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

by

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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 indicies 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 indicies 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 indicies can predict clustering in free recall, it has been found that various associative indicies 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 indicies - 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 indicies 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 interrelated 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 interitem 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