and the index of stimulus equivalence (ISE). The ISE measure is derived from single response free associations to stimuli that are all members of a single category. For example, given the items ant, bee, beetle, and gnat which are all members of the insect category, the ISE measure represents the summation of the number of free associates given as common responses to two or more category items. Bousfield et al also hoped to combine the IIAS and ISE measures to form a more powerful predictor of clustering. Subjects free recalled one of two lists in which Thorndike-Lorge word frequency and taxonomic frequency (Cohen, Bousfield, & Whitmarsh, 1958) were manipulated. It was found that clustering (RR) did not vary as a function of Thorndike-Lorge word frequency, but was significantly greater for the high frequency taxonomic groups when compared with low frequency taxonomic groups. Word recall was significantly greater for the high Thorndike-Lorge frequency list. Deese's IIAS measure was next computed for each of the four taxonomic categories in each list. The IIAS measure was positively correlated with clustering in the high and low taxonomic categories, but underestimated clustering for the low taxonomic categories. In addition, it was concluded that the ISE measure was not readily applicable for assessing the relatedness of taxonomic groups of words, and did not warrant further consideration as a predictive index.

of clustering. The lack of correspondence between indices of associative strength and their relative ineffectiveness as predictors of degree of clustering are major drawbacks against their use as reliable instruments to assess the continuity of organizational and associate concepts of learning. This problem is partly due to the variability of individual subject-directed organizational strategies employed during free recall learning.

Cofer (1965) has aptly illustrated that this variability of organizational strategies is related to how obvious the relationships among the words in a given list may be. The more conspicuous the relationships, the more likely the subject is to group the words according to the experimenter's expectations. Thus in one of Marshall's studies (1963), a free recall experiment was conducted in which six lists of 24 randomly ordered words representing six levels of mutual relatedness (proportion of associations two words have in common over all their associations) were presented to six groups of subjects. Clustering was measured at each level of mutual relatedness by Cohen, Sakoda & Bousfield's (1954) ratio of repetition (RR). As mutual relatedness decreased, clustering did not decrease as rapidly as had been expected. This was because subjects invented their own clustering schemes as the obvious associations between words in the list became less and less common. At the lowest levels of mutual relatedness idiosyncratic clustering accounted for up to 40% of the total clustering obtained, while at high levels of mutual relatedness, clustering accurately mirrored the experimenter's selected pairwise dependencies. Thus, there is no necessity to assume that a subject must organize the words of a list in direct correspondence with assessments of their associative relatedness based on any particular measure.

Indeed, Tulving (1968) has noted that any two words may be considered as related depending upon their context within a list of words or upon some superordinate category title or name under which they may be classified. Also, while specific words may appear unrelated to the experimenter or are unrelated in terms of certain normative data in no way precludes the possibility that a subject may organize words in a way that is meaningful only to himself. Tulving (1962) has shown that "unrelated" (not related in normative data) lists of words are typically organized into sequences

of words related in some meaningful fashion to the subject, and that a strong correlation exists between idiosyncratic clustering and word recall. These sequences of words organized by the subject have been termed "S units" while expected sequences based upon normative data or experimenter defined categories have been termed "E units" (Tulving, 1968). The point is simply that despite the presence of well established normative relationships based upon associative indicies for any given set of words, there is no reason why the subject must organize the words according to a commonly accepted pattern. The composite characteristics of a specific group of words may modify relationships based on free association norms. While associative theory has not precluded this possibility, organizational theorists have been primarily responsible for elaborating the causes and mechanisms of such groupings. It is important to note that groups of words may be well organized on either an idiosyncratic or normative basis. However, assessing degrees of clustering by reference to associative norms may well underestimate the total extent of a subject's organizational schema (Marshall, 1963). As such, correlations between associative indicies and measures of clustering can only be regarded as approximate indications of both the extent and type of clustering (normative versus idiosyncratic) actually present.

The proliferation of associative indicies (Marshall & Cofer, 1963) has not been helpful in devising a quantitatively accurate predictor of clustering, and has shown that associative indicies are inconsistent in predicting clustering (Jenkins, Mink & Russell, (1958); Bousfield, Steward & Cowan, (1964). A question of basic concern given all these associative indicies is to determine which, if any, are most generally representative of subjects' clustering schemes in free recall. This task has received little attention to date due to evidence presented earlier noting that the extent to which a subject's clustering schema corresponds with an associative index varies as a function of the individual list items themselves and their relation to each other as determined by the context of the list as a whole (Tulving, 1968; Cofer, 1965). There is in fact no one "best" associative measure. Despite these inadequacies, the notion that simple associative relationships may predominate in free recall processes has been successfully demonstrated.

Field, (1969, Unpublished Doctoral Thesis) evaluated the effects of IIAS upon clustering within categories of lists. A free recall paradigm was employed in which subjects recalled 30 word lists consisting of six categories of five members each. Categories within lists were selected to represent either low or high IIAS values (ie., the IIAS variable applied only to the words in a list from the same category). The results indicated that interitem associative strength was positively correlated with clustering (RR) of items from the same category and with the number of words recalled from within categories.

The preceding studies have generally shown that the degree of clustering in free recall is directly related to measures of associative strength. This finding supports the notion of a similarity in free recall and associative learning, but the precise nature of this similarity has remained obscure. This is partly due to an inability to develop an associative index with a high degree of generality or predictive accuracy. A second related problem has been the development of a measure of clustering serving to accurately represent the subject's organizational schema. Stojak (1971, personal communication) has outlined the inconsistencies and problems in formulating a truly representative measure of clustering in free recall protocols. This is partly a mathematical problem related to compensating for chance clustering levels and the number of items recalled on any one trial. However, while recent formulas have been derived to compensate for these factors a basic problem of fundamental importance still exists attributable to the nature of the free recall paradigm itself. In essence, free recall protocols do not allow one to define what particular nominal units are part of any given cluster. The clusters themselves cannot be defined and so neither can their exact size (number of nominal units) be determined. It is therefore legitimate to ask upon what logical basis one can assess "clustering" with dependent measures designed to examine only pairwise dependencies. If one accepts the possibility that a cluster may consist of more than two nominal units this problem becomes quite apparent. Despite the fact that various measures have recently become available for assessment of "supposed" clusters of sizes larger than two units (Pellegrino, 1972), free recall protocols do not readily conform to precise statements concerning what is and what is not a given cluster. A verbal or written

record of recalled words does not necessarily provide clear evidence of where one cluster begins and ends, how many words are in the cluster, or how many clusters have been formed. Given the simple free recall paradigm the experimenter is still forced to impose his own conceptions of what a cluster is and thus, evaluation of specific relationships between clusters and S-R units is not possible.

Besides the simple free recall study investigations of the effects of cueing upon recall also merit examination. Demonstrations of the positive effects of cueing upon retrieval after free recall learning allows for a differentiation between available and accessible items (Tulving, 1964, 1968), and supports the notion that dependencies (associations) exist among stored units in memory (Underwood, 1972; Postman, 1972; Wood, 1972). Providing category names during recall facilitates the retrieval of higher order memory units (Tulving & Pearlstone, 1966; Tulving & Psotka, 1971; Weist, 1972). In so far as cues fail to facilitate recall, a case may be made for the independence of events in memorial processes (Slamecka, 1968, 1969, 1972), and higher order units formed during free recall learning would then have no common characteristics with associative conceptions of memory. Examination of the possible reasons why cues may fail to facilitate recall is therefore necessary, as such evidence represents an apparent impasse for associative conceptions of memory in free recall learning.

Generally, it has been agreed that retrieval cues facilitate recall only when presented during both learning and retrieval (Wood, 1972; Postman, 1972; Thomson & Tulving, 1970; Tulving & Madigan, 1970). The efficiency of retrieval cues also depends upon the type of coding operations that occur during input (Wood, 1972). Underwood (1972) has noted that associative attributes (word-word and word-context) probably play an important role in encoding and retrieval processes. Determinants of these coding operations are pre-experimental language habits, type of list (categorized vs. uncategorized), idiosyncratic organizational preferences, and combined "group" characteristics (Wood, 1972; Postman, 1972). The effectiveness of a retrieval cue then varies as a function of the temporal, spatial and semantic characteristics it has in common with nominal units comprising the higher order unit (Tulving & Madigan, 1970; Tulving, 1972). Given the complex list of factors that may influence the effectiveness of

an experimentally provided cue, the failure of some cues to facilitate recall cannot be accepted as *prima facie* evidence for the independence of memorial processes in free recall learning.

Both Postman (1971, 1972) and Wood (1972) have discussed essentially associative interpretations of cueing research speaking of "interitem dependencies" or the "dependency hypothesis". The logic of this approach implies that if nominal units considered to be part of a chunk are inter-related via interitem networks then recall of any one unit should increase the probability of recalling other related units comprising the chunk (Wood, 1972). That is, chunks composed of many nominal units should tend to act as a single unit when recalled or forgotten. This notion of inter-item dependencies and chunks may be subsumed under traditional associative concepts of direct and indirect associative relationships.

Field (1969) has outlined these direct and indirect notions of associative clustering. Briefly, words presented during learning may be perceived by the subject to be related or unrelated. If two or more words are perceived as related or are perceived as part of the same taxonomic category, they tend to be recalled together (Tulving, 1962; Bousfield, 1953). Related words may be classified as either direct or indirect associates of each other. The words "dog" and "cat" may be perceived as direct associates by a subject and therefore occur together in his free recall protocol. If the subject first recalls "dog" the response "cat" may be said to be elicited as a high frequency associate of the word "dog".

In addition to direct associations among items of a chunk, indirect associations may also be developed. Words within a chunk may have one or more common associative responses that have not been presented in the word list. For example, the words "dog" and "cat" may both elicit the common response "animal". Recall may now occur via two major routes. First, provision of the word animal as a recall cue may elicit the words "dog" and "cat" as exemplars of this category (animals) providing the subject has recognized and encoded these two items as "animal" category instances. Secondly, provision of either "dog" or "cat" as a stimulus cue may elicit the category name or mediator (animal) which in turn elicits the other category instance. In free recall studies employing category names or list items as cues, it is expected that recall would increase when these cues

are provided if interitem dependencies had been formed during learning. More specifically, associative notions of chunking must imply the development of interitem dependencies between items of a chunk or between the category name and items of a chunk.

These associative notions of chunking have received empirical support through the demonstration that items paired or learned in a paired associate task are recalled together when later presented in a free recall list (Wood, 1972). While organizational theorists have not emphasized these interitem dependencies in free recall, it is generally recognized that the associations are a necessary component of organization. Tulving has stated:

"To account for trial by trial increments in free recall... the available evidence points only to the secondary organization of the strengthening of interitem associations as the critical ingredient of free recall learning." Tulving, 1968, p. 24 (italics by present author)

Even when associations are de-emphasized, as with Mandler's (1967) discussion of "integration" and "cohesiveness" of chunks, it is recognized that the items are interrelated in some way. Integration is the organizational equivalent of interitem dependencies (Bower, 1969).

Recently, Slamecka (1968) has questioned the organizational view of storage. In doing so, he suggests that while retrieval is organized, items are stored independently. Thus he states:

"Traces may be stored in total independence of each other, as discrete non-interacting units...Storage independence means that traces are functionally isolated so that the fate of one does not influence the fate of any other. Thus, if some items are made directly accessible at recall this should not change the probability of retrieving the rest." (1968, p. 505)

Slamecka (1968) based his hypothesis on the results of six experiments in which list items were presented as recall cues. Two consecutive oral presentations of one 30 word list were administered, and the words were immediately recalled under one of two conditions - no item cues provided or item cues provided. Recall was written with the cued condition providing a number of randomly ordered list items for the subject on the recall sheet. No facilitating effect of list item cues was found upon word recall, but the no cue treatment group displayed significantly superior recall

in four of the six experiments for lists of both unrelated and categorized words. These results are contrary to aforementioned notions of associative and organizational free recall learning. The fact that the cued treatment groups had inferior recall to the non-cued groups is problematical since "independence" implies that providing cues should neither increase nor suppress word recall. Slamecka concluded that the recall of the cued group was suppressed due to scanning of the provided item cues at the beginning of the recall sequence inducing loss of items from short term memory.

Slamecka (1969) attempted to remedy the loss of items from short term memory by imposing a 30 second delay for both cued and non-cued groups. Three study-test trials and a consistent input order were provided to insure the development of associative structure as a function of practice. Treatment groups consisted of no cues, random cues, or serial cues presented on the third trial only and followed by a four minute recall period. Since the list items were presented in a constant order across trials the serial cue condition represented an identical ordering of cues for both study and test trials. There were no significant differences in word recall between any of the three treatments. An identical second experiment was then conducted providing more elaborate instructions to the subjects concerning the nature of the recall trials, but again no significant differences were found among the three treatments. Interestingly, the provision of cues on the third test trial for the cued treatment groups resulted in a significant loss of previously recalled items when compared with the non-cued treatment group. Apparently, the provision of cues again interfered with the retrieval of previously learned items. Slamecka noted that it was possible the item cues interfered with recall since the subjects' organizational groupings or chunks probably did not correspond to the experimenter's ordering of the item cues on the recall task.

