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ORGANIZATION AND ASSOCIATION: ON THE CONTINUITY OF MEMORY UNITS

by

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ABSTRACT

The purpose of this research was to assess the proposition advanced by Postman (1971a) that the subjective memory units of free recall learning share common, functional properties with the pair-wise dependencies of paired-associates learning and the sequential dependencies of serial learning. A concomitant purpose was to compare the analytic potential of associationistic and organizational explanations of the obtained transfer data. Specifically, the predictions emanating from each position regarding appropriate and inappropriate memory units were evaluated. To test these propositions, a two-stage transfer paradigm was used in which subjects transferred from a free recall task to a paired-associates task (Experiment 1) or to a serial learning task (Experiment 2)

During the free recall phase of both Experiments 1 and 2, three independent groups of experimental subjects categorized 30 unrelated words into three, five, or seven sorting categories. Three independent groups of control subjects sorted a different, but matched set of 30 words into the same number of categories. Once a consistent level of organization was achieved, a free recall of the items was required by all subjects. Analysis of the subjects' recall protocols revealed that word recall and level of organization were a direct linear function of the number of categories employed by the subjects, thus confirming previous research (Mandler, 1967). Following free recall, subjects were transferred to the paired-associates or to the serial learning task.

The fifteen pairs of items of the paired-associates task were randomly derived from the original experimental list. As well as provid-

ing differential levels of prior organization the Mandler sorting technique provided a means to operationalize on a priori basis the terms appropriate and inappropriate memory units. Item pairs from within the same category (i.e., within-category pairings) were designated as appropriate memory units while those pairings which originated in two distinct categories (i.e., between-category pairings) were deemed to be inappropriate memory units. All subjects were exposed to six study-test trials on this list. Analyses of the correct number of associates recalled indicated an overall presence of negative transfer relative to the performance of the control condition with the magnitude of this decrement approximately proportional to the level of prior organization of the subjective memory units. Further analyses revealed the presence of negative transfer for between-category pairings (i.e., inappropriate memory units) also in proportion to the level of prior organization. Although this finding was consistent with both the associationistic and organizational models, the absence of any transfer for the within-category pairings (i.e., appropriate memory units) was not consistent with either model.

In Experiment 2, the 15 items of the serial list were also randomly derived from the experimental list. All subjects were exposed to six study-test trials on this serial list. Analyses of the number of adjacent pairs of words correctly recalled demonstrated an overall presence of negative transfer in the experimental, as contrasted with control, groups. The magnitude of this negative transfer was directly proportional to the level of original organization and was manifested on the terminal trials of serial learning. Additional analyses revealed the presence of negative transfer for the between-category pairings as a function of the level of prior organization but also indicated negative transfer for the within-category pairings. This latter finding, although not inconsistent with the associationistic interpretation, offers no support at all for the organizational model.

In summary of both experiments, the overall incidence of negative transfer across different learning tasks provided substantial support for Postman's (1971a) thesis on the continuity of intertask memory units. The operationalization and measurement of the concepts of appropriate and inappropriate memory units revealed results which were consistent with both associationistic and organizational interpretations on the latter measure but provided marginal support of the associationistic model only on the former measure. Although the overall pattern of results did not allow for a reliable differentiation to be made of the predictive power of the two theoretical positions, the results did suggest possible avenues of research to clarify the nature of transfer phenomena of appropriate memory units.

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In contemporary analyses of verbal learning and memory phenomena, association and organization tend to be treated as mutually exclusive and fundamentally dissimilar concepts. Historically, these concepts served explanatory functions in two, antithetical approaches to the understanding of memorial processes. These approaches are the associationistic tradition with its origins in Greek thought, British empiricism and American functionalism and the organizational approach which is a derivation of the classical Gestalt school.

The traditional associationistic approach borrowed heavily from research in animal learning in the belief that rote, verbal processes in humans could be extrapolated from similar processes in animals (cf. Hull, Hovland, Hall, Perkins, & Fitch, 1940; Nelson, 1971). Its advocates relied upon the methodology of behaviorism to assess the formation of interitem associations or dependencies between verbal units of varying complexity. The data generated from this approach and the empirical generalizations which followed have provided the underpinnings of the interference theory of forgetting (Postman, 1968) and led to the development of sophisticated models of human memory (Anderson & Bower, 1972, 1973).

In contrast to the associationistic tradition, the proponents of the organizational approach have appealed to the concepts of the Gestalt school. This approach emphasized the roles of item grouping and relational principles in the understanding of memory (Katona, 1940). However, these original Gestalt concepts were both poorly defined and difficult to manipulate experimentally. The failure to provide specific testable definitions for basic concepts led to a period of unproductive research. Recently, however, improved operational definitions have brought about a resurgence of interest in organizational factors and their role in memory (Mandler,1967, 1970; Tulving & Donaldson, 1972).

In addition to their differences in theoretical background the concepts of association and organization are further differentiated in terms of their experimental paradigms and reportage typically preferred. As the name suggests, associative processes are generally analyzed via the method of paired-associates (PA) or serial list (SL) learning. Followers of the associative position usually describe their research in stimulus-response terminology. They document the acquisition and retention of verbal items as a function of repetition or exposure. Learning of a PA list, for example, is described as the attachment or association of responses to stimuli through frequent, contiguous pairings of the items and forgetting is referred to as the unlearning of prescribed associations and interference from competing associations (Runquist, 1975). As applied to a SL task, traditionalists refer to the acquisition of a chain of stimulus-response associations in which all items except the first and last, function as both stimuli and responses (Johnson, 1968).

Organizational processes, on the other hand, are typically investigated by the method of free recall (FR). Advocates of the organizational position adopt the language of an information processing model and describe their research in terms of the storage and retrieval of information. Learning is viewed as the formation of subjective memory units which, in turn, are inferred from the increasing consistency in the output order of items during the recall phase. These higher order memory units or "chunks" are stored in memory in an hierarchical fashion which facilitates the efficient retrieval of the information (Mandler, 1967; Tulving, 1962).

At a theoretical level, association and organization both refer to the relationships among verbal units. However, the associative relationships derive from the temporal contiguity of items prescribed by the experimenter whereas organization is a function of the relational characteristics of the entire set of verbal items. Tulving and Madigan (1970) suggest that the differences between the associationistic and organizational approaches may be more fundamental than dissimilarities of tradition, methodology or terminology. They say,

> Whether we need one set of laws governing the learning and recall of associated items and another set to handle memory of organized items remains an interesting and important question. Available evidence though scant and indirect, suggests the answer to the question is affirmative (p. 445).

There is, however, an alternative view which suggests that the associationistic-organizational dichotomy as characterized above may be more apparent than real. The theme of a series of studies by Postman (1971a) is that the subjective memory units of free recall and the pair-wise dependencies of controlled associative learning share common functional properties. Postman tested this hypothesis by employing a transfer task in which subjects first learned a list of unrelated words by the FR method and then immediately relearned the same words in the context of a PA task. The logic for this procedure is as follows:

> If subjective groupings are a product of learning (or a property of storage), it follows that after free recall practice there should be interference in the acquisition and retention of transfer tasks that require the disruption of such groupings. The logic of this approach

> starts with the strong assumption that progress in free recall learning implies ipso facto the achievement of organization. Once such organization has occurred, it will become a source of interference when the transfer task requires the establishment of new relations among the component items (Postman, 1971a, p. 292).

Postman predicted that there should be negative transfer for an experimental condition in which memory units of the first phase of the experiment are inappropriate to the second phase compared to a control condition in which the items of the first and second phases of the experiment are unrelated and, therefore contain little or no overlap of memory units.

Statement of the Problem

The present investigation was concerned with the proposition that the memory units of organization and association are functionally continuous or similar. It paralleled the reference study by Postman (1971a) in that a two-stage transfer paradigm was used in which subjects transferred from a free recall task to a paired-associate task (Experiment 1) or to a serial learning task (Experiment 2). The present studies attempted to replicate in part the findings of Postman (1971a) but also to provide an intensive analysis of the presumed relationship between the subjective memory units of free recall learning and the prescribed associations indigenous to paired-associates and serial list learning. This analysis was made possible by altering the manner in which organization was manipulated in the free recall task. Typically, the number of free recall trials is used to vary the level of organization prior to transfer. In the present study, however, trials were held constant and the number of subjective categories became the vehicle for manipulating the level of organization. This variation in design provided the means to operationalize the terms appropriate and inappropriate intertask memory units which, although often employed in the memory literature, are plagued by circularity of definition.

By incorporating this design change the present investigation also provided a data base to differentiate between the predictions that are consistent with the associationistic approach and those predictions which must logically follow from the organizational approach.

Encoding Processes in Free Recall, Paired-Associates and Serial List Learning

The previous descriptions of the organizational and associative viewpoints, although satisfactory as introductory characterizations, were basically superficial and warrant a more comprehensive treatment. This elaboration will be in the form of brief historical perspectives on the concepts of organization and association; each review will be followed by the formal definitions adopted in this investigation. Speculative analyses from various areas of memory research will then be summarized with the intent of suggesting the fundamental similarities and areas of overlap of the two processes under examination. These similarities might be evident to such a degree as to arouse a question of the efficacy of maintaining the theoretical distinction between the concepts of organization and association. In addition, however, this research design allowed an assessment of which theory has the greater predictive and analytic value with respect to free recall to paired-associates or serial learning transfer. But first, the construct of encoding, relevant to the present study, must be described in the context of verbal learning and memory research.

Encoding processes. In its broadest aspect, the present investigation was concerned with the manner in which human subjects encountering a problem-solving task, utilize their past verbal experiences in conjunction with the present task-demands, to acquire a solution to that problem. Further, and regardless of the nature of the task, it is generally conceded that the subjects--at least adult subjects--are not passive agents who learn through some type of automatic reinforcing effect of a stimulus in close temporal contiguity with a response. Rather, the subjects are viewed as active, planning agents who test, accept, or discard various learning strategies. That is, they perform mental operations on the physical test material, to transform that material to an highly idiosyncratic version of the original. It is suggested that these subjective modifications to the nominal stimulus allow for an increased acquisition rate and an overall superior retention due to a decreased susceptibility to interfering effects of previous and subsequent learning (Adams & McIntyre, 1967).

These mental operations by which subjects transform a physical stimulus into a psychological one fall under the rubric of encoding processes. Other labels, such as coding (Miller, 1956a, 1956b) have been applied to similar, storage phenomena while decoding usually refers to the process of retrieving information. Underwood and Erlebacher (1965) broadly define coding as "...the changes, transformations, additions, subtractions, adumbrations, and so on which occur to and between verbal units as presented and which are we assume reflected in what is stored in memory" (p. 1). Tulving and Madigan's (1970) version of coding similarly implies that differences may exist between the physical stimulus as presented and the memorial representation of that information.

As suggested, the types of encoding strategies available to subjects are manifold and have been the subject matter for much recent research. For example, it has been shown that subjects encode information on the basis of its imagery content (Paivio, 1969, 1971, 1976); through a form of relational or pegword mnemonic (Bower, 1970a, 1972a); via hierarchically organized categories (Buschke, 1976; Friendly, 1977; Mandler, 1967); by the associative characteristics of the entire list (Deese, 1959; Wallace, 1970). In addition, several researchers have advanced theories which indicate that encoding may proceed along several dimensions and eventuate in a multicomponent representation in the memory store (Atkinson & Shiffrin, 1971; Bower, 1967; Underwood, 1969; Wickens, 1970, 1972). While this discussion implies a wide variety of possible encodings for verbal material, the subsequent coverage will focus only on general associative and organizational strategies.

Each of these concepts will be examined in turn in the form of a selective review of studies which were critical to their respective developments. Following these brief historical perspectives the formal definitions of organization and association will be advanced and related to the present investigation.

Development and definition of organization. Organizational variables have long been the primary interest of Gestalt psychologists (Katona, 1940; Koffka, 1935). The Gestaltists were interested in the perception of relationships between elements or parts and functional wholes. According to them, humans solved problems rationally, dynamically, and insightfully rather than through the mechanical application of prior habits. As it applied to memory research, organization was coextensive with understanding and facilitated the learning and retention of material. Katona (1940) utilized designs which, although simple in nature, were adequate in comparing rote versus insightful learning. The performance of subjects who employed rote learning techniques was contrasted with the performance of subjects who were enjoined to discover the rules relating the series of numbers. Those subjects sensitized to the presence of organizational rules outperformed the rote learners in an immediate test of retention. The difference between the groups was magnified in a delayed test. But for many researchers, the Gestalt concepts, such as organization, had a subjective, somewhat emotional connotation and Katona's work had little impact on other workers in this area.

Following a period of relative quiescence in organizational thought and research, a fresh impetus to this approach was provided by Miller (1956a, 1956b). His chunking hypothesis provided one of the more frequently invoked explanations to account for the superior retention of subjectively organized material. Miller who favored information-processing terms, described memory as a communication channel with a restricted capacity for processing and retrieving information. Two important characteristics of human memory, derived from his research and that of others, were hypothesized to be: (a) a limitation to 7 ± 2 units that could be processed at one time and (b) the ability to overcome this limitation by a process called chunking or unitization. Chunking functioned to break the information bottleneck in the following way. The subjects, faced with a series of items that exceeded their immediate memory span cannot merely add on new items to the original 7 ± 2. They must actively reorganize the material into seven new units which integrate all items, old and new, in a meaningful manner. The original seven items are now enriched in the sense that they contain more information. These new information-rich memory units are called chunks. Miller suggested that these first order chunks may themselves be unitized into higher-order chunks in a similar, recursive manner. Thus, the subjects have organized the material into a hierarchy of unitized items which may later be retrieved in an efficient manner by utilizing as retrieval or decoding cues the same mnemonics that were used to encode the material.

A similar approach to the study of supra-memory span lists of words is found in the research of Tulving (1962, 1964, 1968). Also using information processing notions, Tulving employed a multitrial free recall paradigm with interest focused on the output of words over successive trials. Each subject's recall protocol was scored for the number of times that pairs of words occurred adjacently over trials. A ratio was then obtained by comparing the observed consistency of output to the maximum possible consistency. The obtained ratio was a measure of subjective organization and such organization was hypothesized to occur when the retrieval order of items was governed by the semantic or other encoding relationships among the items. The appearance and maintenance of adjacent pairs of words over trials was presumed to reflect the presence of subjective memory units. The subjective organization measure was positively correlated with word recall both across subjects with trials held constant and across trials with subject effects partialled out. A limitation to Tulving's subjective organization measure--the restrictive use of subjective memory units of size two--has been rectified by a procedure initiated by Pellengrino (1971; Pellegrino & Battig, 1974) which allowed for the analysis of subjective memory units of sizes greater than two units.

The research on subjective organization is highly relevant to the present investigation especially those studies dealing with the formation of higher order memory units and the degree of appropriateness of these units across various tasks. These studies, which usually involve a free recall to free recall transfer paradigm, take two basic forms. The first type of study is described as a whole-part transfer design in which subjects learn a complete list and then learn a subset or part of the complete set of items (e.g., Hasher, 1971; Sternberg & Bower, 1974; Tulving & Osler, 1967). In the second design, known as part-whole transfer, subjects learn a set of items and then are required to learn a longer list which includes the original set (e.g., Birnbaum, 1968, 1969; Bower & Lesgold, 1969; Carey & Okada, 1973; DeRosa, Doane, & Russell, 1970; Elmes, Roediger, Wilkinson, & Greener, 1972; Ornstein, 1970; Schulze & Gorfein, 1976; Slamecka, Moore, & Carey, 1972).

The logic involved in these studies, for example, the whole-to-part transfer, is fairly standard and may be characterized with a hypothetical example. Subjects first learn a list of 18 unrelated items for a suitable number of free recall trials to allow for the establishment of subjective memory units. The control subjects learn a different but equivalent list of 18 unrelated items. The subjects are then transferred to a shorter, nine item list which, for the experimental subjects is composed of nine of the original items, but for the control subjects the list is entirely novel. Typically, the experimental subjects enjoy a slight, initial advantage due to a familiarity with the items; however, the control subjects quickly overtake and surpass the performance of the experimental subjects. The poorer performance of the experimental subjects is interpreted as evidence that the memory units formed during initial learning become inappropriate in the context of part-list learning. In effect, the experimental subjects are unable or unwilling to discard their previous organization and therefore continue to use it inappropriately during the learning of the part list. The eventual result is a reduction in their performance, or negative transfer, relative to that of the control group. Informing the experimental subjects of the whole/part list relationships appears to sensitize the subjects to alternate, more appropriate encoding strategies during the second phase of learning and effectively reduces, if not eliminates, the incidence of negative transfer (Novinski, 1969, 1972; Wood & Clark, 1969).

The interpretation of this data in terms of inappropriate organiational memory units must also allow for the possibility of appropriate memory units. That is, it is conceivable that the subjective memory units formed during whole-list learning could carry over and facilitate the learning of the part list. The reasons for this assertion follow from an appreciation of the internal structure and dynamics of higher order memory units. Two lines of research suggest the nature of such memory units. The first source of information stems from studies in which pertinent retrieval cues were provided to subjects at some point in the recall process (Slamecka , 1972; Tulving & Pearlstone, 1966). Results of these studies indicated that such cues allowed subjects to gain access to, and therefore recall, higher order memory units that were available but not retrievable without the priming provided by the cues. However, the retrieval cues did not actually facilitate the recall of items within the higher order memory units as the amount of items recalled appeared to be governed by an all-or-none principle. That is, if one item from a memory unit was recalled, most, if not all, of the remaining items from that memory unit were also recalled.

The second source of relevant data is provided by research which was concerned with the output order of the composite items which define a higher order memory unit. Several studies (e.g., Pellegrino & Battig, 1974; Tulving, 1962, 1964) have shown that such memory units typically have an internal sequential variability across successive recalls. For example, Pellegrino & Battig (1974) demonstrated that a memory unit composed of the items ABC may be recalled in that sequence on Trial t but then recalled as BCA - or any of the three factorial possible orderings - on Trial t + 1. This inconsistency of orderings across successive recalls typifies the type of organization inherent in higher order memory units. The variable pattern of output also suggests that any sequence of the items, or a subtest (e.g., AB) is equally probable and similar in relative strength to any other sequence or subset (e.g., BC). Therefore, the demands of recalling subset BC, following the learning of ABC should be less, relative to the demands of recalling a novel grouping (e.g., DE). Taken together, these distinct lines of research - that higher order memory units are recalled in an all-or-none fashion and that these units typically vary in sequential reproduction - supports the proposition that the memory units of original learning may be compatible with the demands of subsequent learning. Therefore, in the context of whole-to-part free recall studies the resultant positive transfer is then used as the basis to infer the existence of appropriate memory units. However, such positive transfer has been both tenuous and transitory and is usually restricted to the initial trials of the transfer task (Bower & Lesgold, 1969; Ornstein, 1970). However, when consideration is given to the development of interlist relationships pronounced positive transfer can be obtained (Slamecka et al., 1972).

The presence of negative transfer and under certain conditions the incidence of positive transfer in the context of free recall to free recall transfer studies has been documented and generally accepted. However, the interpretation that these phenomena are a function of inappropriate and appropriate memory units, respectively, is not without its critics (Bower & Sternberg, 1974; Carey & Okada, 1973; Petrich, Pellegrino, & Dhawan, 1975; Slamecka, Moore, & Carey, 1972).