Postman (1972) has also noted that if a retrieval plan is actually directing recall, then a random presentation of items could disrupt the retrieval process. If cueing procedures disrupt retrieval they are biased against demonstrating any positive effects of organization on recall. Instead of following an efficient output format developed during learning, subjects may scan the provided items searching for missing members which they attempt to supply. This strategy is a less efficient means of

retrieval provided one assumes it requires scanning of accessible items in the store together with matching operations to avoid duplications of items already on the recall sheet. In contrast, free recall without provided cues requires no such initial matching operations.

Wood (1972) has noted alternative explanations of Slamecka's results can be phrased in terms of accessibility of the subject's memory units. Since only 30 words were presented in Slamecka's (1968, 1969) studies, Wood (1972) hypothesized that all the subjects' memory units formed during learning may have been accessible at the time of recall. If so, there would be little reason to suspect that the provision of item cues would facilitate recall. Slamecka (1972) has indirectly provided support for this hypothesis by noting the average category recall for uncued subjects receiving categorized lists (Slamecka, 1968) was 4.9 out of 5.0 categories. If item cues act by reinstating access to chunks formed during learning little effect can be expected if all the chunks are already accessible without the cues.

Alternatives to Slamecka's independent storage hypothesis, then suggest that cues may interfere with recall because the output order imposed by the cues conflicts with the "preferred" output order. In the case of Slamecka's particular studies, no facilitation occurred because the Ss could remember all of the chunks without cues. Thus, the chunk label served as an implicit retrieval cue for the control subjects. A third factor entering into the interpretation of Slamecka's results is that the cues selected may not have been the ones necessary to permit access to what is presently available in storage. For example, the cue may have required a backward associative retrieval. Relatively little is presently known concerning what variables affect the efficiency of cueing other than the need for some type of correspondence between the stored information and the cue. This correspondence may be of an idiosyncratic variety having been developed as a product of intra-experimental learning and/or may be related to pre-experimental associations based directly on natural language habits (Mandler, 1967; Tulving & Madigan, 1970). These alternative hypotheses however are questioned by additional cueing studies that indicate cues only facilitate recall when the list is very highly structured. Thus Allen (1969) found that item cueing significantly facilitated word recall

provided highly related pairs of words were presented in a consistent, sequential order during learning. This same trend was observed for "unrelated" words, but was not significant.

Hudson & Austin (1970) in a first experiment found a significant effect of providing item cues on word recall with a 30 word list of 10 well defined three word categories. A second experiment using identical procedure, but less clearly defined categories failed to find any effect of item cues on recall. In general, positive effects of item cueing upon word recall appear highly tentative being dependent on rigid constraints of presentation order and experimenter defined word relatedness. Unless strict measures are taken to ensure a well integrated organizational schema, item cues will have no effect or may interfere with word recall causing item loss from short term memory (Slamecka, 1968). These data, then, suggest that organized storage based on interitem relationships only occur when the relationships are well defined. If the relationships are strong, cue facilitation occurs even if the cue ordering may conflict with the S's output ordering. Similarly, there is no cue facilitation with weak experimenter defined organization regardless of the number of categories. Thus, Slamecka's independent storage hypothesis appears tenable for the uncategorized list situation.

Although list item cues have facilitating effects on only limited situations, a number of studies on category cueing have indicated the effectiveness of these cues. Dallett (1964) found a facilitatory effect of providing category name cues upon word recall in an experiment in which presentation order (blocked vs. random) and number of categories (2,4,6) were manipulated. Significant main effects for categories, presentation order, and the categories by presentation order interaction were found. Recall was superior in the blocked treatments for the four and six category conditions with the interaction attributed to a sharp drop in recall for the four category random group relative to all other groups. Tulving & Pearlstone (1966) found similar results on word recall when category names were provided for both study and test trials. List length (12,24,48 words) and the number of items per category - IPC (1,2,4 words) were manipulated. Cued recall (provision of category names) was significantly higher than non-cued recall for all lists except for the 12 word

4 IPC list. The superiority of cued recall to non-cued recall was an increasing function of list length and a decreasing function of the IPC. Results concerning list length indicate that the potency of cueing upon recall is directly related to the amount of information presented for learning. However, interpretation of the effectiveness of cueing as a function of IPC remains ambiguous since IPC and the number of provided recall cues were confounded. In each treatment an increase in IPC was accompanied by a decrease in the total number of cues provided on the recall trials. Despite the reduction in mean words recalled in the two and four IPC treatments, the probability of recalling two or more words in succession from the same category given one word was recalled varied between 89 and 97 percent. Tulving & Pearlstone (1966) interpreted this as supportive of a dependent storage notion wherein items within chunks are related by interitem dependencies. Wood (1967) replicated Tulving & Pearlstone's (1966) findings while attempting to evaluate the effects of providing category name cues during learning for experimenter defined taxonomic categories. Improved word recall was not dependent upon the provision of category name cues during learning, and provision of cues during test trials produced significantly improved word recall relative to the no cue control group. However, category name cues were found to be effective in facilitating word recall only when the category items were high (as opposed to low) frequency associates of the category title. Hudson & Austin (1970) also found facilitatory effects of providing category name cues on word recall when compared with both item cue groups and no cue controls for experimenter defined categorized lists. Category name cues effectively increased word recall for both high and low frequency associates of the provided category names.

Tulving & Psotka (1971) employed category name cues to assess the effects of retroactive inhibition (RI) in free recall learning. Subjects learned from one to six different 24 word lists containing six categories of four words each. After presentation of the final list, subjects free recalled all lists three times in succession. Cues were presented on only the third recall trial where they acted to eliminate the retroactive effects of multiple list learning, confirming the hypothesis that higher order memory units (chunks) were only inaccessible and not unavailable. It was

also noted that the number of items recalled per category remained fairly constant regardless of the total number of lists learned indicating that the effects of RI were predominantly confined to the loss of whole categories rather than items within categories. It was concluded that individual items within chunks were stored together so that retrieval of one nominal unit implied retrieval of all nominal units. This cueing study provides tentative support for a dependent notion of chunking in which many nominal units act as a single unit. Such results could be explained by the organizational effects of category titles (indirect associations) and/or interitem relations (direct associations) as noted by Field (1969).

In general, category name cueing studies have been supportive of dependent notions of category recall, and have provided evidence supportive of the potential presence of interitem dependencies. Conversely, item cueing studies have not supported a dependent notion of chunking in free recall learning, but have instead suggested the possibility of storage independence. Interpretative problems of storage independence have been discussed and related to the potentially biasing factors in item cueing studies as noted by Postman (1971, 1972), Wood (1972), and Slamecka (1968).

Of importance are the previously cited studies of Bousfield and his associates which have provided data relevant to the contention of the similarity of the associative and organizational products (S-R bonds and chunks) described in the introduction. That is, free recall protocols may display sequential consistencies highly similar to normative free associational indices based upon both single word free associations and multiple associates of taxonomic groups (categories). Due to the variance of the findings between item and category name cueing techniques, together with limitations of correlational studies such as Bousfield's, Postman (1971, 1972) has felt that it is necessary to go beyond the simple manipulation and analysis of free recall data in order to determine whether a dependent associative model of chunking in free recall is tenable. If chunks can be characterized as highly cohesive associative networks (not independently stored items), then free recall learning of a list of words should serve as a source of transfer in the subsequent learning of these same words in an associative task. Whether negative or positive transfer is incurred will be dependent upon whether first list learning

(the specific associative bonds formed) is complimentary to the selected S-R pairs presented for list 2 learning. Within this context, organizational processes in free recall can be viewed as grouping operations involving the linking of list 1 nominal units to form a chunk. As such, Wood (1972) has noted that "organization" may be considered as a descriptive label for a set of specific associations linking the nominal units of a chunk.

We will turn therefore to an examination of transfer paradigms to assess the data they provide relevant to dependent notions of chunking in free recall learning. In addition, the confusion resulting from the indiscriminate use of the terms "appropriate" and "inappropriate" memory unit will be assessed to develop a critical test of what is and what is not an appropriate memory unit.

Transfer studies: Free recall to free recall learning

The concerns of free recall to free recall (FR-FR) transfer paradigms have been primarily directed toward examining the relative effectiveness of different kinds of higher order subjective groupings upon free recall. The research has not been directly concerned with the relation between organization and association per se, but has nevertheless provided information relevant to the notion of the presence of interitem dependencies within chunks in free recall learning. Because of this they are relevant to the notion of an associative interpretation of clustering and the relationship between the S-R and organizational conceptions of learning.

The first relatively firm evidence for the dependency notion of clustering in free recall learning came from Tulving's (1966) FR-FR part/whole study. Two experiments were conducted employing FR-FR part/whole lists of 18/36 and 9/18 items respectively. Experimental groups had all first list words embedded in the second list in a random fashion while the control groups had different words in first and second list learning. This is the typical control procedure for all part/whole or whole/part studies wherein both control and experimental groups learn the same second list. In both experiments, examination of recall curves revealed a superiority of the experimental groups on only the first two trials, and a superiority of the control groups on the last 3 to 4 trials. Differences in the slopes of the experimental and control groups' learning curves indicated significantly faster acquisition for the control group. Thus, first list learning inhibited acquisition of list 2 items rather than facilitating performance as would have been expected due to prior familiarity with some of the items. Apparently, the positive effects of item familiarity were limited to the initial trials of the second list. Tulving (1966) concluded that first list learning could be effective in producing increments in recall only if first list organization was "appropriate" to second list organization. Since list 2 performance was inhibited, list 1 higher order units were consequently "inappropriate". This post hoc inference concerning the "inappropriateness" of list 1 chunks was subsequently employed in the transfer literature as a ready explanation for evidence of negative transfer while, in fact, the appropriateness of list 1 memory units as used

by Tulving (1966) was only a descriptive term providing no information about list 1 organizational processes nor the specific nature of list 1/list 2 relationships.

Tulving and Osler (1967) extended Tulving's (1966) findings to the FR-FR whole/part transfer paradigm. A first list task comprising 18 items and a second list task comprising 9 items was designed to evaluate the assumptions of independence versus dependence of items within higher order memory units. The results were similar to Tulving's (1966) showing negative transfer for experimental groups regardless of the degree of first list learning (6, 12 or 24 trials). Apparently, the number of list 1 trials had no effect on the amount of transfer. While this finding first appears contrary to associative notions of chunking, additional research on practice effects suggests that organization was probably maximal after only six list 1 trials (Wood, 1972). In this case, a practice effect would not be expected. Negative transfer was again attributed to the formation of "inappropriate" list 1 memory units which were, by definition, incompatible with the larger second list chunks the experimental subjects should have developed in order to match the control group's learning rate. These results support a dependent associative notion of chunking in free recall learning, but fail to provide information concerning what inappropriate memory units are, how many were formed, or what their composition is in terms of list items.

When speaking of associative transfer the importance of practice in the acquisition of the associative S-R bonds should be emphasized (Ellis, 1972; Kintsch, 1970; Martin, 1965; Postman & Schwartz, 1964). Assuming that the formation of chunks in free recall learning entails the development of associative interitem dependencies, it follows that practice effects should also be apparent in free recall learning and transfer. Tulving (1962, 1967) and Mayhew (1967) have demonstrated the importance of both study and test trials as opportunities to establish increased word recall and increments in word organization. Mayhew (1967) pointed out that subjective organization and the number of words recalled are highly correlated factors. He found that the number of words learned on any one trial remained invariant, but that increases in word recall were largely a function of intertrial retention (the number of words retained from the previous trial) which improved as the list was practiced. The degree of

organization was highly dependent upon practice since the discovery of interrelations among words was obviously dependent upon being able to remember them.

Bower, Lesgold, & Tieman (1969) have provided information regarding conditions of practice for the integration and consolidation of chunks in free recall learning for both related and "unrelated" lists of words. Four word groups were presented one at a time while subjects imagined a scene wherein the items of the group interacted together. Improved word recall was only achieved provided the nominal units in a given chunk remained the same from trial to trial. When items from different chunks were mixed on every trial no improvement in recall was found. It was also noted that the probability of the recall of all the items of a chunk (given atleast one item was recalled) was high only when the nominal units of a chunk remained the same from trial to trial. These results are consistent with the position that the development of well integrated memory units is dependent upon conditions of practice which is also the case for the development of simple S-R dependencies. Provided well integrated memory units are formed, the chunk will exhibit interitem dependencies in free recall consonant with the notion of the development of associative strength. Bower (1969) has also shown that well integrated memory units (3 word cliches) exhibit dependent characteristics in free recall indicative of high interitem associative strength. It was found that after one study trial 3 word cliches tended to be recalled in a perfect "all or none" fashion while 3 word "unrelated" groups did not display this characteristic.

Wood (1969b) re-examined Tulving & Osler's (1967) findings in a whole/part free recall to serial list transfer task using a basic two group design (different words in lists 1 and 2 vs. same words) together with degree of list 1 practice as variables of interest. The first study which employed 10 learning trials in both lists 1 and 2 showed no significant results, but a second analysis of only the last four list 2 trials indicated significant negative transfer for the experimental group. The second experiment revealed significant negative transfer for the experimental group in the six trial treatment only. Examination of high and low organizing Ss based on clustering scores indicated that experimental subjects achieving a high degree of organization during list 1 practice did

notably worse on list 2 than high organizing controls. For low organizers, list 2 performance was reversed. This interaction supports the notion that memory units formed by experimental subjects during list 1 learning can be responsible for negative transfer. Wood's (1969b) results support Tulving and Osler's major findings in showing that while list 1 practice is a necessary pre-requisite for negative transfer, practice per se is not alone sufficient to cause negative transfer. It must be assumed that practice results in the achievement of a relatively high degree of list 1 organization which is related to random individual differences and abilities - not all subjects may achieve the necessary degree of organization in N trials to produce observable negative transfer.