Slamecka et al. (1972) clearly specified the circularity of definition inherent in the terms appropriate and inappropriate memory units and further argued that this leads to a situation where it is virtually impossible to falsify the organizational hypothesis regarding part-to-whole transfer. Their central argument was that these terms are generally applied after and only after an examination is made of the transfer data. Thus, the presence of negative transfer is attributed to inappropriate intertask memory units. Conversely, if positive transfer obtains, then this transfer must be a function of appropriate intertask memory units. In neither case are the terms appropriate and inappropriate defined a priori.

Slamecka et al., then contrasted how the associationistic and organizational positions would account for three possible outcomes in part-to-whole transfer. For example, the presence of positive transfer would be consistent with both approaches. The organizational explanation would entail an appeal to the formation and carryover of compatible or appropriate memory units. The associationistic approach would relate the positive transfer to the experimental group's prior exposure to half of the items in the whole list. In effect, with only one half of the whole list to learn the experimental group should outperform the control group. The presence of negative transfer is, of course, inconsistent with the associationistic position but can be accommodated within an organizational framework by invoking, in a post hoc fashion, the operation of inappropriate memory units. Even the absence of transfer is damaging to the associationistic position. However, the organizational approach could relate the lack of transfer to a balanced interaction of appropriate and inappropriate memory units.

Slamecka et al. clearly outlined the inadequacy of current transfer designs. The critical weakness in these designs lies in their failure to allow for the independent specification of the future appropriateness or or inappropriateness of the memory units.

One possible solution to this problem may reside in the work of Mandler (1967, 1970) where organization was defined in an intuitively appealing yet highly operational manner. Mandler (1967) extended Garner's (1962) definition of structure to encompass the organization of verbal material, and defined organization in the following manner:

> A set of objects or events are said to be organized when a consistent relation among the members of the set can be specified, and specifically, when membership of the objects or events in subsets (groups, concepts, categories, chunks) is stable and identifiable (p. 330).

The critical concepts in this definition refer to the stability and identifiability of the subsets of items. The sense of these concepts can be illustrated by considering the research design employed by Mandler. In a typical experiment the subject, tested individually, was given a number of cards (e.g., 50) each with a common word printed on it. The subject was encouraged to sort the words into categories on the basis of their semantic, or other, relational attributes. The number of categories was either prescribed by Mandler or left to the discretion of the subject. Stability referred to the subject's ability to sort the cards in the same fashion on consecutive sorting trials. Once this criterion was reached, the subjects were requested to recall as many words as possible and in any order that they wished. The second concept, the identifiability of subsets, was determined from the subject's recall protocol and was a measure of the tendency for words that were sorted together to be recalled together in clusters. From the measurement of the characteristics of the recall order it was possible to obtain an index of the amount of organization utilized by the subject.

Organization in this sense is objectively determined and amenable to various quantitative indices (cf., Shuell, 1969; Sternberg & Tulving, 1977). In addition, this technique allowed for the detection of subjective memory units or chunks of various sizes as opposed to Tulving's (1962) technique which was limited to memory units comprised of only two items. As word recall and amount of organization were both linearly related to the number of categories used by the subjects, this methodology is ideal for manipulating levels of organization across subjects. This feature, along with the rationale for determining a priori the degree of appropriateness of the intertask memory units will be developed in a subsequent section.

By highlighting several historical developments this section has led to a rationale forthe adoption of Mandler's definition of organization and his experimental technique of manipulating the level of organization in subjective memory units. The discussion now turns to the concept of association where historical trends in the development of this concept will be reviewed. The presentation will encompass the role of association as an explanatory device in paired-associates, serial, and free recall learning and will lead to an introduction of the seminal work of Postman (1971a).

Development and definition of association. The concept of association has an extended history that predates that of experimental psychology itself. Aristotle provided the earliest systematic treatment of this concept by anchoring the association of ideas to the variables of similarity, contrast, and contiguity. Describing the act of remembering, Aristotle distinguished between the selection of a probe (viz., a stimulus) which was a voluntary action, and the automatic elicitation of a response to that probe (Anderson & Bower, 1973). Association was perpetuated as a philosophical doctrine until revitalized and transformed into a psychological principle by the British empiricists. The phrases "association of ideas" and "train of thought" were coined by John Locke to characterize the relationship between, and among, mental events. Later David Hume added cause and effect relationships to Aristotle's list of variables which influenced the associative connection. Practice and degree of recency also supplemented those variables influencing the strength of association.

Ebbinghaus (as abridged in Herrnstein & Boring, 1966) translated the doctrine of association into a empirical hypothesis testable by the method of serial learning and thus initiated the experimental study of learning and retention. His logic was straightforward: If thoughts are connected or bonded by frequent contiguities, then it should be possible to use frequency of presentation or repetition as the independent variable and measure learning or retention as the performance variable. With the realization that words had many old associations which could confound his measure of learning, Ebbinghaus devised the nonsense syllable to obtain a purer measure of the formation of new associations. To explain the learning of sequences of items Ebbinghaus introduced the concept of remote association. This concept suggested how adjacent items in a sequence develop a high associative strength and how the associative strength deminishes with the degree of remoteness or non-adjacency of the items. This concept also explains how the cumulative associative strength among items can elicit successive elements in the serial list.

Shortly after, and independently of Ebbinghaus, Calkins (1896, as cited in Herrnstein & Boring, 1966) originated a technique now known as the method of paired-associates. Calkins showed frequency of repetition to be a prime determiner of the strength of association although variables such as vividness and position of pairs in the list also contributed, but on a lesser scale, to the strength of the bond. Frequency of repetition as an index of the strength of the connection was made the cornerstone of the doctrine of association - a tenet that has remained unchanged to the present.

Paralleling the growth of empirical methods of investigating inter-item connections was the development of a normative method of studying associations called the technique of free- or word-associates (Galton, as reported in Boring, 1950). Free associations were presumed to reflect the characteristics of words, specifically, the interrelationships which have been instilled through previous language acquisition. However, it was not until much later - around the early 1950's - that the methodologies of Ebbinghaus and Calkins were used in conjunction with the data provided by free-association norms (Cofer, 1971). Association in this sense was used as an explanatory concept to account for the degree of organization demonstrated in free recall tasks (Deese, 1959, 1961, 1962).

Traditionally, the method of serial learning was used to study the connections between verbal units. However, in the last 25 years research using the paired-associates technique far surpassed that of serial learning. The general opinion was that the paired-associates method offered a less complex vehicle for studying the formation of specific associations.

The doctrine of association stated that a subject exposed to a series of items by the traditional methods, learns associations between stimuli and responses (PA learning) or between successive items (SL learning). The frequent and contiguous presentation of the prescribed items was taken as a sufficient condition for learning to occur. But what association actually means has been the subject matter of much analysis, speculation and debate. Several general usages will be briefly reviewed, then applied to the analyses of paired-associates, serial learning, and free recall clustering effects. Then, as was done in the previous section on the development and definition of organization, an illustrative study will be provided to suggest possible limitations of the associationistic approach.

The importance of the concept of association originates from the observation that verbal behavior occurs in an orderly sequential fashion.

At the completion of paired-associates learning, given the stimulus (S), the response (R) will be elicited with a certain probability. The stronger the association between the S and R the more probable R will occur given S. Used in this manner, the concept of association is entirely descriptive and must itself be explained. A likely explanation of this associative hook-up is known as an associative-probability theory (Underwood & Schulz, 1960) which originated several years earlier in the following way:

> ...in adult learning new associations are mediated by previously learned associations to stimulus- and response-terms. From this it can be deduced that the more such associations are elicited by the stimulus- and response-members in a paired-associate task, the greater will be the probability that a particular combination of a stimulus-association and a response-association can be found to provide a mediating bridge or a "meaningful" link between the two (Mandler & Huttenlocher, 1956, p. 424).

Glanzer (1972) described this process more succinctly by suggesting that the greater the number of associations that extended from a word, then the greater the probability that the word would, through the mediation of one of those existing associations, form a connection with a newly paired item.

In addition to the descriptive and mediational usages described above, Postman (1968) reviews four other senses in which the concept of association is used. These include the role of pre-experimental associative hierarchies; contextual associations which are of vital importance for specifying the conditions initiating recall - even for the organizational advocate (Mandler, 1968); nonverbal associations of the type studied by Paivio (1972, 1976); and finally, of little concern to the present investigation, association as a physiological substructure to account for behavioral phenomena. A common element in these usages is that association is essentially a dispositional concept. That is, R will follow S, given that certain other requisite conditions are met; in this sense association refers to a potentiality for behavior. Postman (1968) related these conditions to certain performance variables such as drive levels, instructional sets, and coding processes employed by the subjects. However, to assess what has been learned Postman (1971a, 1971b) recommended the use of transfer tasks rather than any internal analyses of the learning situation.

A component analysis of paired-associates learning reveals the operation of three major subprocesses. The first process involves stimulus discrimination (Gibson, 1940). The second process involves the learning of the responses (Hovland & Kurtz, 1952; Mandler, 1954), and the final aspect involves associating each stimulus with its appropriate response (McGuire, 1961; Underwood & Schulz, 1960). Suggestive of the actual complexity of paired-associative learning, Battig (1968) advances seven other subprocesses which may be operating concurrently with, or independently of, the first three variables. But at a gross level, learning associations is mainly a process of acquiring a response pool and then forming bonds between stimuli and their prescribed responses.

Forgetting is described as interference among associations which were learned prior to (proactive interference), or subsequent to (retroactive interference), the items of interest. The component analysis of forgetting and the study of transfer phenomena have been closely intertwined in terms of experimental paradigms and theoretical interpretations. On the same basis negative transfer and interference are viewed as complementary effects of the same underlying process. This component analysis is the hallmark of the interference theory of forgetting — the evolutionary product of the doctrine of association and the most viable, comprehensive approach to the problems of learning and retention. For the purpose of the present investigation a review of interference theory is not considered necessary as more cogent presentations are available elsewhere (Adams, 1967; Keppel, 1968; Postman, 1971b, 1976; Postman & Underwood, 1973; Runquist, 1975).

In serial learning, the associative interpretation is more complex, less compelling and, in fact, Young (1968) suggested that the serial learning task is relatively inappropriate as a paradigm to analyze associative processes.

At a descriptive level, serial learning involves a string of items in a prescribed sequence, for example, item A leading to item B, B to C, C to D, etc. Each item except the first and the last serves a double function as both a stimulus and a response. The probability of acquiring the entire chain of items is simply viewed as the sum of the probabilities of the individual links. Within this S-R interpretation one controversial issue is the debate over what functions as a stimulus in serial learning. The theoretical contenders are (a) the traditional chaining or remote association hypothesis described above and earlier in this paper; (b) the position hypothesis which states that each item is labelled with or associated with a particular position-tag in the sequence; and lastly, (c) a dual-process theory which is a combination of the two former hypotheses (cf. Bewley, 1972). Regardless of the preferred hypothesis the general assumption is that interitem associations are a sufficient condition for learning to occur. Also, regardless of the preferred hypothesis there is agreement that an adequate test for distinguishing between the relative merits of each hypothesis could involve serial learning to derived paired-associates transfer tasks. Several studies (Lesgold & Bower, 1970; Postman & Stark, 1967; Shuell & Keppel, 1967) and review articles (Underwood, 1963; Young, 1968) have suggested that the positive transfer expected from a simple chaining theory has been notoriously hard to achieve.

Alternative formulations (Battig, Brown, & Schild, 1964; Jensen, 1962; Jensen & Rohwer, 1965; Martin & Noreen, 1974; McLean & Gregg, 1967; Wickelgren, 1967) have questioned the adequacy of the associative interpretation and have advanced a more cognitive or organizational account. According to the organizational account, serial list learning is seen as an instance of response integration, that is, the chunking or organization of an entire set of items rather than as the learning of discrete associations between successive items (Martin & Noreen, 1974). The parallel to the subjective organization of free recall items should be apparent and similar interfering effects have been demonstrated when optimal organization units are disrupted (Johnson, 1968; 1972, Winzenz, 1972).

To examine the explanatory role of association in free recall phenomena, another aspect of the associationistic position must be reintroduced at this point. Earlier in this paper, the idea of free- or word-associations was briefly presented. Association, in the sense of pre-experimental associative dependencies, was offered as an alternative to the organizational explanation to account for the level of organization present in free recall. Basically, the associationistic position maintains that items are consistently recalled in groups or clusters not because they are subjectively or conceptually organized by the subject under some superordinate category label (Bousfield, 1953; Bousfield & Bousfield, 1966; Tulving, 1962) but rather because they tend to elicit each other as free associates. This tendency for stimulus words to elicit their primary responses is found in the normative data of free assocaition tests (Kent-Rosanoff, 1910; Russell & Jenkins, 1954). Thus, organization depends upon the direct interim associations among the items of the list, and as associative overlap (i.e., the tendency of each item in the list to be elicited by the remaining items) increases, so does clustering and word recall. Researchers in this area (Deese, 1959, 1960, 1961; Jenkins & Russell, 1952; Jenkins, Mink, & Russell, 1958) were led to the conclusion that associative growth was the cause of organization or at least a major determinant of organization (Wallace, 1970). Support for this position is found in paired-associates to free recall transfer studies (Delprato & Hudson, 1971; Postman, 1971a; Wood, 1970). These studies indicated the presence of positive transfer and a significant degree of clustering in the free recall of items based upon the prior, prescribed associations.

At this point it should be noted that the associationistic position also has its critics and that various studies have been initiated in an attempt to ascertain the relative contributions of organizational and associative growth variables in accounting for the observed clustering effects in free recall learning. For example, Cofer (1965) matched categorized and non-categorized word pairings on associative strength, and found that the categorized word pairings led to superior clustering effects. However, Foote and Pollio (1970) showed that the extent to which organizational factors or associative factors contribute to clustering depends upon a number of variables related to the demands of the experimental task. When the study items were presented in a discrete mode, the subjects capitalized on any relationship among the item and therefore high interitem associative strength led to higher clustering and recall. But, when the subjects were able to view all of the items simultaneously they developed idiosyncratic relationships and thus the benefits of high interitem associative strength were minimal in accounting for clustering effects. Allen, Puff, and Weist (1968) suggested a dual level process in which subjects (a) attempt to determine and store coded information about the conceptual relatedness or organization of the items and then (b) form associations among the items of a given conceptual category.

However, when put to a rigorous test by Slamecka (1972) dual process theories, and in fact the associative-growth hypothesis of clustering in free recall, were found lacking. In experiment 1 subjects were presented aurally with a list of items blocked into either four, eight, or 12 conceptual categories. Each category contained five items. Following a single exposure to the list of items and a brief distractor task, the subjects were requested to recall as many words as possible. At recall, the subjects were provided with either zero, one or four retrieval cues (i.e., items) from the original list. The results of the experiment indicated that the retrieval cues facilitated the accessibility to those categories which were not recalled unaided, but did not alter the mean proportion recalled of words within categories. It was also demonstrated that an increase in the number of retrieval cues from one to four had no effect on the proportionate recall of the words within categories. In Experiment 2, Slamecka employed three learning trials rather than one and corroborated his initial findings.

These findings are not consistent with associative-growth theory but are compatible with an organizational or cognitive account of the learning of conceptually related material. According to the associationistic position multiple pathways should form among the component items. Providing one of these items as a cue should activate these pathways and thus enhance the recallability of the remaining items within that category. Providing additional cues should presumably make more associative pathways available and hence lead to proportionately higher recall of the remaining items within that category. As these hypotheses were not sustained, Slamecka suggested that the primary function of the cue was to provide access to the higher order memory units. Once the higher order memory units were retrieved the subjects could then generate the appropriate category exemplars using the various decoding strategies alluded to earlier in this presentation.

However, it should be noted that the absence of intracategory dependencies found by Slamecka in Experiments 1 and 2 occurred at low levels of list mastery (one and three trials, respectively).
At higher levels of list mastery, Postman (1971a) and others (Barton, 1973; Barton & Young, 1972; Johnson, 1972) have documented the development of interitem associative dependencies in both unrelated and conceptually related materials. It was shown, in the context of a transfer design, that it is possible to equate at a functional level, the higher

order memory units which develop during the course of free recall learning with the prescribed intrapair associations which occur during paired-associates learning. The details and logic of Postman's transfer designs will be elaborated upon shortly, but first a few additional perspectives on organizational and associative encoding.

Encoding: Organizational and/or Associative?

In the previous two sections, the respective developments of the concepts of organization and association were selectively traced. Representative studies dealing with these concepts were reviewed primarily with the intention of capturing the flavour and substance of each theoretical framework, but also to suggest potential limitations of each formulation and the possibility of alternative interpretations. Specifically, the theory of subjective organization and in particular the hypothesis of appropriate and inappropriate memory units was questioned on the grounds that typical research designs were inadequate to provide a fair evaluation of the validity of this approach. Likewise, the proposition that the clustering effects present in the free recall of conceptually related items is a function of the formation of interitem associative connections failed to be substantiated.

Despite obvious limitations, each theoretical position continues to grow, to improve upon its methodological techniques and to attract its advocates as well as critics. Organization as delineated by Miller, Tulving and Mandler has been the subject matter of an increasing amount of research, theoretical speculation and model building. The magnitude and diversity of interests in organizational encoding processes in memory is reflected in the succession of review articles by Tulving (1968) Shuell (1969), Kintsch (1970), Tulving and Donaldson (1972), Brown (1976) plus a host of research articles.

The study of organizational processes in free recall learning has generalized to a search for, and the specification of, similar encoding processes in paired-associates learning (e.g., Battig, 1966; Bower, 1970a, 1970b; Runquist, 1970; Segal & Mandler, 1967; Wood, 1969c) and in serial learning (e.g., Bower, 1970a, 1972; Johnson, 1972; Martin, 1974; Martin & Noreen, 1974; Wickelgren, 1967; Winzenz, 1972). The pervasiveness of organizational encoding strategies as revealed by these many studies has led to a re-assessment of the claim that organization is a sufficient condition of learning. Sufficiency is seen as an understatement and rather, organizational encoding tends to be viewed as a necessary condition of learning.

It should be noted however, that the operation of organizational encoding does not preclude the possibility of concurrent association by contiguity (Postman, 1976). Numerous researchers have viewed the same clustering data as the pro-organizationalists and have offered alternative associative interpretations (e.g., Deese, 1959; Wallace, 1970) and in fact the most comprehensive analysis of human memory is based upon an associationistic position (Anderson & Bower, 1973).

The nature of encoding--specifically the involvement of organizational or associative processes--has recently received much attention (cf., Brown, 1976; Melton & Martin, 1972; Voss, 1972). Much of the current research and theoretical speculation appears to be leading towards a merging or rapproachment of the two positions (Postman, 1971a, 1972) and to the development of hybrid models of encoding (Estes, 1972). The origins of this liberalized approach may be traced back to Tulving (1964) who described his concept of subjective organization in terms of the encoding or the rearrangement of the items to be remembered. He stated that:

> such rearrangement manifests itself and can be described in a variety of ways--development of association of the type that define the associative meaning of the word (Deese, 1962); clustering in terms of conceptual (Bousfield, 1953; Cohen, 1963); associative (Jenkins & Russell, 1952); synonymic (Cofer, 1959); categorical; chunking, unitization, or recoding as envisaged by Miller (1956a, 1956b); construction of a plan or creation of a hierarchical structure (miller, Galanter & Pribram, 1960)...the ordering of items in recall according to a previously learnedcode such as the alphabet (Tulving, 1962b)...and probably many others. Subjective organization is just a general name for all these processes (p. 234).