Wood (1971) extended Tulving and Osler's (1967) findings with a 54/27 FR-FR whole/part experiment in which list 1 items (18 groups of 3 words) and list 2 (9 groups of 3 words) items were categorized. Experimental Ss were expected to have to reorganize list 1 memory units for list 2 learning. The results indicated significant negative transfer when list 2 items were presented randomly without respect to the list 1 groups. In contrast, maintenance of identical list 1 groups during list 2 learning resulted in a non-significant amount of positive transfer. These results imply that decrements in list 2 performance are related to the interfering effects of list 1 organizational units provided the arrangements of list 2 items during learning are not identical with list 1 groups. It would appear that specific interitem dependencies may be formed during free recall learning, and that these interitem dependencies are a potential source of negative transfer in list 2 learning.

The preceding FR-FR transfer studies have all been concerned with inappropriate memory units and their negative effects on transfer list performance. While they have been in general, supportive of an associative dependency notion of chunking in free recall learning, the evidence can only be considered tentative and indirect. That is, the formation of specific interitem dependencies has been inferred on the basis of decrements in transfer list performance. Specific interitem dependencies have not been identified in either list 1 or list 2 learning. In addition, the possible effects of attentional factors upon learning have been called

into question (Postman, 1972), and firm evidence of negative transfer has not been consistent (Wood, 1969b). Essentially, the problems involved stem from the failure of the experimenter to accurately define what the list 1 memory units and their component items may be (Bower, Lesgold & Tieman, 1969), how many chunks there are, and the relative extent of the organizational structure after list 1 learning (Tulving & Osler, 1967). While various types of constrained presentation orders (Wood, 1971) may help to ensure the development of certain organizational units, assessment of clustering in free recall protocols to determine the effectiveness of specific presentation procedures is not a satisfactory method of determining what the subject's memory units are (Cofer, 1965; Tulving, 1968). In effect, the failure to accurately identify list 1 chunks has resulted in the subsequent failure to determine what an appropriate memory unit is and what an inappropriate memory unit is. As such, the only alternative has been to conclude that inappropriate memory units are those which interfere with list 2 learning. Conversely, appropriate memory units should not interfere or should facilitate list 2 learning.

This latter assumption is based on the notion of the transfer of identical elements which is a fundamental tenant of both associative and organizational theory. For organizational theory, the "elements" of interest are the chunks formed during free recall learning. FR-FR transfer studies have so far provided only weak evidence to support the notion that provided list 1 chunks remain identical during list 2 learning positive transfer can be obtained (Bower & Lesgold, 1969; Ornstein, 1970; Wood, 1970). It would appear that positive transfer is quite transitory (first one or two trials) without rigidly constrained types of presentation sequences involving the blocking and segregation of old and new list items by the experimenter. The FR-FR experiments obtaining positive transfer with these presentation constraints have not served to explicate the processes involved in idiosyncratic organizational structures developed by subjects and have not served to clarify the reasons for negative transfer in the majority of the previously cited FR-FR studies which allowed subjects to construct their own organizational groupings during learning.

In the instances where indications of positive transfer have been

obtained (Tulving, 1966; Novinski, 1972; Tulving & Osler, 1967; Wood, 1971) it has been limited to the first one or two trials despite emphasis upon list 2 construction (Novinski, 1972) and constrained presentation orders (Wood, 1971). As such, this positive transfer may be due to item familiarity acquired as a consequence of list 1 practice. Noble (1955) has clearly demonstrated that prior intra-experimental exposure to list items may act to significantly improve serial list performance, and that the percentage of correct responses on the first anticipation trial is a direct function of the prior frequency of item exposure. In so far as familiarity effects occur most prominently during the initial stages of transfer care must clearly be exercised when attributing positive transfer effects to the presence of "appropriate" memory units.

Among the attempts to obtain positive transfer employing chunks as the unit of transfer was a study by Bower & Lesgold (1969) in which both the experimental and control groups were presented with 16 list 1 items (A items) in pairs (ie. A_1-A_2 , A_3-A_4 , etc.) and instructions to imagine a relationship between each word pair. The transfer list items (B items) were then combined with list 1 items to form four word groups presented one at a time for learning. Transfer list presentation formats used for the two experimental groups were constructed as follows: 1) $A_1A_2B_1B_2$ or 2) $A_1A_2A_3A_4$ followed by $B_1B_2B_3B_4$. Subjects practiced list 1 for four free recall trials at a two second presentation rate, and transfer list learning continued for six free recall trials. While a significant superiority was obtained in word recall for both experimental groups relative to the control group, the two experimental groups did not differ in word recall. These results support a notion of transfer of identical chunks (list 1 relationships) which is similar to the associative notion of the transfer of identical elements, and argue for the functional equivalence of transfer rules in associative and organizational theory. One drawback in placing too much emphasis upon these results is related to the fact that the organizational schema was fully experimentally contrived, and may not reflect the processes involved in idiosyncratic organizational processes (Postman, 1972). In general, while Bower & Lesgold (1969) found clear evidence of positive transfer, other FR-FR studies have not been so successful.

Wood (1970) in the first of two free recall experiments had subjects first learn an 18 word list composed of direct associates of the words used in the free recall transfer list. That is, the 18 words of the transfer list could be organized in analogous fashion to those of the first list. Optimal organizational structures can here be considered equivalent although the words in both lists were different. Although the control group surpassed the experimental group, the difference was not significant. The results are inconclusive although it might be hypothesized that in cases where application of organizational groupings could actually be similar in both lists, the potential amount of interference may be reduced.

Maintaining the similarity of organizational groupings between lists has also been attempted by direct manipulation of items in efforts to obtain positive transfer. Ornstein (1970) in a first experiment blocked old (list 1) and new (list 2) items to maintain similar organizational groupings in a part/whole free recall paradigm. Treatments comprised a control group and five experimental groups in which list 1 and list 2 items were presented separately in discrete groups or randomly mixed in the 24 item transfer list. Positive transfer was only found on the first two of eight transfer trials, and only when old and new words were grouped in two separate blocks. In the second experiment a 24/56 part/whole transfer task was used employing 12 list 1 words in the experimental groups' transfer list. The experimental groups consisted of a compatible (C) group (same conceptual groupings in both lists) and an incompatible (IC) group (different conceptual groupings in each list). Presentation order was blocked in both list 1 and transfer list learning to achieve the organizational structures intended by the experimenter. Positive transfer was found for the C group on only the first of five trials. Novinski (1972) attempted to replicate Tulving's (1966) part/whole free recall transfer paradigm with the addition of further instructions to one group of subjects for the purpose of informing them that their list 1 organizational strategies were now inappropriate for transfer list learning. Although the informed group displayed a significant superiority over the uninformed group in word recall, the informed group displayed no positive transfer when compared with the control group.

It is apparent in considering the results of the majority of the aforementioned studies, that despite efforts to obtain positive transfer,

the control groups continued to surpass or at least equal the experimental group's rate of learning. Only when extremely rigid experimentally contrived constraints were instituted (Bower & Lesgold, 1969) did experimental groups develop and maintain positive transfer as a function of prior list 1 practice. Given these considerations, it is apparent that item familiarity is a relatively weak variable in these paradigms having only highly tenuous and transient positive transfer effects when an idiosyncratic organizational schema is developed by subjects during learning. If the development of higher order memory units during list 1 practice serves as the major impediment to positive transfer, then item familiarity might be expected to produce more stable positive transfer if: 1) item familiarity is an operative variable in FR/FR paradigms, and 2) if no or relatively little idiosyncratic organizational schema is developed as a function of list 1 practice. Several studies will now be cited that bear on these considerations.

Both Slamecka, Moore, and Carey (1972) and Elmes, Roediger, Wilkinson, and Greener (1972) found positive transfer for experimental groups employing FR-FR part/whole transfer paradigms. Although both of these studies reported positive transfer as a function of list 1 learning they have been unable to adequately clarify the reasons why this positive transfer was obtained. The Elmes et al study bears directly upon the effects of idiosyncratic organizational strategies in free recall learning due to the use of "unrelated" words and random presentation orders. Elmes et al conducted a set of three experiments each employing identical methods, but varying in the number of part and whole list learning trials, 6, 8, and 16 for experiments I, II, III respectively. Words in list 1 and transfer list learning were presented in either a successive (one at a time) or in a simultaneous presentation mode (whole list exposed at once). The input orders for the items were different on each learning trial period. The list 1 task consisted of 11 two syllable nouns, and the transfer list consisted of 22 nouns. Experiments I and II found superior word recall for the experimental groups. The control group (different words in each list) displayed faster acquisition than the experimental group, but failed to surpass the experimental groups' word recall. Analysis of list 1 clustering revealed no significant effects of presentation modes nor of trials, implying

either that no stable list 1 organization schema was established or that maximal list 1 organization was achieved very rapidly within the first two list 1 trials. If a stable list 1 organization was achieved, the finding of positive transfer for the experimental groups would not support the notion of interfering effects of organizational schema upon list 2 acquisition and consequently, the associative notion of free recall learning could not be supported. Elmes et al, hypothesized that the subjects did not form higher order memory units in list 1 learning thus eliminating negative transfer effects due to organizational unit incompatibility. The assumption that no stable organizational schema was established during list 1 learning seems reasonable since approximately $1/3$ of the words were very low frequency words (ie. octroi, quisy, rennet, stamen, trollop, waiver, zenith) and their meanings were likely unknown to the majority of the subjects. Given no stable list 1 organization was formed, the positive effects of item familiarity and word integration could have contributed to the improved word recall displayed by the experimental groups (Bower, 1969; Noble, 1955).

The results of experiment III will be examined although their impact on experiments I and II is ambiguous due to the absence of statistical analysis of the transfer data. Sixteen trials were employed for both lists in experiment III to ensure the development of higher order subjective units, and a more common set of words was used (Thorndike-Lorge count 50-AA). Analysis of list 1 learning indicated that by the sixteenth trial 94% of the subjects had one or more perfect recall scores. A significant effect of trials on degree of list 1 clustering was obtained, and no significant differences between presentation modes was found. No statistical analysis of list 2 transfer was provided, but figures of experimental and control group recall indicated positive transfer for all experimental groups except where the successive presentation mode was used in both list 1 and list 2 learning. Explanations offered concerning the failure of list 1 organizational structures to interfere with transfer list acquisition centered around the possibility that subjects eliminated interference by arranging words in groups of old (list 1) and new (transfer list) items. Given the similar positive effects of maintaining experimenter generated units in both list 1 and list 2 learning (Bower & Lesgold, 1969, Exp. II), this

suggestion remains a tentative possibility, but Ornstein (1970) has demonstrated that manipulation of clusters in terms of old and new list items produced only highly transitory positive transfer on the first one or two transfer list trials. Bower & Lesgold (1969) in replicating Tulving's (1966) FR-FR part/whole study also found a predominantly negative effect of list 1 learning upon transfer list recall although it was not statistically reliable. The only positive effects of list 1 training occurred on the first two transfer list trials as was similarly observed by Ornstein (1970). It would now appear that Elmes et al, have found persistent facilitatory effects of list 1 learning upon transfer list performance despite the formation of chunks during list 1 learning which Tulving (1966) originally hypothesized to be the major reasons for decrements in transfer list performance.

Elmes et al results may partially reflect the fact that a simultaneous presentation procedure during transfer list practice allows subjects to overcome the interfering effects of list 1 organization by selectively attending only to words that are part of one chunk at once. While simultaneous presentation procedures appeared to produce positive transfer similar to experimenter controlled blocking techniques employed by Bower and Lesgold (1969), negative transfer was still found when both list 1 and list 2 items were presented successively, (Exp. III) which is the presentation method utilized by most of the previously cited FR-FR studies. Elmes et al also noted that apparent positive transfer was obtained for the simultaneous-successive presentation mode in which interfering effects of list 1 organization upon transfer list performance due to selective attentional factors cannot be ruled out. While Elmes et al do not provide evidence on whether these positive effects are significant (Exp. III), the trend towards positive effects of list 1 learning upon transfer list performance is decidedly contrary to previously observed trends in the data (Tulving, 1966; Tulving & Osler, 1967; Ornstein, 1970; Wood, 1970; Novinski, 1972).

In summary, FR-FR transfer studies have provided tentative support of the hypothesis that free recall learning entails the development of chunks which may be characterized by specific interitem dependencies. This hypothesis has been based upon the finding that familiarization

(practice) with list 1 materials in most cases does not improve transfer list performance, but rather retards it when compared to a control group. Elmes et al (Exp. I & II) has provided additional evidence which suggests that item familiarity is operative in FR-FR studies and can even facilitate list 1 performance provided no stable higher order memory units are developed during list 1 practice. Provided that list 1 materials are sufficiently familiar to be organizable, it appears list 1 practice can actually interfere with transfer list recall by inhibiting the formation of optimal higher order organizational units most conducive to the improved recall of the nominal list 2 units. Problems with these previously cited FR-FR studies have been the possible confounding of negative transfer effects due to inappropriate memory units with attentional variables (Postman, 1972); the basic failure to clearly identify the causes of negative versus positive transfer effects (Tulving, 1966; Wood, 1969b; Wood, 1970; Elmes et al, 1972); and the inability to adequately identify or control the formation of higher order memory units formed during list 1 learning (Wood, 1972). As such, the distinction between appropriate and inappropriate memory units has remained ambiguous although some FR-FR experiments demonstrating positive transfer have given tentative support to the notion that an appropriate memory unit is one in which nominal units remain the same in list 1 and list 2 learning (Bower & Lesgold, 1969).

Transfer studies: Free recall and paired-associate learning

In view of the aforementioned problems found in FR-FR studies, Postman (1971, 1972) has recommended that precise evaluation of the relationship between the development of idiosyncratic organizational structures in free recall learning and associative conceptions of the development of simple S-R interitem dependencies can best be evaluated within the context of free recall to PA (FR-PA) and PA to free recall (PA-FR) transfer studies. One reason for preferring this approach is that the PA task allows direct assessment of pairwise interitem dependencies and is thus an appropriate tool for assessing the correspondence between the basic associative unit (the S-R bond) and the products of free recall learning (chunks). Traditionally, both the PA task and serial learning tasks have provided the framework within which associative bonding has been examined. Of these two approaches, the PA task has been considered the best for examination of the simple associative S-R interitem dependency (Young, 1968). In the same sense, the free recall task has provided the working model for organizational theory, and the examination of free recall protocols has provided the basis for inferences concerning organizational processes (Shuell, 1969). Since the primary effort of the present paper is to establish a clear basis for the similarity of S-R bonds and chunks, information must be obtained that unambiguously identifies the relationship, if any, between the products of free recall learning and basic associative units.

Postman (1971) has phrased the question in the following manner:

"A basic empirical question is whether subjective organization in free recall entails the development of linkages between discrete units that share the functional properties of the sequences established in controlled associative learning." (Postman, 1971, p. 292)

Postman (1971, 1972) has contended that FR-PA transfer should be predominantly negative if items from free recall learning are arbitrarily (randomly) paired in the PA transfer list since it would be expected that in most cases the S-R pairs would differ from the associative arrangements developed in free recall learning.

The FR-FR studies have exemplified the problems encountered in developing an organizational basis for the notions of positive as well as negative transfer effects - the direction of transfer being assumed to be a function of the appropriateness or inappropriateness of list 1 memory units (Tulving, 1966). Postman (1971, 1972) has demonstrated that when a paired associate list is formed by randomly pairing items from a free recall list negative transfer is produced. However, this finding has not resolved what appropriate or inappropriate memory units are. This is because the random pairing of items does not require specifying what the list 1 chunks are, but only requires the assumption that list 1 practice results in the formation of higher order memory units (ie. interitem dependencies). While there appear to be functional similarities between the products of free recall and associative learning, specification of precise relationships between given S-R units and specific chunks developed in free recall learning has not been accomplished. Although previous FR-FR studies have approached this problem, evidence relevant to the interrelation of the products of list 1 and list 2 learning has remained ambiguous due to difficulties in accurately identifying specific list 1 and list 2 chunks. Apparently, list 1 chunks produce positive transfer or are appropriate for list 2 learning only when rigid experimentally imposed constraints are used (Bower & Lesgold, 1969). Since this data has been based upon experimentally controlled organizational techniques and not subject directed strategies, it remains unknown whether these same relationships hold for idiosyncratic organizational schema (Postman, 1972). PA-FR and FR-PA studies will now be examined noting their contributions relevant to the contention of the interrelationship of S-R units and chunks in free recall learning.

The PA-FR studies will be reviewed first. These studies have been primarily concerned with the relevance of pairwise interitem associations upon the development of chunks in free recall learning. Relative to previously examined FR-FR designs, PA-FR studies allow precise manipulation of list 1 units permitting clearer inferences concerning the relationships between interitem dependencies and chunks (Wood, 1972). Segal & Mandler (1967) examined organizational processes in a PA-FR transfer task, in which

subjects first practiced a 16 pair PA list for 16 trials by the anticipation method using an unidirectional, bidirectional, or combination uni- and bi-directional presentation format. Subjects then transferred to one of four free recall lists comprising either 16 PA stimulus items, 16 PA response items, 8 stimulus and 8 response items previously paired, or 8 stimulus and 8 response items not previously paired. While an associative notion would predict greatest positive transfer for previously paired list 1 items and negative transfer for previously unpaired items failure to employ a control group in this study makes assessment of positive and negative transfer impossible. For unidirectional list 1 learning, recall of previously unpaired stimuli and responses was significantly inferior to the other three FR lists, while for bidirectional list 1 learning all FR lists were significantly inferior to previously paired stimuli and responses. No other significant differences were observed. Consonant with an associative notion of transfer, recall of previously paired items was always significantly superior to recall of previously unpaired items. The previously paired items also displayed significantly greater clustering in free recall regardless of type of list 1 learning. These results provide support for the contention that interitem dependencies developed in PA learning may be used in free recall learning to improve both word recall and development of higher order memory units (ie., clustering).

Wood (1969a; 1969c; 1970) also employed PA to free recall transfer paradigms in an attempt to manipulate higher order memory units as Segal and Mandler (1967) had done, while correcting for their lack of a control group. Wood(1969a) presented 18 PA pairs in a bidirectional list for 10 study test trials, and then an 18 item free recall list consisting of either 0,6,12 or 18 words from the PA list. Only one member of each PA pair was included in the free recall task and other new words made up the rest of the free recall list. It was hypothesized as more PA words were added to list 2 negative transfer would increase due to the added inappropriate associative responses now evoked by the PA stimuli. The hypothesis was substantiated, and it was concluded that recall of items in free recall paradigms reflects the use of associative relationships among words. These findings support a basic dependent associative notion of free

recall learning. Wood (1969c) sought to extend these findings by obtaining positive transfer through employing list 1 PA pairs in the free recall transfer list. As in Segal & Mandler's (1967) study, Wood (1969c) assumed that interitem S-R dependencies developed in PA learning could be used during free recall to aid development of higher order memory units and improve word recall. Three types of free recall lists were constructed. Group 1 received only one word from each PA pair for list 2 learning. Group 2 received half of the PA pairs presented in consecutive order for free recall. Group 3 received half of the PA pairs presented in random order. It was hypothesized that Group 2 would produce the most positive transfer relative to the control group because of the opportunity to use PA list interitem dependencies, and negative transfer was hypothesized for Group 1. The recall data indicated negative transfer for Group 1 as expected, but Group 2 and 3 revealed no significant differences relative to the control group not supporting the hypothesis concerning positive transfer.

Wood (1970) again attempted to obtain positive transfer in a study where subjects learned a 12 pair PA word list and then a free recall list. List 2 presentation order (constrained or random) and list 2 item composition (24 PA words, 12 PA words and 12 category names, 12 PA words and 12 category instances) were manipulated in a 2x3 factorial design with additional control groups. Category names and instances were conceptually related to the PA words. Recall data indicated the constrained groups (related items presented in consistent, sequential order) were superior to the random groups, and that the 24 PA word group was superior to the controls in both presentation orders. Both word category lists showed superior recall in only the constrained presentation mode relative to the controls. These results imply that associative interitem pairwise dependencies established in PA learning can facilitate subsequent free recall performance provided free recall presentation order maintains the same sequential dependencies developed in PA learning. While Wood (1970) reported superior recall for the 24 PA word groups, the assertion that PA learning facilitates subsequent free recall learning in this case requires careful assessment.

Most previous studies have been unable to obtain positive PA-FR transfer (Wood, 1969c) or very minimal facilitation of free recall performance as a function of prior PA learning (Segal & Mandler, 1967). Only Postman (1971) has presented relatively unambiguous evidence indicating the facilitating effects of PA learning upon free recall performance. Postman's (1971) study employed 10 study test transfer list trials under both typical recall and multiple choice recall procedures. Word recall was significantly superior to the control's under both recall procedures, but it was noted that in the multiple choice procedure the experimental and control groups' word recall was essentially the same by the fourth test trial remaining approximately equivalent through trial 10. While it appears that interitem pairwise dependencies may facilitate the initial trials of free recall learning, these same interitem dependencies may not facilitate the formation of larger higher order memory units during the latter trials of free recall learning. Wood's (1970) results must be carefully interpreted since only four free recall trials were employed. Visual inspection of the learning curves for the 24 PA word groups indicates that average recall on the fourth trial included approximately 75% of the items. In addition, the slopes of the control group curves indicate that had learning continued, the control group would have surpassed the 12 pair groups after the fourth trial before a ceiling effect was reached. Average word recall for the 12 pair group under the random presentation mode increased by only one word across four trials making the slope of the curve essentially flat.

This information together with results of previously cited PA-FR studies, indicates that the facilitatory effects of PA learning upon free recall are primarily of a transitory nature. Nevertheless, Wood's (1970) results together with those of Postman (1971) indicate that pairwise interitem dependencies can be used to facilitate the initial formation of chunks in free recall learning. As such, these results argue for a dependent associative notion of free recall learning entailing the formation of interitem dependencies in chunking processes.

While the previous PA-FR studies give some support to the notion of the similarity of the products of paired associate and free recall learning,

this approach may be biased in terms of finding correspondences between S-R units and chunks. Individual pairwise interitem dependencies may not typically occur in free recall learning without prior PA training. Excepting Postman's (1971) study, positive transfer effects in PA-FR studies have been limited to the first few trials of FR learning. Reasons for this limited effect may be due to the type of interitem dependencies characteristic of well integrated higher order memory units. If it is assumed that organization is a necessary condition for the efficiency of memorial processes and that the number of nominal units per category is typically greater than two (Mandler, 1967), then highly learned pairwise interitem dependencies may have to be modified (broken up, recombined, or enlarged) to ensure a meaningful, maximally efficient conceptual schema for free recall. Segal & Mandler (1967) have also provided evidence to indicate that bidirectional PA learning permits more efficient use of interitem dependencies in free recall compared with unidirectional PA learning. In so far as items in FRL are typically presented in different random orders on every trial, conditions for the development of higher order units characterized by bidirectional associations is a likely possibility. In light of these considerations, the positive transitory effects of PA learning upon free recall may reflect the difficulty in adopting pairwise interitem dependencies to the formation of larger higher order units at some point in FRL.

FR-FR studies, where indications of positive transfer have been obtained (Tulving, 1966; Novinski, 1972; Tulving & Osler, 1967; Wood, 1971), also bear the same initial transitory effects now seen in these PA-FR studies. Due to the apparent similarity of results between these two paradigms and the consistent transitory nature of their initial positive effects, careful consideration must be given to the relative influences of interitem dependencies versus item familiarity. A major problem of the preceding studies has been their failure to distinguish between the relative contributions of these two variables in instances where transfer has occurred.

FR-PA studies will now be examined to assess the correspondence between chunks formed in free recall learning and pairwise interitem dependencies. Postman (1971, 1972) has hypothesized that the arbitrary reordering of items

after free recall learning must necessarily involve disruption of organizational units thus producing negative transfer. This is based upon the assumption that free recall learning must always involve the formation of organizational units or chunks. Postman (1971) conducted a FR-PA experiment in which the PA task employed both multiple choice recognition and the typical recall methods with an alternating study test procedure. Free recall learning was carried to a criterion of 16/20 correct plus three additional study test trials. Negative transfer was obtained across all 10 PA trials. Since negative transfer was obtained Postman concluded the PA pairs were "inappropriate" memory units.

Rogers & Battig (1972) attempted to test Postman's (1971) hypothesis using a low criterion (12 out of 24 words recalled) list 1 learning group to evaluate the effects of degree of practice upon transfer. It was hypothesized that the low criterion group would not incur as much negative transfer due to its lack of time to develop strong interitem dependencies in higher order subjective units. Significant negative transfer was found for the high criterion experimental group (1 perfect recall trial), but not for the low criterion group. It was concluded that interitem organizational units developed in free recall learning represent a major source of interference provided they are given sufficient time to develop. Johnson (1972) sought to determine whether interitem pairwise dependencies would always produce negative transfer when adjacent or non-adjacent pairs were matched from subjects' free recall protocols in a FR-PA study. Although adjacent pairs produced less negative transfer than non-adjacent pairs, both experimental groups were significantly inferior to the control group.

A possible reason for consistent failures to obtain positive transfer may be that subjects' free recall protocols do not reflect the exact organizational units they have developed. Primary organizational factors are typically mixed with secondary organizational schema (Tulving, 1968). Since neither the number of chunks nor the size of the chunks for a given subject were determined, some of "adjacent" pairs may well have been members of different higher order units. Another possible reason for the failure to find any evidence of positive transfer may be that well integrated

higher order memory units cannot be characterized by pairwise S-R inter-item dependencies. Mandler (1967) and Stojak (1971) have shown that subjects typically organize lists of words into chunks of between four and five nominal items regardless of list length. If multiple item chunks are composed of multidirectional bonds, then random removal of two nominal units for PA learning may entail interference from other pre-established multiple associations to those two specific items (Postman, 1972).