This quote is essentially the position of Postman (1971a) who does not argue for the primacy of either organizational or associationistic position. His recommendation was that theoretical chest-beating was to be avoided and a decision made solely on the basis of which formulation had greater analytic, explanatory and predictive power.

This brief review of the concepts of organization, association and encoding was carried out with the intention of providing a theoretical background for the proposition that the processes of organization and association are functionally similar. In the next two sections more direct evidence for this proposition will be advanced as it applies to free recall to paired-associates transfer and free recall to serial learning transfer.

Free Recall to Paired-Associates Transfer

Until recently, marginal and inconsistent transfer effects have been found in studies which involved the learning of a paired-associates list composed of items from a previously learned free recall list. These transfer effects have ranged from positive (e.g., Battig, Merikle, & Schild, 1965; Underwood & Ekstrand, 1967; Underwood, Runquist, & Schulz, 1959) to negative (e.g., Barton, 1973; Beach, 1968; Burke & Battig, 1968; Johnson, 1972; Postman, 1971a; Rogers & Battig, 1972) to mixed

(Kearn, Note 1). Such transfer effects are usually explained in terms of the interaction of two variables: (a) item-familiarization or response-learning effects (Mandler, 1954; Underwood & Schulz, 1960) and (b) formation of subjective memory units during free recall (Tulving, 1962) which may be either compatible or incompatible with the processing requirements of the paired-associates task.

An example of a study which illustrated the interplay of these two variables may be found in Battig et al., (1965). They had subjects learn a list of 15 three-letter anagrams by the free recall method to a criterion of one errorless trial or a maximum of 15 trials. During this phase of the experiment the subjects were instructed to reproduce the anagrams either in the exact letter order or they were allowed to transform or encode the anagrams and recall them in any order. Consistent with much of the evidence for the facilitating effects of subjective organization, the group allowed to transform the anagrams made both fewer errors and required fewer trials to reach the criterion of one errorless trial.

Approximately one minute after the achievement of criterion, the subjects were transferred to a paired-associates learning task. The paired-associates list was composed of seven pairs of familiar anagrams from the free recall list and three unfamiliar or novel pairs. However, these latter pairs were equivalent to the familiar anagram pairs.

Item familiarity effects, that is, positive transfer was demonstrated by comparing the proportion of familiar pairs recalled with the proportion of unfamiliar pairs recalled. Both groups showed better retention of the familiar pairs of anagrams although these effects were more pronounced for the exact-order group.

The main analysis of total pairs recalled indicated that the group that was requested to maintain the exact order of the anagrams had a significant advantage over the group that transformed the anagrams (24.7 versus 11.5 pairs correctly recalled over the course of five trials). The interpretation drawn was that the subjects who transformed or encoded the anagrams did so in a manner which was inappropriate to the efficient learning of the paired-associates task. In the terms of interference theory, they were obliged to unlearn their idiosyncratic transformations and to relearn anagram pairs as prescribed and were thus at a disadvantage when compared to the group which maintained the exact order of the anagrams across tasks.

Underwood and Ekstrand (1967, Experiments 1, 2, and 3) exposed their subjects to lists of words and trigrams for either 10, 20, 30, or 40 trials and then transferred the subjects to a paired-associate task in which the same items were present. Although incidental to the main interest in massed versus distributed practice effects, the free recall to paired-associates transfer data indicated that the paired-associates learning was inversely related to the amount of prior, free recall learning. That is, fewer trials were required to learn the paired-associates list for those subjects who received the high number of free recall trials. Although the authors suggested that processes such as learning to-learn, warm-up, stimulus-selection and response-learning effects could account for the positive transfer, they did not include appropriate control groups to determine the relative contributions of the various factors. However, it had been shown earlier (Underwood et al., 1959) that prior response learning facilitates subsequent paired-associates performance.

While there is this evidence suggestive of positive transfer in the free recall to paired-associates situation most researchers hold that negative transfer effects should obtain when the same items constitute both lists and a substantial degree of first-list learning is involved. For example, Burke and Battig (1968) had subjects learn a list of CVCs to two successive errorless trials and then transferred the subjects to a paired-associates task. The group which enjoyed prior training and the control group of nontrained subjects performed at the same level on all trials except the first. Here previous exposure to the items gave the trained subjects a slight, but significant advantage. As stimulus-discrimination and response-learning effects as well as warm-up benefits should have given a greater advantage to the trained subjects and led to positive transfer, the presence of some other interfering variable was considered. The lack of any transfer given the favourable conditions enjoyed by the trained group was considered as evidence for negative transfer.

The most convincing evidence for negative transfer in the free recall to paired-associates paradigm was generated from a series of studies by Postman (1971a).

In Experiment I subjects learned a list of 20 unrelated words via the free recall paradigm to a high criterion of 16/20 correct plus three additional study-test cylces. The subjects immediately transferred to the learning of 10 paired-associates. In the experimental condition the same words were used in the free-recall stage and the paired-associates stage with the words arbitrarily paired in the latter stage. In the control condition, the words in the free recall stage were different from those used in the paired-associates stage but both experimental and control subjects learned the same paired-associates list. This procedure was adopted so that the organization developed during the free recall stage would be incompatible with the prescribed associations of the paired-associates task, and result in negative transfer for the experimental group. Half of the subjects learned the paired-associates list by the recall method while the remaining half of the subjects learned by a multiple-choice recognition procedure. The latter method, which eliminates the necessity of response recall (i.e., is free of item-familiarization effects) provides a purer estimate of the associative stage of learning.

Under both methods of assessing transfer effects, the control subjects surpassed the experimental subjects. In the recall method, negative transfer was evident on the first trial and increased over several following test trials. In the multiple choice procedure negative transfer was maximal on the first paired-associates trial and gradually diminished over the remaining 10 trials. From these results, Postman concluded that the positive component of response learning initially counterbalanced the negative, associative transfer but that these item-familiarity effects were transitory and were soon attenuated by associative interference. Further evidence for the interfering effects of incompatible memory units was provided by the analysis of overt stimulus and response errors. The mean percentages of intralist errors were 15.6 for the experimental group but only 3.3 for the control group.

Postman (1971a, Experiment II) replicated these results by using either categorized or uncategorized materials in the development of the experimental lists. For the paired-associates task, each prescribed pairing was formed by selecting the stimulus and response items from different conceptual categories. In this instance the concept of an inappropriate memory unit has some predictive value providing that the subject used the organization defined by the experimenter. Negative transfer was again in evidence with the magnitude greater for categorized than noncategorized lists but not reliably so. Analyses of intralist errors showed more errors under the experimental and categorized condition than under the control and noncategorized conditions. Postman used both recall and multiple choice procedures to partial out the positive influence of item familiarization from the negative transfer effects. The negative transfer occurred when the prescribed pairings of the associative task were incompatible with the organizational units developed during free recall learning.

This series of studies by Postman generated further research (Barton, 1973; Barton & Young, 1972; Johnson, 1972; Kearn, Note 1; Rogers & Battig, 1972) which attempted to specify the nature of the relationship between subjective memory units and prescribed associative connections. Rogers and Battig (1972), who employed a transfer design similar to Postman's (1971a), had subjects learn a 24 word list by the free recall method and then had the subjects learn a derived paired-associates list composed of 12 pairs of items. They had previously manipulated the level of free recall training to establish differential levels of organization prior to transfer. A higher criterion group was required to achieve one errorless trial, or all items correct at least once and three trials with at least 21 words correct. The low criterion group was required to recall only 12 items on one trial. Following the training, the paired-associates task was continued to one errorless trial for all subjects. Their results substantiated Postman's findings. An analysis of total paired-associates errors showed that the high criterion experimental group committed almost twice the errors (21.6) as did the remaining low criterion and appropriate control groups (mean = 10.9). An analysis of trials to criterion paralleled the error results with the high criterion experimental group requiring a mean of 5.8 trials and the remaining three groups needing a mean of 4.0 trials to reach criterion. Not only had Postman's (1971a) results been replicated but it had been shown that substantial amounts of free recall organization are necessary for the subjective memory units to interfere with the learning of a paired-associates list derived from the free recall list.

Johnson (1972) used a different rationale to assess the presumed continuity between the organizational linkages of free recall learning and the prescribed associations of paired-associates learning. Also using a free recall to paired-associates transfer design, she attempted to manipulate the compatibility of the intertask memory units. This manipulation was achieved by slightly modifying the manner in which the paired-associates list was derived from the free recall items. Typically the prescribed pairs are randomly selected from the free recall items. However, Johnson reasoned that a selection of adjacent pairs of items from the free recall output would be a closer approximation to a subjective memory unit than a selection of non-adjacent items. It was predicted that linkages between adjacent items would be more likely to be compatible intertask memory units and lead to positive transfer than the connections between nonadjacent pairs, which were not compatible memory units. Results indicated that relative to appropriate control groups, there was marked negative transfer for the nonadjacent pairs but only a slight and nonsignificant facilitation for the adjacent pairs of items.

Barton (1973) and Barton and Young (1972) provided further insight into the nature of intertask memory units by focusing on Postman's (1971a) multi-pathway analysis of transfer phenomena. Postman reasoned that during development of higher order memory units the component items became associated together in a multiplicity of connections or pathways. He argued that if a subsequent learning task involved the disruption of the original multiple pathways, or if the task involved the learning of only one pathway at the exclusion of all other connections, then negative transfer would occur.