Barton & Young (1972) also predicted differential transfer when pairing items from the same chunk (within pairs) or pairing items from different chunks (between pairs). It was hypothesized that within FR pairs would display positive transfer on the PA task since they were from the same conceptual unit. Negative transfer was expected for between group FR pairs since they were from different conceptual units. The subjects first practiced a free recall list of four experimenter defined categories of six items each for five alternate study-test trials. Recall data indicated significant negative transfer for both between category pairs and within category pairs. No trials by treatments interaction was found indicating similar negative transfer for both experimental groups across trials. Failure to obtain positive transfer for the within category PA pairs was attributed to item interference.

These results may indicate that higher order memory units cannot be characterized by pairwise interitem dependencies, but rather multi-item associative networks (Postman, 1972). An alternative interpretation is that the subjects did not employ the experimenter defined categories, but rather imposed their own organization. An assumed within category pair may or may not have been a within category pair. However, clustering assessed by the modified ratio of repetition gave scores of .79 for the experimental and .82 for the control groups indicating substantial compliance with the experimenter defined categories. Despite this compliance, it is possible that sufficient differences were present in the subjects organization to obscure any positive effects of the assumed within group pairs.

In summary, the major faults of the preceding transfer studies center about: 1) the failure to accurately specify through operational means an

adequate definition of organizational memory units; 2) the indiscrete use of the terms appropriate and inappropriate to characterize first list organizational units after reference to list 2 results; and 3) the assumption that free recall learning must always imply the achievement of organization.

The Present Research

The purposes of the present research were as follows: 1) to obtain evidence testing the dependent associative notion of chunking in FR learning; 2) to test for differential transfer as a function of the type of item pairings selected from list 1 organizational schema; 3) to clearly distinguish between memory units which are appropriate and inappropriate for use in a transfer list; and 4) to attempt to demonstrate that the associative network of a given chunk consisting of more than two nominal units can be characterized by pairwise interitem dependencies.

The present research employed a variation of the FR/PA paradigm in which sorting comprised the free recall task. In a sorting task subjects are typically given a pack of cards with a single word on each card. After placing or sorting the cards into separate categories, the subjects may be asked to recall the words. Sorting procedures thus allow visual inspection of subjects' organizational schema on a trial by trial basis. The need for identifiability and stability of organizational units discussed earlier led to the selection of sorting as the most appropriate free recall procedure.

Mandler (1967) has demonstrated that sorting words into categories in multitrial free recall faithfully reflects the development of organizational units and accurately mirrors the positive relationships between recall and degree of organization found in free recall studies not employing sorting procedures. Instructions informing subjects that recall would be required after sorting had no effect on recall compared to uninformed groups provided both groups actively sorted words with the intention of organizing them. Mandler (1967) also found that subjects consistently preferred four or five sorting categories regardless of the number of list items (52 or 100). Sorting procedures constitute a well accepted method for investigation of free recall learning (Posner & Warren, 1972).

Mandler & Pearlstone (1966) and Basden & Higgins (1972) have found the Mandler sort does not guarantee items sorted into the same category always represent within group pairs since subjects may adopt a sorting schema before the entire range of relationships among all the words in a

list is apparent. In this case, subjects may continue to sort words in the same manner to reach criterion quickly although the categories do not fully represent their preferred groupings. The present research employs an additional pre-sort task in which subjects view all the words simultaneously and group them in the most preferred manner. In this way, words sorted into the same category are assured to be within group pairs. A criterion of two successive, perfect sorts for FRL was chosen because of the needs for stability and identifiability of within and between group pairs, and is consistent with Mandler's (1967) definition of organization. A limit of 10 sorting trials was chosen since the pilot data indicated subjects failing to reach criterion after 10 trials either lost interest or concluded the task was impossible to complete.

Subjects first sorted 24 words into four categories and then received seven PA study/test trials. Selection of seven study/test trials for the PA task was based upon data collected in a pilot study where it was found that PA learning was completed by most subjects after seven trials. Both members of a given PA pair were either from the same sort category or from different sort categories. Specific hypotheses were as follows: 1) positive transfer would be obtained for within group pairings relative to a control group; 2) negative transfer would be obtained for between group pairings relative to a control group.

Hypotheses concerning item pairings were based on the requirement that components of higher order units must be correctly identified in every instance to ensure all group pairings are accurate. Second, all higher order units must be well integrated to ensure a clear and stable organizational schema for each subject. Provided these two requirements are met, item interference for within group pairs should be markedly reduced since all pairs would be from the same conceptual category, and interitem dependencies developed during FRL would facilitate PA learning. Negative transfer for between group pairs was hypothesized as items would be from different conceptual categories, and item interference should be maximal. Performance for within and between group pairs was predicted to be significantly different as a function of these considerations. Such results would support a dependent storage notion for higher order units in which the direction of transfer varies as a function of the interitem dependencies

formed during FRL. In contrast, an independent storage notion would predict positive transfer for both within and between group pairs since no inter-item interference is expected - no interitem dependencies are developed in FRL. Positive transfer for both types of pairs is a result of prior item familiarization and practice.

Experiment I

Method

Subjects. The Ss were 45 undergraduate female students attending introductory psychology courses at the University of Manitoba. Participation was voluntary, but the Ss received course credit for participation in the experiment. All Ss were required to be fluent in the English language, and not over thirty years of age.

Materials. Two different lists of 24 words each were selected from the Thorndike-Lorge (1944) frequency of usage tables with the following restrictions on word selection: 1) All words were nouns; 2) All words contained exactly five letters; 3) No two words in the same list began with same letter; 4) No two words in the same list were direct associates of each other; 5) No words began with the letters X or Z; 6) Words represented as high a frequency of usage as possible within the preceding constraints. These words are listed in Appendix A. Each word was typed in upper case letters on a 4x6 inch white index card for the sorting task. Ten different random orders of words were prepared for each list. For the PA task, 24 decks of approximately 22 PA pairs each were formed. Each pair was typed on a 4x6 white index card in upper case letters with two spaces between the members of the pair. The PA pairs represented all possible combinations of two words excluding repetition of the same word, and forward and backward first letter alphabetical sequential dependencies (ie. A-B, or B-A, etc.).

Design. A 3x7 factorial design with one between Ss factor (pairing type) at three levels and one within Ss factor (trials) at seven levels was employed. In the two experimental groups, all words were the same in both the sorting and PA tasks, while the sort and PA words were completely different for the control group. Either within group pairs (words randomly paired from a single sorting category) or between group pairs (words randomly paired from different sorting categories) were practiced by experimental Ss for PA learning. Each control S practiced a randomly paired PA word list containing the same words used by experimental Ss.

Procedure. Once S was comfortably seated, the first of three sets

of instructions were presented (Appendix B). The S was required to read each set of instructions aloud and then again silently a second time. After each set of instructions, S had an opportunity to ask any questions concerning clarification of the task. The Ss were first given a pre-sort in which they were required to spread out one of the sets of 24 words on a table so that they could all be seen at once. The S was instructed to keep all the words exposed throughout the pre-sort task. Once all 24 words were exposed, S proceeded to organize them into four rows (categories) of six words each. The constraint that six words be grouped in every category was necessary to ensure that all the words could consistently be used in the PA learning task for the construction of between and within group pairings. After S had spent as much time as she wished organizing the words, E encouraged S to look closely at all the words to make sure no changes needed to be made. Once S assured E that all the words were organized as preferred, S was again instructed to look one last time at the way the words were organized since she would be expected to duplicate this organizational schema later on. A maximum of 45 seconds was allowed for this final check. Once S was satisfied with her sort and had studied the cards, she was given a new set of these cards in a random order and asked to sort the words into the original four groups by placing the cards in four piles in spaces outlined on the table. Each of the four spaces were outlined with 3/4 inch masking tape and approximated the size of the 4x6 inch index cards S was required to sort. Words were taken from the stack one at a time and placed in one of the four categories or spaces outlined on the table. The procedure of sorting new decks of the same 24 words continued until S had sorted the words in the same way twice in succession. Restrictions involved: 1) Always placing six words in each of the four categories; 2) Not changing a word on a given sort after it had been placed in a given category; and 3) Not looking at any word other than the last (top) word in a given category. The Ss were told that organizing the words on the basis of the alphabet was not acceptable. The sorting task was self-paced with

the restriction that S meet criterion within 10 trials, but S was informed only that sorting would continue until criterion was reached. If criterion was not met in 10 trials, S was discarded.

Reading of the PA instructions lasted approximately three minutes during which time E selected the appropriate pairs for the PA list. The steps in the selection of the PA pairs for the experimental treatments are listed in Appendix C. Essentially however, group BT received pairs chosen so that stimulus and response terms came from different sort categories, group WI received pairs with both stimulus and response terms from the same conceptual category, and the control group was given words from a completely different set of 24 words. There were 12 PA pairs so all the words of the sort task for group BT and group WI were used in PA learning. In addition, Ss were told that the words were the same (E groups) or different (C groups) and guessing was encouraged.

Immediately before presentation of the PA lists, S was told to make all responses and guesses aloud for the PA test sequences, and pronounce all the stimulus pairs aloud in the study sequences. The pairs were presented manually at a two second rate for both study and test trials with an eight second intertrial interval. Different random orders of stimuli obtained by shuffling the cards at the end of each sequence, were used for all seven study/test sequences. The S's responses were recorded on tape and transcribed at the end of each day.

Results and Discussion

The raw data from the experiment are contained in Appendix D for each of the three conditions. Data from five control Ss, four within group Ss, and three between group Ss were discarded due to failure to complete the sorting task within 10 trials. The data for one other subject in the between group was lost due to experimenter error.

Examination of trials to criterion for the sorting task was performed to check the equivalence of treatments before transfer. The analysis of variance (ANOVA) (Appendix E) yielded no significant differences among group means, $F(2,42)=1.930$, $p>10$. The mean number

of sorting trials to criterion for Ss in the within group treatment, between group treatment, and the control group were 4.20, 3.13, and 4.66 respectively. As expected, both control group words and experimental group words represented fairly homogeneous lists of approximately equal difficulty.

Examination of transfer list performance for the three treatments

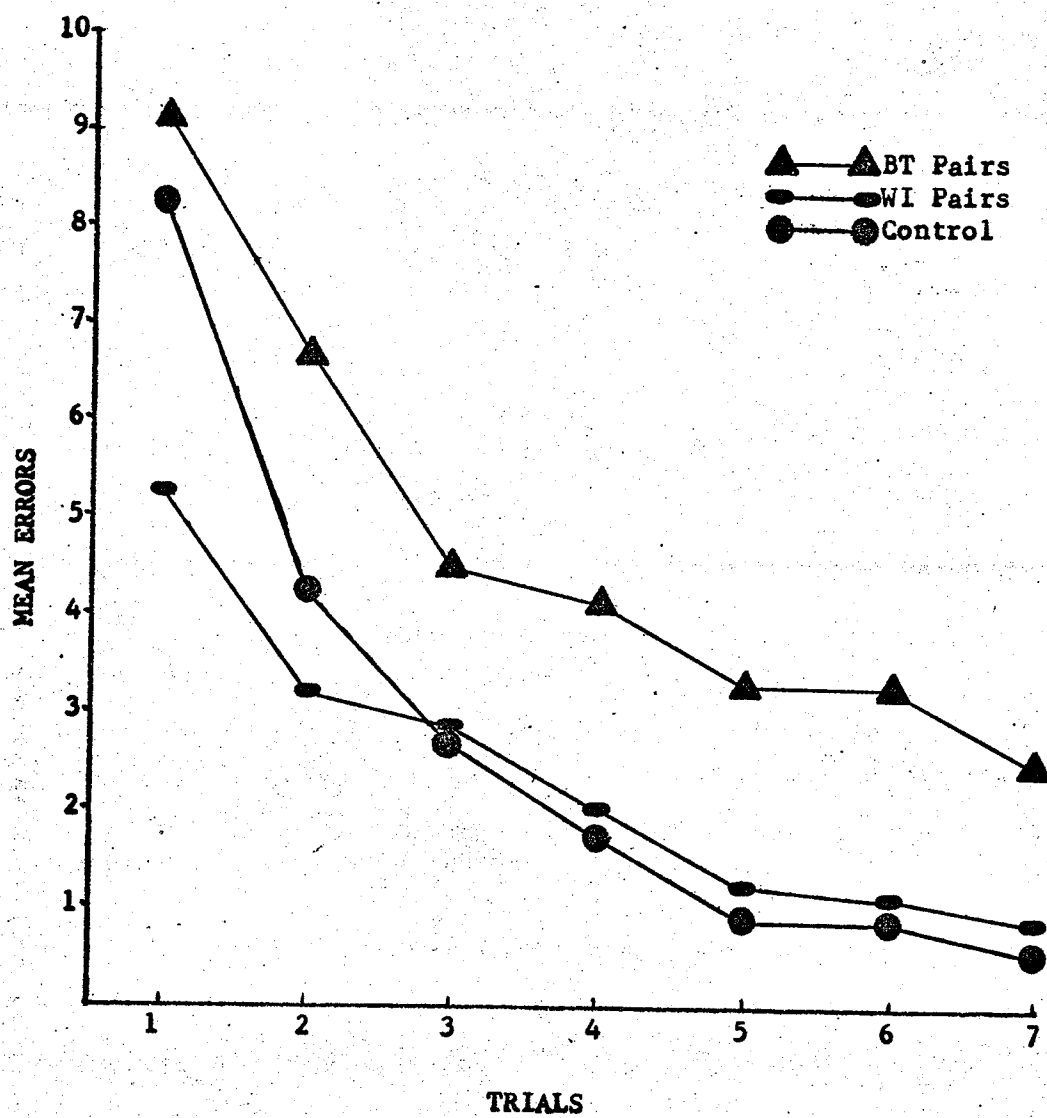
Refer to Figure 1

indicates that the BT group incurred more errors throughout learning than the other treatments as expected. However, the WI group and control group appear essentially equivalent except on trial 1 where the superiority of the WI group is apparent.