Over the course of two experiments Barton (1973) and Barton and Young (1972) systematically varied the size of the conceptual categories that provided the pool of items. With list length held constant at 24 words and the number of conceptual categories equal to 2, 4, and 12, they produced transfer lists of 12, 6, and 2 items per category, respectively. Across these conditions pairs of items were then selected from within the same conceptual category or from between two distinct categories. Based upon Postman's (1971a) multi-pathway analysis, predictions were made concerning the valence of transfer for each of the pairing types. It was anticipated that as the number of items per category increased, negative transfer would also increase for the within-category pairings; conversely an analysis of the between-category pairings would indicate that negative transfer would increase as the number of items per category decreased. The results of these experiments were generally in agreement with Postman's theory. The within-category pairings showed maximum negative transfer for the condition of 12 items per category relative to 2 items per category. The between-category pairings indicated more negative transfer in the condition where there were 2 items per category relative to 12 items per category. However, for this pairing negative transfer was maximum when there were 6 items per category.

In summary, the available evidence on free recall to paired-associates transfer indicates that positive transfer will result under experimental conditions which allow item familiarization effects to be operative, that is, prior exposure to the items but a minimum amount of organization. Positive transfer is also expected but remains to be conclusively demonstrated when the subjective memory units of free recall are compatible with prescribed pairings of a subsequent paired-associates task. Conversely, transfer will be negative when the free recall organizational units are incompatible with the subsequent associative requirements.

However, a significant weakness resides in the studies previously reviewed. This weakness lies in the assumption that the list organization as defined by the experimenter is entirely congruent with the organization as perceived and utilized by the subject. The possible discrepancies and the implications of making this assumption have been dealt with elsewhere (Mandler, 1967; Postman, 1972; Tulving, 1968). However, it should be noted that defining words from the same conceptual categories as an appropriate memory unit may not truly represent the subject's appraisal of the situation.

A brief re-examination of the Barton (1973) and Barton and Young (1972) studies should illustrate this point. One of the conditions in the Barton (1973) study involved 12 items in each of two dissimilar conceptual categories. Barton then randomly selected pairs of items from within each category and defined these as within-category pairings. However, Mandler (1967) has shown that subjects typically form higher order memory units composed of four or five items only. Thus, Barton's selection of a pair of items from a conceptual category consisting of 12 items and his definition of that pair as a within-category pairing may be inaccurate. It is quite possible that the pair originated from two distinct subcategories and is therefore a between-category pairing and thus the obtained negative transfer.

This particular problem can be circumvented to some extent by resorting to techniques which measure subjective organization rather than experimenter-defined organization. Following the next section on free recall to serial list transfer a method of manipulating a subjective organization will be proposed.

Free Recall to Serial List Transfer

The effects of free recall to serial list transfer are influenced by the same factors which are operative in free recall to paired-associates transfer tasks. Item familiarization and the degree of compatibility of the intertask memory units interact to produce positive or negative transfer in a manner similar to that described in the last section. In an early study, for example, Hovland and Kurtz (1952) had subjects pronounce nonsense syllables until they could recognize all the items in a partial-exposure test. The subjects were then transferred to a standard serial learning task of six, 12, or 24 syllables in length. For these different list lengths, the prior exposure groups required means of 2.2, 11.4, and 30.2 trials to reach a criterion of one perfect trial as compared to groups without prior familiarization who required 4.1, 15.9, and 33.0 trials to reach the same level of mastery. Presumably, only item familiarization effects were present in the experiment and therefore positive transfer was obtained. The prior exposure to the nonsense syllables was based upon a recognition task and did not entail the formation of memory units which could interfere with subsequent learning.

That prior organization or association structure may facilitate serial list performance was suggested in a study by Weingartner (1963). In this study the internal structure of the lists to be learned was manipulated by varying the interitem associative overlap of the items comprising the lists. In one list, words which occurred together as associates in normal usage (e.g., moth, butterfly, insect, bug) were placed in adjacent positions. In another list the same words were randomized throughout the list. Performance was best when the internal associative structure of the list was intact, that is, when items of high associative overlap were sequential. The facilitation occurred primarily during acquisition of the middle items of the list which are ordinarily the most difficult to learn. Postman (1967) replicated these results.

Evidence that prior organization could lead to negative transfer was suggested in a study by Earhard (1969, Experiment 1). In the experiment of interest to the present investigation, groups of subjects learned a list of unrelated words for 1, 5, 9, 16, or 21 free recall trials. Following the free recall phase, the subjects were requested to recall the items in alphabetical order, which is, within the context of this experiment, a prescribed serial order. The alphabetical recall varied inversely with increasing amount of prior free recall practice. The dependent variable indexing this relationship was a difference score between word recall during the free recall and recall under the alphabetical constraints. The difference score indicated the number of words which were rendered inaccessible as a result of the alphabetical recall. As the serial recall instructions were given after the free recall phase learning, i.e., after the storage of the items, the decrement in performance was attributed to a conflict of retrieval cues. Apparently, the subjects stored the items using idiosyncratic organizational cues but were required to retrieve the items on the basis of alphabetical or serial cues. The lack of congruence between these cues resulted in the progressive decrement in performance.

Two additional studies (Shapiro, 1970; Wood, 1969a) which employed free recall to serial list transfer designs, are highly relevant to the present investigation. Wood (1969a) used a whole-to-part-transfer paradigm in which subjects learned an 18 word free recall list and were transferred to a nine-word serial list. In the experimental group the nine-word serial list was composed of items from the free recall list while the control group learned the same serial list but had previously free recalled a different 18 word list. Negative transfer was evident in the latter stages of serial list learning only. In the early stages of serial list learning item familiarization effects tended to reduce the difference between experimental and control groups. However, as the transfer training progressed, the effects of item familiarization attenuated and the negative transfer effects became apparent.

In a following study Wood (1969a, Experiment 2) the logic of the basic transfer design remained the same; however, the number of free recall trials was manipulated as an additional variable. Subjects received one, three or six free recall trials prior to transferring to the serial task. It was anticipated that as free recall trials increased negative transfer should also accrue as a function of the progressive development and subsequent disruption of the higher order memory units. As predicted, the analysis of the serial list data indicated a groups by trials interaction. When fewer than six free recall trials were given control and experimental groups did not differ in serial list performance. However, when prior free recall training was extended to six trials control group performance on the serial task was superior to that of the experimental group.

Subjects, depending on their free recall performance, were then designated as high or low organizers. Further analysis showed a significant organization (high vs. low) by groups (control vs. experimental) by lists (free recall vs. serial list) interaction which was attributable to high organizers in the experimental group performing better on the free recall stage but poorer on the serial list stage of the study. These results are consistent with the view that inappropriate memory units in free recall learning were responsible for the negative transfer.

Shapiro (1970) also investigated the relationship between prior free recall practice and subsequent serial learning. To extend Wood's (1969a) findings, Shapiro attempted to measure the level of organization of the higher order memory units prior to transfer and also the degree of appropriateness of these memory units to the serial learning task. In addition, he attempted to devise a score which would account for and partial out the item familiarity effects which predominate on the initial transfer trials. These objectives were met in the following manner.

Groups of subjects studied 16 unrelated words by the free recall method for five, 10 or 15 trials. Shapiro then measured the amount of organization present at the completion of free recall practice. The measure of organization he used was the number of observed, bidirectional intertrial repetitions minus the expected number of bidirectional intertrial repetitions (Bousfield & Bousfield, 1966; Gorfein, Blair & Rowland, 1968). The mean scores (observed-expected) for the groups receiving five, 10, or 15 free recall trials was 1.05, 0.98, and 1.90, respectively. However, no statistical evidence was provided as to the significance of these differences other than they exceeded chance values.

Next he calculated the degree of overlap between the bidirectional memory units of free recall and the serial order of the transfer task and found the overlap to be uniformly low for all groups. This lack of congruence was considered by Shapiro to be evidence that the intertask memory units would be inappropriate. As Shapiro restricted this analysis to memory units composed of only two items this asserted inappropriateness of memory units may not be entirely valid. However, it was a commendable attempt to operationalize the concept of inappropriate memory units.

The serial learning stage of the experiment immediately followed the free recall phase. Subjects were requested to write their responses, guessing where necessary, sequentially down the lined, test sheets. The dependent measure was total recall in lieu of correct serial placement of items. Difference scores were derived for each subject in an attempt to account for item familiarization effects. For serial trial one, this entailed subtracting a subject's performance on the last free recall trial from his recall on serial trial one. For the remainder of the serial trials, the difference score was obtained by subtracting the recall on trial N from the recall on trial N+1. Results indicated that the groups receiving 5 or 10 free recall trials did not differ from each other but both performed significantly better than the group receiving 15 free recall trials. The lack of difference between free recall groups 5 and 10 trials was explained in terms of the near identical organization scores (1.05 and 0.98, respectively) during free recall learning. The inferior serial list performance of the group which received 15 free recall trials was attributed to a higher level of organaization, that is, well established memory units, which were inappropriate to the learning of the serial list.

In summary, the previous studies indicate that the free recall to serial learning transfer effects may be positive or negative. Positive transfer is obtained when item familiarization increases the availability of the items during the serial learning stage. This variable is most potent in the early stages of transfer training (Wood, 1969a) and no doubt influenced Shapiro (1970) to employ a derived score based on differences between final free recall and initial serial recall. Also, when the serial order of the items is congruent with the interitem relationships developed through extensive pre-experimental verbal habits, positive transfer will occur (Postman, 1967; Weingartner, 1967). Negative transfer is obtained in those cases where the organizational units of a prior task are incompatible with the demands of a subsequent task (Earhard, 1969; Shapiro, 1970; Wood, 1969a). It is highly conceivable that both positive and negative transfer effects may be present in the same study. If the intertask memory units are compatible then positive transfer should result and conversely if they are incompatible negative transfer should be present. But notice, as was the case in free recall to paired-associates transfer, the apparent circularity of the definition of the concept incompatible memory unit. Shapiro (1970) attempted to break the circularity of the definition by showing that successive pairs of words from the serial list were incompatible with the free recall memory units, but only for higher order memory units of size two. It is conceivable that contiguous pairs of words from the serial list may not be adjacent in the free recall list but instead be part of a higher order memory unit of size three, four, or five (Pellegrino & Battig, 1974). Thus, Shapiro's claim that negative transfer was due to inappropriate memory units may not be entirely valid.

In the following section a procedure will be outlined which will provide a more serviceable definition of the degree of appropriateness of intertask memory units by providing an alternative way of manipulating the level of prior organization.

Organization and Number of Subjective Categories

The previously cited studies on free recall to paired-associates or serial list transfer have, without exception, varied the level of organization in the free recall stage by manipulating the number of trials. Although varying trials in this manner is an entirely adequate method for producing changes in subjective organization (e.g., Tulving, 1962; 1964) it is not the only method nor perhaps the most satisfactory way for specifying a priori the degree of appropriateness of the intertask memory units. Another method of varying free recall organization may be found in the pioneering work of Mandler and his associates (Mandler, 1967, 1968a, 1968b, 1970, 1972; Mandler & Pearlstone, 1966; Mandler, Pearlstone & Koopmans, 1969; Mandler & Stephens, 1967). A detailed account of Mandler's research may be found in Stojak (Note 2) and only findings relevant to the present investigation will be highlighted at this point.

Mandler required subjects to sort a list of unrelated words into from two to seven subjective categories. Instructions were that the subjects could sort the words, printed individually on cards, using any rules but the physical characteristics of the words (i.e., length, number of syllables, initial letters, etc.). The subjects, tested individually, were not informed that a recall test would follow but only that the sorting would be continued to a criterion of two successive, identical sorts. Once subjects achieved this level of consistency they were requested to recall as many words as possible, in any order that they wished. The data showed two important relationships. As the number of categories increased from two to seven the amount of word recall and organization (as measured by the words from the same category being recalled in adjacent positions) also increased. In addition, word recall and level of organization were correlated with the number of categories used by the subjects, but not with the number of sorting trials which were necessary to reach the consistency criterion. Mandler concluded that organization and not merely a repetition effect due to trials was the critical factor in the recall of supramemory span lists of unrelated words. In anticipation of potential criticism that the results were due to subject selection effects, that is, a general intelligence factor, Mandler (1967) randomly assigned subjects to the number of categories and found the same category-recall relationship. Melkman (1975) provided corroboration of this finding by contrasting the category-recall function when the number of categories was the preferred selection of the subject or when the number of categories was imposed by the researcher. Within the range of categories used in the present investigation the positive relationship between number of categories and word recall was maintained.

Mandler (1968) also used a within-subjects design to demonstrate the category-recall relationship and thus extend the generality of his findings. In a further variation on his basic design, Mandler (1967) held the number of sorting trials constant and allowed his subjects to select a preferred number of categories (restricted to values between two and seven). Again, the results showed that the level of organization and word recall varied directly with the number of categories used by the subjects. This latter study was substantiated by Nelson, McRae and Sturges (1971). Thus, by holding trials constant and randomly assigning subjects to a certain number of categories between two and seven, it is possible to vary the level of organization between subjects.

The feasibility of this procedure has been demonstrated recently by Fullerton, McIntyre and Stojak (Note 3) and Stojak, Klein and McIntyre (Note 4). To illustrate, in the former study, which was a whole-to-part free recall transfer task, subjects were tested in groups of six. They were randomly assigned to experimental or control groups and to a designated number of categories (either three, five, or seven). The experimental procedure, which involved a slight variation of Mandler's format, utilized test booklets in which a list of 30 unrelated words was typed above the number of categories appropriate for that subject. The subjects were allowed four sorting trials in which to subjectively categorize the words into the designated number of categories. They were constrained to six, five, five, and four minutes, respectively, for each of the four sorting trials. A recall phase, previously unmentioned to the subjects, was then initiated. First list organization varied directly with the number of categories assigned as indexed by the adjusted ratio of clustering scores (Roenker, Thompson & Brown, 1971) of .622, .718 and .833 for three, five, and seven categories, respectively.

That the sorting procedure either produces a short range, stable organization or taps some underlying organization was further demonstrated in a study by McIntyre, Stojak and Mostoway (1973). These investigators demonstrated that release from proactive inhibition will occur when subjects shift, on a short-term memory trial, to items from a different subjective category determined during a previous Mandler sorting task. Over longer periods of time, the persistence and stability of the subjective memory units formed in this manner was demonstrated by Fisher (1971) and Mandler (1967).

The major advantage in using the Mandler sorting technique as a means of manipulating the level of organization prior to transfer is that it allows an a priori means of establishing the degree of appropriateness of the intertask memory units. Once the status of the memory units has been established, it becomes possible to assess the differential transfer effects which must be predicted by the organizational and associationistic position. An example, from a hypothetical free recall to paired-associates transfer task, should clarify the utility of this design.

Assume that the experimental list is comprised of the items A, B, C, D, E, and F. The paired-associates list is derived from these items by randomly selecting two items at a time. Let the transfer list formed in this manner consist of the pairs A-C, B-F, and D-E. The subject is first exposed to the free recall list and encouraged to sort the items using any type of grouping strategy. Further assume that the subject consistently sorts items A, B, and C into one category and items D, E, and F into another category. Units ABC and DEF are, in effect, well organized, higher order memory units or chunks. As previously described these units cannot be construed as having fixed sequential dependencies among the component items. Rather these units could be recalled as ACB or FDE and thus the prescribed pairings A-C and D-E involve no disruption of the original memory units. Viewed in this manner, the task is in effect an extreme case of a whole-to-part transfer paradigm with each prescribed pairing a part of a larger, higher order memory unit.

It is now possible, prior to transfer, to specify the inappropriate and appropriate memory units. For example, the pairing B-F (now defined as a between-category pair) is composed of items which originate in two distinct memory units. The prescribed B-F pairing involves the disruption and exclusion of the prior, intrachunk linkages and the formation of one, new connection. Thus, the between-category pairs which are inappropriate memory units, should result in negative transfer. This outcome would be consistent with the predictions of both the organizational and associationistic positions.

The pairings A-C and D-E (defined as within-category pairs) are composed of items which are, in effect, subsets of the original chunks. Therefore, there is a degree of overlap or commonality among the interitem connections which were formed during the free recall phase and the prescribed pairings in the transfer task. However, an application of the organizational theory and associationistic theory to determine the status of the within-category pairings leads to a prediction of opposite transfer valences. That is, from the organizational position, the within-category pairings are presumed to be but one interitem connection of the many possible connections which are formed during the development of the higher order memory units. As these within-category pairings do not involve a disruption of the previous connections, but rather the maintenance of one specific connection, they are viewed as appropriate intertask memory units and would yield positive transfer.

Conversely, the associationistic position suggests that the within-category pairs would produce negative transfer effects. It is presumed that, as the higher order memory units develop, multiple pathways or connections form among the component items. However, in the paired-associates phase one associative pathway must be learned to the exclusion of all of the other intrachunk connections. But upon presentation of the stimulus element, the previous associative connections will be aroused and proactively compete with the development of the prescribed association. Thus, negative transfer would be anticipated for the within-category pairings.

Further differential transfer effects would be expected to vary as a function of the level of organization or the degree of cohesiveness of the higher order memory units. For example, the organizational point of view would predict that the amount of positive transfer of the within-category pairings and the amount of negative transfer of the between-category pairings would be directly related to the degree of cohesiveness or organization of the memory units.

The associative position would also predict that the amount of negative transfer of the between category pairings would relate to the level of original organization. On the other hand, the locus of interference leading to negative transfer in within-category pairings is presumed to be in the number of multiple pathways and therefore the number of items in the higher order memory unit.

Thus, the subjective sorting technique, which allows for the development and identification of higher order memory units of various size and levels of cohesiveness provides a viable method for analyzing associative and organizational processes in transfer studies. The specificity of the prediction which may be derived from this methodology are developed in the subsequent section.

Experimental Paradigms and Hypotheses

The purpose of this investigation was to assess the proposition that the interitem relationships formed during the establishment of higher order subjective memory units share common functional attributes with the interitem connections established during the course of prescribed associative learning. As well as being a partial replication of previous research on this issue, the present investigation integrated a subjective sorting technique into the transfer design and thus provided the means to operationally define and clarify the terms appropriate and inappropriate memory units.

The general paradigm used to investigate the nature of the intertask memory units was a two-stage transfer design. Specifically, subjects transferred from a free recall task to a paired-associates task (Experiment 1) or from a free recall to a serial learning task (Experiment 2).

The free recall phase of Experiments 1 and 2 involved the same basic format. Three randomly derived experimental groups of subjects (E3, E5, and E7) sorted 30 unrelated words into either three, five, or seven subjective categories, respectively. Three randomly obtained control groups (C3, C5, or C7) sorted an equivalent but different set of 30 words into a comparable number of categories. At the completion of four successive sorting trials an unannounced free recall of all items occurred. It was predicted that:

1. Word recall would be a positive linear function of the number of subjective categories with no differences between the experimental and control groups.

2. The level of organization would similarly increase as a function of the number of subjective categories and would also indicate an equivalence between experimental and control groups.

Experiment 1: Free recall to paired-associates transfer. At the completion of the free recall phase, subjects were immediately transferred to a paired-associates task composed of 15 random pairings from the original 30 item experimental list. Both experimental and control groups learned the same paired-associates list. For the experimental groups, it was possible to specify those word pairings which were compatible with the subjective memory units and those word pairings which were not compatible.