Analysis of errors for the transfer list revealed significant effects of treatments $F(2,42) = 7.329, p < .05$, trials $F(6,252) = 120.366, p < .05$, and the interaction $F(6,252) = 3.754, p < .05$, (Appendix E). While both the control and the between group (BT) made approximately the same number of errors initially, the learning rate for the control was considerably faster. Tukey's method of pairwise comparisons for split-plot designs (Kirk, 1969) indicated the BT and control groups differed on all trials but 1, 3, and 7 ($HSD = q' .05^{3.398}$). The BT group PA pairs are clearly inappropriate memory units since they incur significantly more errors than the control group in most of the trials throughout learning. These results support Barton and Young's (1972) findings of negative transfer for PA pairs selected from different categories.

More errors were incurred by the BT group across all the trials relative to the within (WI) group. Tukey's method of pairwise comparisons indicated the BT and WI groups differed on all trials but 3 and 7. Differences were in the expected direction with BT pairs incurring significantly more errors on five of the seven trials. This result indicates a significant reduction in interference for within group PA pairs relative to between group pairs. Since Ss in both the BT and WI groups were equally familiar with all PA test items, explanations of inferior performance of the BT group Ss can only be due to the presence of interitem dependencies manipulated or assessed in FR learning. Thus, the results do not support the

Fig. 1



hypothesis of independent storage of nominal units in free recall learning.

This BT versus WI comparison finding is contrary to Barton & Young's (1972) results where both BT and WI pairs tended to incur similar negative transfer. However, Barton et al noted that only the BT group incurred significant negative transfer when assessed by the Newman-Keuls test. Generally, this indicates a similar tendency for WI pairs to incur less negative transfer in both studies. The failure of Barton et al to find a marked difference in BT/WI pair transfer is possibly related to the method of FRL employed in that study. Rather than sorting, Ss free recalled words which were later assessed for degree of compliance with experimenter defined categories. Although an apparently high degree of compliance was obtained, there was no accurate means of assessing the actual extent of the differences in Ss' organizational chunks relative to the expected groupings. Barton et al also employed the modified ratio of repetition (MRR) to assess Ss' clustering levels which has been criticized (Stojak, personal communication) because it does not compensate for chance clustering levels which vary as a function of the number of categories recalled, and number of items per category. Thus, the actual extent of subject compliance with experimenter defined groupings relative to a chance clustering level remains ambiguous in the Barton et al study. Such potential questions related to the extent of subject compliance and the "appropriateness" of given PA pairs can be eliminated by the sorting technique used in the present research. By reducing the probability of error in PA pair selection, one source of random error is eliminated that may have tended to obscure the results of the Barton et al study.

While consistent negative transfer was obtained for BT pairs, pairwise comparisons by Tukey's method indicated the WI and control groups differed only on trial 1. As such, this result is typical of the majority of previous studies wherein only transitory positive transfer was found, (Novinski, 1972; Ornstein, 1970; Tulving, 1966; Tulving & Osler, 1967; Wood, 1969c; Wood, 1971). The hypothesis that WI group pairs are appropriate memory units is not supported as item

familiarity could have contributed to the reduction of errors on trial 1 for the WI group Ss relative to the control group.

The control group also consistently incurred fewer errors than the WI group after trial 3 although these differences were not statistically significant. This same trend was also reported by Postman (1971) in a PA-FR study. Whether one employs a PA-FR or FR-PA transfer design, evidence indicates that Ss tend to have difficulty adapting pairwise associations to chunks and chunks to pairwise associations. While in both Postman's (1971) and the present research this difficulty has been minor, it tends to support Postman's (1971, 1972) notion of intra-chunk interference. Briefly, Postman has assumed that in FRL Ss develop higher order units characterized by many alternate pathways or associations within the chunk, but in PA learning, S must learn to use one association exclusive of all others. The result is intra-chunk competition. If this hypothesis is accurate, it follows that a reduction in intra-chunk competition should produce better performance. The relative appropriateness of WI pairs must take account of the strengths of association between items of a given chunk. The molar terminology of higher order units is not sufficiently precise to identify reasons for the failure to find clear positive transfer for WI pairs - one must refer to the nature of inter-item dependencies within chunks. The present research now attempts to assess the importance of intra-chunk dependencies in clarifying the nature of "appropriate" memory units.

Experiment II

In experiment II, interest was focused on identifying factors influencing the relative appropriateness of interitem dependencies within well integrated higher order memory units. It has been hypothesized that Ss organize certain words together in chunks during FRL, and that these chunks may be characterized by interitem dependencies. The results of experiment I have supported the notion that careful selection of word pairs for PA learning may significantly affect the number of errors made during PA acquisition. In organizational terms these results indicate that during FRL Ss develop certain conceptual schema based upon natural language habits and idiosyncratic preferences and group words accordingly (Mandler, 1967; Bower, Lesgold & Tieman, 1969; Wood, 1972). An associative view would emphasize the presence of interitem dependencies of varying strengths between certain groups of words. words from different groups appear to be less strongly associated than words from the same group. Provided pairs are selected for PA learning that use pre-established inter-item dependencies subsequent learning can be facilitated. It is proposed that this relationship is also characteristic of words within a single higher order unit.

It was hypothesized that: 1) Word pairs from a single chunk would display consistent positive transfer provided they were paired in a manner consistent with S's organizational schema; 2) Word pairs from a single chunk would display consistent negative transfer provided they were paired in a manner inconsistent with S's organizational schema. These hypotheses reflect the general notion that intra-chunk organizational schema or intra-chunk interitem dependencies may be selected so as to reduce the amount of potential item interference. An associative view would propose that interitem dependencies within a chunk vary in strength, and that in selecting the most strongly associated word pairs for PA learning interference can be reduced. Differences in associative strength between words of a chunk is an extension of the well accepted notion that certain words in language are more strongly associated than others (Jenkins, Mink and Russell, 1958; Bousfield, 1953; Marshall and Cofer, 1963; Field, 1969). The preceding hypotheses extend Postman's

(1971) original proposal concerning PA-FR transfer in which he hypothesized arbitrary pairings of items in the transfer stage would incur negative transfer since they would conflict with pre-established groupings. Organizational theory has not dealt directly with the nature of item relationships within a single chunk. It was hoped that the present research would demonstrate the usefulness of associative concepts (interitem dependencies) in explaining positive and negative transfer results after higher order units have been developed in FRL.

The Ss followed the same procedure as in experiment I with the addition that words were paired in groups of two after sorting in all but one condition, an additional control group. The purpose of pairing was to identify S's preferred groupings of items within single higher order memory units after which either preferred or nonpreferred pairs were presented for PA learning. Identification of Ss pairing preferences was necessary in order to present items for PA learning in a manner consistent with organizational schema developed during FRL.

Method

Subjects The Ss were 100 undergraduate male and female students attending courses at the University of Manitoba summer session who volunteered to participate in the experiment. The Ss were required to be fluent in the English language and were under thirty years of age.

Materials Two new lists of 24 words were selected and prepared as in experiment I except that words could be five or six letters in length. The words are presented in Appendix A.

Design A 5x7 factorial design with one between S factor and one within S factor was employed. The between S factor was pairing preference (preferred, non-preferred, or randomly selected pairs presented for PA learning). The within S factor was trials in PA learning (seven trials).

Procedure All Ss received four sets of instructions except Ss in the control-random group who received three sets of instructions. All Ss received identical first and second sets of instructions. Once S was comfortably seated, the first set of instructions (Appendix B) was read aloud and then again silently a second time. The S always had an opportunity to ask any questions to clarify the task. The instructions explained the pre-sort task in which S spread out one of two sets of 24 words on a table so that they could all be seen at once, and then organized them into four rows (categories) of six words each. Six words were placed in each category to ensure that all words could be used in PA learning for the construction of within group pairings.

After the pre-sort task was completed, and S had assured E that all words were organized as preferred, the second set of instructions was presented on tape while S read them silently. The S was required to sort a stack of the same 24 words that had just been organized into four spaces outlined on the table. The four spaces were outlined with 3/4 inch masking tape and approximated the size of the 4x6 inch index cards. words were taken from the stack one at a time and placed in one of the four spaces outlined on the table.

This procedure was self paced and continued until S had sorted the words in the same way twice in a row. Restrictions were: 1) always placing six words in each of the four categories; 2) not changing a word on a given sort after it had been placed in a category; and 3) not looking at any word except the last (top) word in a category. Organizing the words on the basis of the alphabet was not acceptable. The S was required to meet criterion within 10 trials, but was informed sorting would continue until criterion was reached. If criterion was not met in 10 trials, S was discarded.

After completing sorting, all Ss except control-random Ss received pairing preference instructions. All Ss then formed two word combinations by placing all 24 words on the table and selecting the preferred word pairs one at a time. While experimental Ss formed two word combinations from within the previously sorted categories, control Ss formed word pairs from a new stack of 24 randomly arranged words. All Ss then received PA study-test instructions noting that all PA words were the same words that had just been paired. The Ss who received preferred pairs were presented the same two word combinations they chose for PA learning. The Ss in the experimental nonpreferred groups received randomly matched pairs from within the same sort category that were not preferred pairs. The Ss in the control nonpreferred groups received randomly matched pairs that were all different from those selected as preferred pairs. Steps in the selection of PA pairs for all conditions are listed in Appendix C. The PA instructions were presented on tape and lasted approximately three minutes during which E selected the appropriate pairs for learning. The Ss were told the PA task would continue until all the pairs were learned and guessing was encouraged. The 12 PA pairs were presented manually at a two second rate for both study and test trials with an eight second intertrial interval. Different random orders of stimuli were used for each study test sequence. The Ss pronounced all stimuli and responses aloud which were recorded on tape and transcribed at the end of each day.

Results and Discussion

The raw data for the experiment are listed in Appendix D for each of the five conditions. Data from six control-random (CR) Ss, six control-preferred (CP) Ss, four control nonpreferred (CNP) Ss, four experimental-preferred (EP) Ss, and five experimental nonpreferred (ENP) Ss, was discarded due to failure to complete the sorting task within ten trials.

A one way analysis of variance of the trials to sort yielded no significant differences among group means $F(4,95) = 1.130$, $p > .10$ (Appendix E). Mean sorting trials to criterion for the five conditions were as follows: CR-4.50, CNP-4.30, CP-3.55, EP-3.15, ENP-4.40. All groups appear homogeneous with respect to task 1 performance as expected.

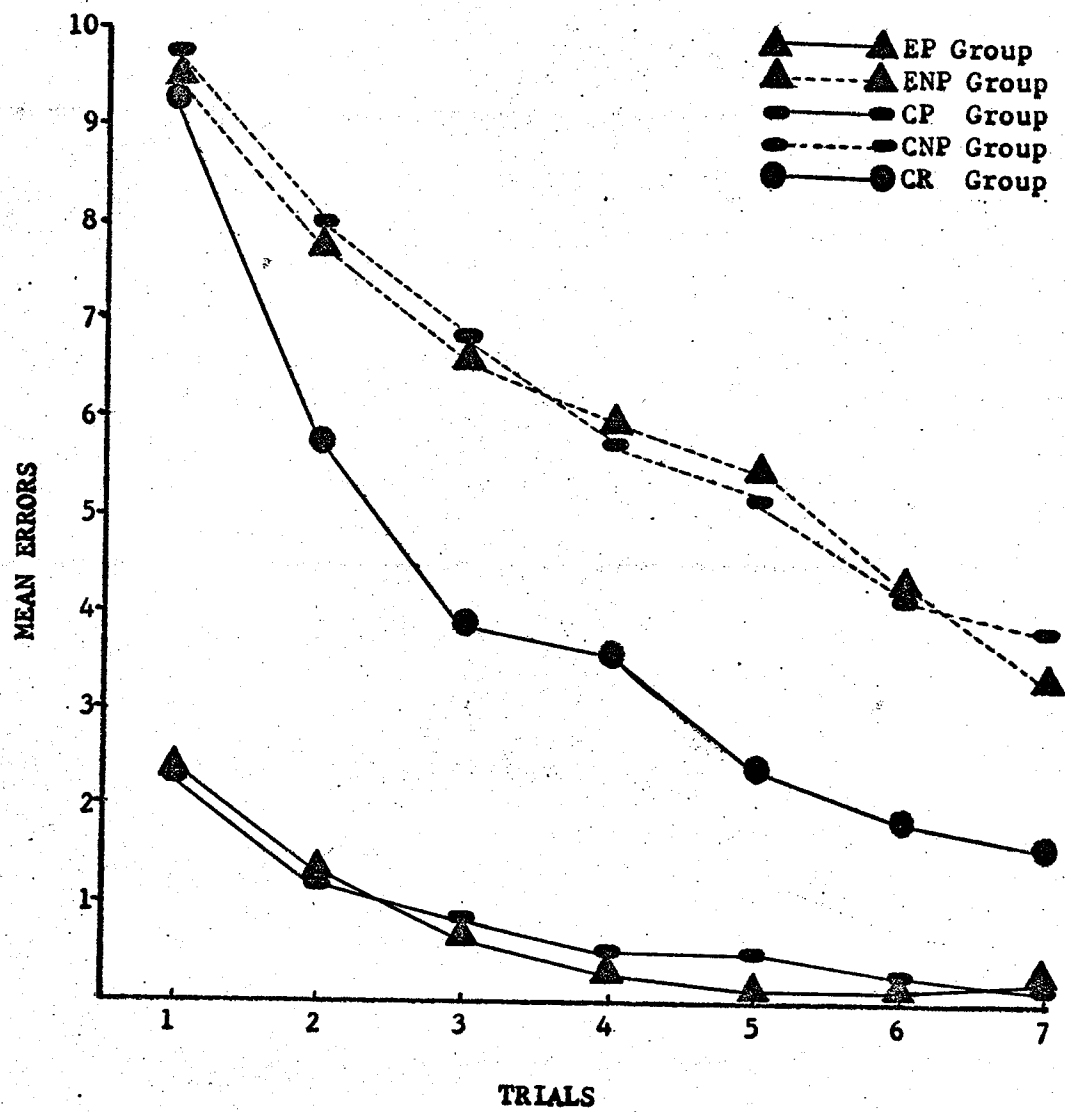
Examination of transfer list performance indicates that preferred

Refer to Figure 2

groups EP and CP incurred notably less errors than control group CR as anticipated. In contrast, groups ENP and CNP incurred notably more errors as expected for nonpreferred pairs. However, regardless of whether preferred or nonpreferred pairs were presented for learning, there was no apparent difference between the control and experimental groups.

A 5x7 ANOVA of errors for transfer list performance revealed significant effects of treatments $F(4,95) = 49.328$, $p < .05$, trials $F(6,570) = 166.687$, $p < .05$, and the interaction $F(24,570) = 10.670$, $p < .05$, (Appendix E). The interaction may be attributed to the faster decrease in errors for the nonpreferred groups relative to the preferred groups. All mean differences across trials between condition CR and the other four conditions were assessed by Tukey's method for pairwise comparisons (Kirk, 1969). All mean differences exceeded $HSD = q' .05 3.899$ in every instance except CR vs. CNP on trial 1 and CR vs. ENP on trial 1. All mean differences were in the expected direction with the preferred groups incurring consistently fewer errors than condition CR, and the nonpreferred groups incurring more errors than condition CR except on trial 1.

Fig. 2



These results demonstrate that Ss' PA performance was markedly affected by the pairing preference factor. Groups ENP and CNP incurred significantly more errors in PA learning than the control group where no pairing preference was identified. The superior performance of groups EP and CP relative to the control suggests that pairing strengthens interitem dependencies and therefore interferes with the learning of nonpreferred pairs.

Despite the clear effects of pairing preference on learning, it is also clear that sorting had no effect upon PA learning regardless of whether preferred or nonpreferred pairs were presented. It had been expected that prior learning would facilitate PA performance for preferred pairs while impeding performance for nonpreferred pairs. This assumption was based on the concept that both organization (or sorting) and PA learning involved the formation of interitem dependencies, and therefore PA pairs could be selected to reduce or increase the amounts of interitem interference. If sorting has no effect on learning, it must be concluded that differences in PA performance are largely due to pre-experimental language habits. In this case, the sorting of words does nothing more than group those words together that are most strongly associated relative to those that are less strongly associated. Sorting appears to have no effect in altering preestablished relationships among words in the case where high frequency, familiar words are presented for learning. To the extent that words presented in the experimental context have strong preestablished associations, it appears difficult for sorting practice to override these relationships for even a short period of time. The results of experiment II demonstrate only that word pairs that are strongly associated are learned faster than word pairs that are less strongly associated. Groups ENP and CNP do not differ indicating that a nonpreferred pairing from within a category is no more detrimental to learning than a nonpreferred pairing from the entire list of words. This same relationship is characteristic of groups EP and CP where only preferred pairings were presented for PA learning. When words are randomly paired as in

treatment CR both strongly and weakly associated pairs are presented for learning. Consequently, the learning rate for treatment CR would be expected to fall between the preferred and nonpreferred pairing treatments which is in fact the case.

Examination of results for experiments I and II indicate an apparently different effect of organization (sorting) on PA learning. In experiment I, it was hypothesized that BT group pairs would incur more negative transfer than WI group pairs, and this hypothesis was supported. It appeared more difficult for Ss to learn pairs selected from different categories than from the same category. However, if sorting has no effect on associative relationships then the relatively poorer performance of the BT group Ss can be attributed to larger numbers of nonpreferred pairs which were presented for PA learning. Thus, the poorer performance of the BT group Ss may be regarded as an artifact of the selection procedure for PA pairs. In addition, the failure of the WI group Ss to perform better than the control Ss in experiment I may be regarded as a function of the fact that both preferred and nonpreferred pairs occurred within a given sort category. This is clearly demonstrated in experiment II. Experiment I demonstrates that a random selection of word pairs from within a sort category is no more conducive to PA learning than a random selection of word pairs from all 24 words.

While demonstrating only that preferred pairs are learned more quickly than nonpreferred pairs, the results of the present research question the notion that sorting techniques are effective in developing higher order memory units. The present results tend to indicate that the sorting of words into categories is more analogous to an ordering of preestablished associates than to organizational theorists' conceptions of a well integrated memory unit (Bower, 1969). If the sorting of words into categories and other free recall methods serve only to group words together on the basis of preestablished associative relationships, appropriate and inappropriate memory units can be regarded as synonymous with traditional conceptions of simple interitem dependencies based on direct and indirect associative relationships.

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Appendix A

Appendix A lists experimental and control group words for experiments I and II.

Experiment I

Experimental Words

Angel
Blood
Crime
Dozen
Event
Fever
Glove
Humor
Image
Judge
Knife
Light
Motor
Nurse
Organ
Pupil
Quote
Radio
Sheet
Tooth
Union
Verse
Wagon
Youth

Control Group Words

Agent
Basis
Clock
Devil
Eagle
Flood
Giant
Hotel
Ideal
Jewel
Knock
Lover
Model
Novel
Opera
Pearl
Quiet
Range
Sheep
Tribe
Uncle
Vapor
World
Yeast

Experiment II

Experimental Group Words

Animal
Blood
Crime
Desert
Empire
Fever
Garden
Hunter
Income
Jewel
Knife
Leader
Motor
Nurse
Office
Pupil
Quartz
Radio
Street
Tooth
Union
Valley
Wagon
Youth

Control Group Words

Artist
Battle
Church
Dollar
Escape
Favor
Grape
Hotel
Island
Judge
Knight
Lover
Model
Novel
Opera
Prison
Quiet
Ruler
Sheet
Tower
Uncle
Voyage
Weapon
Yeoman

Appendix B

Appendix B contains all instructions used in experiments I and II listed in the order presented to the Ss. Identical first and second sets of instructions were used in both experiments.

Instructions for Experiments I & II - Set 1

This experiment will require you to organize words. These words are printed on the cards which you see in front of you. To begin with I would like you to take the cards and place them in four rows on the table so that there are six cards in each row. The idea, is to put those words that you think go together in the same row on the table. There is no right nor wrong way of organizing the words. You may organize the words in any way that they seem to go together, except on the basis of the alphabet. Place the cards in the rows so that you can see them all at once. After you have finished placing all the cards in the four rows you may make any changes you wish so that the words are organized just the way you want them.

Are there any questions?

Instructions for Experiments I & II (Cont'd) - Set 2

In this experiment you will be required to organize words. These words are printed on the cards which you see in front of you. You will also notice that there are four spaces outlined on the table in front of you. It will be your task to take the top card from the stack and place it in any one of the four spaces or categories provided on the table. Do the same for the second card, the third card, etc. until you have gone through the entire stack of cards. The idea is to put those words that you think go together in the same category on the table. There is no right nor wrong way of organizing the words. You may organize the words in any way that they seem to go together, except on the basis of the alphabet. After you have gone through the stack of cards, I will give you another stack of cards which contain the same words, but in a different order. You will then follow the same procedure as you did with the first stack of cards. This procedure will continue until you have organized the words in the same way twice in a row. Once you place a card in a category you must leave it there. You may change it when you go through the next stack of cards. Also, you may only look at the top card in each of the four spaces.

In organizing the cards there is one restriction that you must follow. When you have finished sorting each stack of cards there must be an equal number of cards in each space on the table. However, you need not be concerned about this since I will keep track of the cards and let you know if there are too many in one space. I will simply say, "that space is filled" if you start to put too many cards in one category.

Okay then, let's briefly review what it is you are going to do:

1. Take the cards from the stack one at a time placing them in the four categories in a way you think they go together, except on the basis of the alphabet.

2. After you have finished the first stack you will receive another stack of the same words, but in a different order. This procedure will continue until you organize the words in the same way twice in a row.

3. You may only look at the top card in each category.

4. I will tell you if you attempt to put too many cards in one category.

Are there any questions?

Instructions for Experiment II (groups EP & ENP) - Set 3

Okay, you have now finished sorting the cards into four categories. I now want you to examine all 6 words in each category, and arrange them in "pairs" in the way you think they go together best. That is, match the words in each category to form 3 groups of 2 words each in the way you like best. Do this as quickly as possible, and let me know when you are finished.

Are there any questions?

Instructions for Experiment II (groups CP & CNP) - Set 3

I now want you to examine a completely different set of words, and arrange these new words in "pairs" in the way you think they go together best. That is, match the words to form groups of 2 words each in the way you like best. Do this as quickly as possible, and let me know when you are finished.

Are there any questions?

PA Instructions for Experiments I & II
(Exp. I control & Exp. II group CR)

Okay, the first part of the experiment is now over. The second part will begin shortly, but before it does, I have a small task to attend to during which I would like you to carefully listen to the instructions for the second part of this experiment since this will tell you what it is you will be doing.

During the second half of this experiment you will be learning to associate certain pairs of words. These words are all different from the ones you saw during the first half of the experiment. You will learn a list of 12 word pairs so that when I show you one of the words you will be able to tell me what word went with it. For example, if one of the pairs you saw was "bird lake", you would learn that "lake" goes with "bird" so that whenever I presented the word "bird" you would say "lake".

To begin with I will show you all the 12 pairs (such as "bird lake") one at a time for 2 seconds each. Study each pair when I show it to you and try to learn that pairing. We'll call this the "Learn Sequence" since you will be learning which words go together.

After the learn sequence there will be a "Recall Sequence". That is, I will present only the first word of each pair and you will tell me the word that went with it. Thus, if I showed you the word "bird" you would say "lake". You will have 2 seconds to say the word so you should try to say it as soon as you can. If you can't remember which word goes with the word I show you, you should make a guess. Guessing always has the possibility of improving your score, and

since no answer can ever improve your score guessing is always to your advantage.

Okay, to review then, you will first see all the 12 word pairs for 2 seconds each. Then during the recall sequence you are to tell me for each word I show you the word that was paired with it. After the recall sequence there will be another learn sequence and another recall sequence. This will continue until you learn the pairs. The pairs will be presented in a different order every time. Therefore, you must remember the pairs and not the order in which they were presented.

Are there any questions?

PA Instructions for Experiment I (between and within pairing conditions) and Experiment II (conditions EP & ENP)

Okay, the first part of the experiment is now over.. The second part will begin shortly, but before it does, I have a small task to attend to during which I would like you to carefully listen to the instructions for the second part of this experiment since this will tell you what it is you will be doing.

During the second half of this experiment you will be learning to associate certain pairs of words. These words are the same words you saw during the first half of the experiment. You will learn a list of 12 word pairs so that when I show you one of the words you will be able to tell me what word went with it. For example, if one of the pairs you saw the "bird lake", you would learn that "lake" goes with "bird" so that whenever I presented the word "bird" you would say "lake".

To begin with I will show you all the 12 pairs (such as "bird lake") one at a time for 2 seconds each. Study each pair when I show it to you and try to learn that pairing. We'll call this the "learn sequence" since you will be learning which words go together.

After the learn sequence there will be a "recall sequence". That is, I will present only the first word of each pair and you will tell me the word that went with it. Thus, if I showed you the word "bird" you would say "lake". You will have 2 seconds to say the word so you should try to say it as soon as you can. If you can't remember which word goes with the word I show you, you should make a guess.

Guessing always has the possibility of improving your score, and since no answer can ever improve your score guessing is always to your

advantage.

Okay, to review then, you will first see all the 12 word pairs for 2 seconds each. Then, during the recall sequence you are to tell me for each word I show you the word that was paired with it. After the recall sequence there will be another learn sequence and another recall sequence. This will continue until you learn the pairs. The pairs will be presented in a different order every time. Therefore, you must remember the pairs and not the order in which they were presented.

Are there any questions?

PA Instructions for Experiment II (conditions CP & CNP)

Okay, the first part of the experiment is now over. The second part will begin shortly, but before it does, I have a small task to attend to during which I would like you to carefully listen to the instructions for the second part of this experiment since this will tell you what it is you will be doing.

During the second half of this experiment you will be learning to associate certain pairs of words. These words are the ones you just finished working with, that is, the ones you grouped into pairs of two. You will learn a list of 12 word pairs so that when I show you one of the words you will be able to tell me what word went with it. For example, if one of the pairs you saw was "bird lake", you would learn that "lake" goes with "bird" so that whenever I presented the word "bird" you would say "lake".

To begin with I will show you all the 12 pairs (such as "bird lake") one at a time for 2 seconds each. Study each pair when I show it to you and try to learn that pairing. We'll call this the "Learn Sequence" since you will be learning which words go together.

After the learn sequence there will be a "Recall Sequence". That is, I will present only the first word of each pair and you will tell me the word that went with it. Thus, if I showed you the word "bird" you would say "lake". You will have 2 seconds to say the word so you should try to say it as soon as you can. If you can't remember which word goes with the word I show you, you should make a guess.

Guessing always has the possibility of improving your score, and

since no answer can ever improve your score guessing is always to your advantage.

Okay, to review then, you will first see all the 12 word pairs for 2 seconds each. Then during the recall sequence you are to tell me for each word I show you the word that was paired with it. After the recall sequence there will be another learn sequence and another recall sequence. This will continue until you learn the pairs. The pairs will be presented in a different order every time. Therefore, you must remember the pairs and not the order in which they were presented.

Are there any questions?

Appendix C

Appendix C lists the selection procedures for PA pairs in experiments I and II.

Experiment I

Selection procedure for WI pairs

1. Place each stack of cards separately on the table.
2. Shuffle each stack of cards separately.
3. Pair each successive two cards placing them side by side in a row.
Do this for each stack.
4. Check each stack to see that no restricted pairs have occurred
if there are such pairs then reshuffle that stack and pair them again
as per item #3.
5. Noting the first letter of each word for each pair select the
corresponding pair from the alphabetical stacks.
6. Once all the pairs have been selected, shuffle them and count them.
7. Collect stimulus cards of the pairs from the table.
8. Shuffle the stimulus cards.
9. Present cards for learning.

Selection procedure for BG pairs

1. Place each stack of cards separately on the table.
2. Shuffle each stack separately.
3. Place the stacks side by side in a row.
4. Drawing a card from the top of the first two adjacent stacks
simultaneously match cards from different stacks.
5. Check to see there are no restricted pairs.
6. Noting the first letter of each word for each pair select the
corresponding pair from the alphabetical stacks.
7. Shuffle and count all the selected pairs.
8. Collect stimulus cards of the pairs from the table.
9. Shuffle the stimulus cards.
10. Present the cards for learning.

Selection procedure for control pairs

1. Shuffle all 24 cards.
2. Match each successive two cards from the stack to form 12 pairs.
3. Check to see that there are no restricted pairs.
4. Select pairs from the alphabetical stacks.
5. Shuffle and count the pairs.
6. Collect and shuffle the stimulus cards.
7. Present the cards for learning.

Experiment II

Selection procedure for experimental and control preferred pairs

1. Select the pairs that S has chosen from the alphabetical stacks.
2. Shuffle and count all the selected pairs.
3. Collect and shuffle the stimulus cards.
4. Present the cards for learning.

Selection procedure for experimental nonpreferred pairs

1. Place each stack (S defined category) of cards separately on the table.
2. Shuffle each stack of cards separately.
3. Pair the cards in each stack separately.
4. Check to see that no preferred pairs have occurred.
5. If preferred pairs have occurred reshuffle and repair that stack of cards.
6. Select the nonpreferred pairs from the alphabetical stacks.
7. Shuffle and count all the selected pairs.
8. Collect and shuffle the stimulus cards.
9. Present the cards for learning.

Selection procedure for control-random pairs

1. Shuffle all 24 cards.
2. Match each successive two cards from the stack to form 12 pairs.
3. Select pairs from the alphabetical stacks.
4. Shuffle and count the pairs.
5. Collect and shuffle the stimulus cards.
6. Present the cards for learning.

Selection procedure for control nonpreferred pairs

1. Match S's preferred pairs against a set of 12 randomly preselected pairs.
2. If any matches occur then match S's preferred pairs against a totally different, new set of 12 randomly preselected pairs. Note: A match is the occurrence of the word pair (ie. A-B) S has selected in either forward (A-B) or reverse order (B-A).
3. When no matches occur draw the preselected pairs from the alphabetical stacks.
4. Shuffle and count all selected pairs.
5. Collect and shuffle the stimulus cards.
6. Present the cards for learning.

Appendix D

Appendix D consists of the numbers of errors for each S on each trial of PA learning in experiments I and II. The errors are grouped by experimental conditions.

Experiment I

Between group errors

<u>Subjects</u>	<u>Trials</u>						
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>
1	12	11	7	5	5	4	5
2	4	0	1	1	1	3	1
3	12	4	1	0	0	0	0
4	8	6	6	5	4	4	2
5	12	9	8	11	7	6	6
6	6	7	3	5	3	1	2
7	10	10	9	9	8	8	8
8	10	4	2	0	0	0	0
9	7	5	3	2	3	4	2
10	10	11	8	6	5	4	2
11	7	5	4	3	3	4	1
12	9	2	1	5	1	3	0
13	6	5	1	1	2	2	1
14	11	10	6	4	4	4	5
15	12	10	7	5	4	3	2

Experiment I (Cont'd)

Within group errors

<u>Subjects</u>	<u>Trials</u>						
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>
1	8	2	2	0	0	1	0
2	1	1	0	0	0	0	0
3	4	0	0	0	1	0	0
4	4	1	3	1	0	0	0
5	10	8	7	6	3	0	0
6	8	6	5	6	4	5	4
7	4	3	3	1	2	0	1
8	4	2	3	4	2	0	0
9	2	2	0	0	0	1	0
10	4	4	3	1	1	0	1
11	7	3	3	1	1	1	1
12	6	8	7	5	3	4	2
13	6	6	4	3	2	3	4
14	6	2	1	2	1	2	0
15	6	1	2	1	0	0	0

Experiment I (Cont'd)

Control group errors

<u>Subjects</u>	<u>Trials</u>						
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>
1	5	3	1	0	0	1	0
2	5	0	2	0	0	1	1
3	10	7	4	3	2	0	0
4	11	7	7	4	1	1	2
5	11	6	4	3	3	3	3
6	10	7	3	3	2	3	0
7	9	6	3	2	3	1	0
8	6	2	1	0	0	0	0
9	9	5	4	1	0	0	0
10	8	2	0	1	0	0	0
11	10	5	4	1	0	0	0
12	11	5	1	0	0	0	0
13	5	4	1	1	0	1	0
14	9	5	5	5	3	3	2
15	6	1	0	0	0	0	0

Experiment II

Experimental preferred errors

<u>Subjects</u>	<u>Trials</u>						
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>
1	3	3	1	1	0	0	1
2	3	2	2	0	0	0	0
3	2	0	0	0	1	0	0
4	3	2	0	0	0	0	0
5	6	4	2	0	1	0	0
6	3	3	0	0	1	0	1
7	3	2	4	1	0	0	1
8	1	0	0	0	0	0	0
9	2	0	0	0	0	0	0
10	4	4	3	0	0	1	2
11	0	0	0	0	0	0	0
12	1	1	0	0	0	0	0
13	2	0	1	1	0	0	0
14	2	0	0	0	0	1	0
15	1	0	0	1	0	0	0
16	3	3	1	3	0	0	0
17	1	2	0	1	0	3	0
18	2	2	2	0	0	0	0
19	4	1	0	0	1	0	0
20	0	0	0	0	0	0	2

Experiment II (Cont'd)

Experimental nonpreferred errors

<u>Subjects</u>	<u>Trials</u>						
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>
1	11	6	3	0	1	1	0
2	11	8	6	6	5	3	4
3	12	6	3	1	4	3	1
4	8	5	6	6	4	4	1
5	10	5	4	4	5	3	3
6	11	9	7	8	5	7	4
7	9	10	7	9	6	7	5
8	7	8	6	4	1	2	4
9	9	9	7	9	8	5	4
10	10	8	7	4	3	2	1
11	11	7	8	8	10	5	5
12	10	10	6	3	6	4	2
13	11	7	9	7	6	4	1
14	11	10	11	7	6	4	7
15	12	11	10	10	11	10	7
16	7	6	2	2	0	1	1
17	9	7	8	8	7	6	5
18	11	10	11	10	10	5	5
19	5	7	8	6	5	3	3
20	9	7	6	8	7	7	6

Experiment II (Cont'd)

Control preferred errors

<u>Subjects</u>	<u>trials</u>						
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>
1	0	0	0	0	0	0	0
2	0	0	0	1	0	0	0
3	3	6	5	4	4	0	1
4	2	2	0	2	0	0	0
5	4	2	1	0	1	1	1
6	1	0	0	0	0	0	0
7	3	3	2	0	1	1	0
8	2	0	1	1	0	0	0
9	8	3	3	1	1	2	1
10	3	0	0	0	0	0	0
11	3	2	0	0	2	0	1
12	4	1	0	0	0	0	0
13	4	2	3	1	0	0	0
14	0	0	0	0	2	2	0
15	1	2	0	0	0	0	0
16	4	3	2	0	0	0	0
17	1	0	0	0	0	0	0
18	0	0	0	1	0	0	0
19	2	0	0	0	0	0	0
20	2	0	0	0	0	0	0

Experiment II (Cont'd)

Control nonpreferred errors

<u>Subjects</u>	<u>Trials</u>						
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>
1	12	9	5	4	3	3	4
2	11	7	5	5	5	6	4
3	11	7	8	5	6	4	2
4	12	11	8	8	9	9	8
5	8	8	7	6	8	4	6
6	6	4	2	1	0	0	0
7	12	11	11	9	11	8	6
8	10	5	3	3	1	0	0
9	12	10	7	7	4	2	1
10	12	12	8	9	8	6	4
11	8	4	2	1	0	1	0
12	7	8	9	6	6	3	2
13	10	11	11	11	11	11	9
14	9	8	10	5	4	3	7
15	9	7	7	6	6	3	3
16	9	7	5	4	6	4	9
17	10	5	5	2	3	0	0
18	8	8	6	5	5	4	2
19	10	9	8	8	3	5	3
20	9	10	9	5	6	7	6

Experiment II (Cont'd)

Control random errors

<u>Subjects</u>	<u>trials</u>						
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>
1	10	9	7	5	4	5	2
2	11	10	6	7	6	7	6
3	7	1	0	0	1	1	0
4	11	4	4	3	0	0	1
5	12	7	6	5	3	3	2
6	7	3	3	0	0	0	0
7	12	10	8	9	6	6	8
8	10	8	5	3	2	0	1
9	12	9	4	2	4	3	1
10	10	4	2	2	1	0	0
11	9	5	4	8	5	4	4
12	7	1	0	0	0	0	0
13	12	6	2	1	1	0	0
14	9	6	4	5	3	3	2
15	11	9	7	4	2	0	0
16	12	11	6	7	5	4	4
17	10	5	4	3	3	3	2
18	7	3	4	4	1	0	0
19	7	2	0	0	0	0	0
20	6	2	3	0	1	0	0

Appendix E

Appendix E lists the analyses of variance for experiment I (Tables 1 and 2) and experiment II (Tables 3 and 4).

TABLE 1

ANALYSIS OF VARIANCE OF TRIALS TO CRITERION
FOR THE SORTING TASK

SOURCE OF VARIATION	SS	DF	MS	F
Between subjects	18.533	2	9.266	1.931
Within subjects	201.466	42	4.796	
Total	220.000	44		

* $p > .10$

TABLE 2

ANALYSIS OF VARIANCE OF ERRORS PER TRIAL
FOR EXPERIMENTAL AND CONTROL GROUPS

SOURCE OF VARIATION	SS	DF	MS	F
Between subjects	1317.885	44		
Treatments (A)	340.936	2	170.468	7.329*
Subj. w. groups	976.949	42	23.260	
Within subjects	1854.000	270		
Trials (B)	1313.668	6	218.944	120.366*
AB	81.949	12	6.829	3.754*
B x subj. w. groups	458.385	252	1.819	
Total	3171.885	314		

* $p < .05$

TABLE 3

ANALYSIS OF VARIANCE OF TRIALS TO CRITERION
FOR THE SORTING TASK

SOURCE OF VARIATION	SS	DF	MS	F
Between subjects	28.460	4	7.115	1.131*
Within subjects	597.500	95	6.289	
Total	625.960	99		

* $p > .10$

TABLE 4

ANALYSIS OF VARIANCE OF ERRORS PER TRIAL
FOR EXPERIMENTAL AND CONTROL GROUPS

SOURCE OF VARIATION	SS	DF	MS	F
Between subjects	6035.815	99		
Treatments (A)	4074.199	4	1018.549	49.328*
Subj. w. groups	1961.615	95	20.648	
Within subjects	3134.434	600		
Trials (B)	1721.510	6	286.918	166.687*
AB	440.773	24	18.365	10.670*
B x subj. w. groups	981.138	570	1.721	
Total	9179.250	699		

* $p < .05$