Those word pairings which, through chance, happened to be from two subjective categories (i.e., between-category pairs) would involve inappropriate memory units and therefore result in negative transfer. The amount of negative transfer should be related to the level of organization attained during the free recall phase. That is, the greater the number of categories employed, the higher the amount of organization and thus the greater the interference in learning the paired-associates task.

This line of reasoning would be evaluated statistically by comparing the proportion of between-category pairs recalled with the control condition as a function of the number of categories. It was anticipated that this analysis would yield a two-way interaction with the amount of negative transfer directly proportional to the number of categories. This prediction was considered to be congruent with both the organizational and associationistic positions.

However, when considering the transfer effects of those word pairings which were defined as appropriate memory units, each of the theoretical frameworks must be developed separately as they lead to different predictions.

Within the context of organizational theory, those word pairings which, through chance, happened to be from the same subjective category (i.e., within-category pairs) would involve appropriate memory units and therefore result in positive transfer. The amount of positive transfer should be related to the level of prior organization. That is, the greater the number of categories employed, the higher the level of organization and thus the greater the facilitation in learning the prescribed pairs. Statistically, an analysis of the proportion of within-category pairs with a control condition should yield a two-way interaction. Positive transfer should increase as the number of categories increases.

However, within the context of associationistic theory negative transfer would obtain for the within-category pairs in proportion to the number of interitem connections or pathways. As the number of items per category decreases with an increase in the number of categories it must follow that maximum interference would occur in the three-category condition. As there are fewer items in the seven-category condition these interfering effects should be attenuated. A two-way interaction should result indicating negative transfer which decreases as the number of categories increases.

In addition to the above, other, more general predictions must follow from a consideration of the free recall to paired-associates transfer design. Therefore, it was predicted that:

1. An overall transfer effect would be apparent with the control

group performing significantly better than the experimental group.

2. Item familiarization effects would be evident in the performance of the experimental group during initial trials on the paired-associates task but this effect would attenuate as trials progressed. Statistically, this attenuation would be demonstrated with a groups (experimental versus control) by trials interaction.

3. A groups by number of categories interaction was considered to be most vital to the experimental hypothesis. Groups E3, E5, and E7 should learn the prescribed pairings progressively more slowly compared to groups C3, C5, and C7 which should perform equally. This prediction would be in accord with both the organizational and associationistic theories.

4. An analysis of the stimulus and response intrustion data would show an increasing number of errors for groups E3, E5, and E7, respectively.

Experiment 2: Free recall to serial list transfer. At the completion of the free recall phase, subjects were transferred to a 15-word serial learning task. The serial list items were randomly selected from the 30 words of the experimental list. The serial recall of each subject was scored for the number of successive pairs of words correctly recalled on each trial. Each of these pairs was then identified as a within- or between-category pairing depending upon the compatibility of those pairings with the previous subjective memory units. Based upon this approach and the logic advanced in the previous sections it was predicted that negative transfer for the between-category pairings and positive transfer for the within-category pairings would be an increasing function of the number of categories. Statistically, two-way interactions should result between pairings (between-category pairs versus controls; within-category pairs versus controls) and the number of categories used during the free recall phase.

In addition to the above, it was predicted that:

1. The presence of an overall transfer effect would be indicated by the inferior performance of the experimental groups relative to the control groups.

2. The experimental groups' familiarization with the words in the serial list should enhance their performance, but this facilitation would be restricted to the initial trials of the serial learning task. Thus, a groups (experimental and control) by trials interaction was predicted.

3. The higher levels of organization which was anticipated as the number of categories increased should lead to increasing amounts of interference in the learning of the serial list. As the three control groups should perform at the same level, a groups by number of categories interaction was considered to be critical to the hypotheses advanced in this investigation.

EXPERIMENT I

Method

Experimental Design

The sorting of a list (List 1) of 30 unrelated words into a predesignated number of subjectively determined categories was followed by a free recall test and subsequently by the acquisition of a list (List 2) of 15 paired-associates derived from List 1. Independent groups sorted List 1 into either three, five, or seven categories. Following the recall of List 1, the three experimental groups received six paired-associates trials on List 2 with the pairs selected randomly from the List 1 words. The three control groups also received six paired-associates trials on List 2 but for these groups the List 2 words were different from the List 1 words. The major dependent variable was, of course, the number of correct responses during each of the six paired-associates trials of List 2 learning.

The experimental design was, therefore, a 2 x 3 x 6 design with two independent factors (control and experimental groups; number of List 1 sorting categories) and one repeated factor (trials).

Subjects

The subjects for this experiment were obtained from the introductory psychology courses at the University of Manitoba winter session. Participation in this experiment was voluntary; however, subjects received a nominal course credit for their involvement. The subjects were female students between the ages of 18 and 25 and had English as their native language.

Of those subjects tested, 11 subjects in the experimental groups and 11 subjects in the control groups (with a near-equal distribution across the number of categories condition) failed to reach the criterion of at least 90% consistency on the last two sorting trials. Therefore, additional subjects were tested to stabilize the groups at 16 subjects per group.

Lists

Two lists of 30 nouns were selected from the entire set of words used by Tulving (1964). The two lists, randomly designated as experimental list or control list, were equated for Thorndike-Lorge (1964) frequency of usage, initial letters and word length. An attempt was made to minimize any obvious intralist and interlist relationships. To ensure that all subjects were familiar with the words, only words with a frequency count of greater than four per million were used. (The lists of words are shown in Table 1 of Appendix A.)

A whole method of presentation (Bower, Clark, Lesgold, & Winzenz, 1969; Winograd, Conn, & Rand, 1971) was used in which the 30 words were arranged in six columns of five words each at the top of a sorting page. Below the words were the number of sorting categories appropriate to that condition. Four random orderings of the words appeared on four sorting pages with each sorting page separated by a filler page.

For paired-associate learning, fifteen pairs of words were randomly selected from the experimental list with the following restrictions: (a) no two words which were used as stimuli or as responses started with the same letter; (b) no pair of words began with the same letter; and (c) obvious relationships between stimulus and response pairs were minimized. A second list of paired associates were randomly selected. This list met the previous restrictions and had the additional constraint that no two pairings were identical between lists. The two lists were counter-balanced across conditions and served to reduce any pair-specific relationships which might occur with the use of only one list. Four random orders of each list were prepared. (The word pairings of each list are shown in Tables 2 and 3, Appendix A.)

Procedure

All subjects received a booklet containing sorting pages, test pages and filler pages between the sorting and test pages. The design of the booklets allowed all conditions to be tested simultaneously. Subjects, randomly assigned to treatments, were tested in groups of, or multiples of, six. For List 1 learning, the subjects were informed that the study concerned how words are organized (see Appendix B for complete instructions). Basically, the subjects were instructed to organize the 30 words on a sorting page into a specified number of categories located below the list. The method of complete presentation was used to facilitate organization of the items. The subjects were told to use any method of categorization except the physical characteristics of the items as the basis for sorting. The organizational factor was stressed; however, recall was not mentioned. Also, the subjects were urged to balance the number of words across categories.

Following the completion of the first sort trial subjects were asked to turn to the next specified page and attempt to replicate their organization. A total of four sorting trials to achieve consistency of organization were used. The length of time allowed for each of the four sorting trials was six, five, four, and four minutes, respectively.

Following the last sorting trial, the subjects were asked to recall as many of the 30 words as possible in any order. Four minutes were allowed for this free recall test.

The List 2 paired-associates task followed immediately after the free recall tasks and paired-associates instructions (see Instructions, Appendix B). The study-test method was utilized for the paired-associates task. The pairs were presented via a Kodak Carousel projector at a 2 sec rate during the study portion of each trial with 5 sec being allowed for the recall of each response term during the test phase. A 5 sec interval separated the study and test phases, with a 10 sec interval between the end of a test phase and the beginning of a new trial. All subjects received a total of six trials on the paired-assocates task. Four different random orders of the pairs and four random orders of the stimuli alone were cycled over these six study-test trials.

Each test page for the paired-associates trials contained 15 blanks vertically centered on the page. Subjects wrote only their responses in the spaces provided, giving either the associate, a guess, or in lieu of guessing, they drew a line through the appropriate response space as an aid to maintaining their position within the test sequence (cf., Cieutat, 1967).

Results and Discussion

The raw data from Experiment 1 are contained in Appendix C and the summaries of the various analyses of variance on this data are contained in Appendix D.

First List Performance

The data from the free recall phase of the experiment were separately analyzed according to the following measures: (a) the consistency or stability of organization between the third and fourth sorting trials; (b) the number of words recalled; and (c) the levels of organization present on the free recall protocols.

Consistency of organization. The mean percentages of sorting consistency for all groups are shown in Table 1. Analysis of variance yielded no significant differences among groups, F (1, 90) = .13; conditions, F (2, 90) = .76; or the interaction, F (2, 90) = .22. The overall percentage of consistency of organization was approximately 96%. As Mandler (1967) found no substantial differences in recall performance between subjects achieving 100% consistency and those obtaining 95% consistency it appears reasonable to assume that the subjects in the present investigation had achieved a stable pattern of organization.

TABLE 1

Mean Percentages of Consistency Between the Third and Fourth Sorting Trials in Experiment 1

Condition	Number of Categories 3	5	7
Experimental	97.7	96.2	94.8
Control	96.9	97.8	95.6

Word recall. The mean list 1 recall is shown in Figure 1. As expected, the control and experimental groups did not differ in mean words recalled, F (1, 90) = .48. However, there was a significant difference in the number of categories condition, F (2, 90) = 25.1, $p < .01$. As Figure 1 indicates, and a Tukey HSD test (Kirk, 1968) confirmed, recall increased systematically as a function of the number of subjective

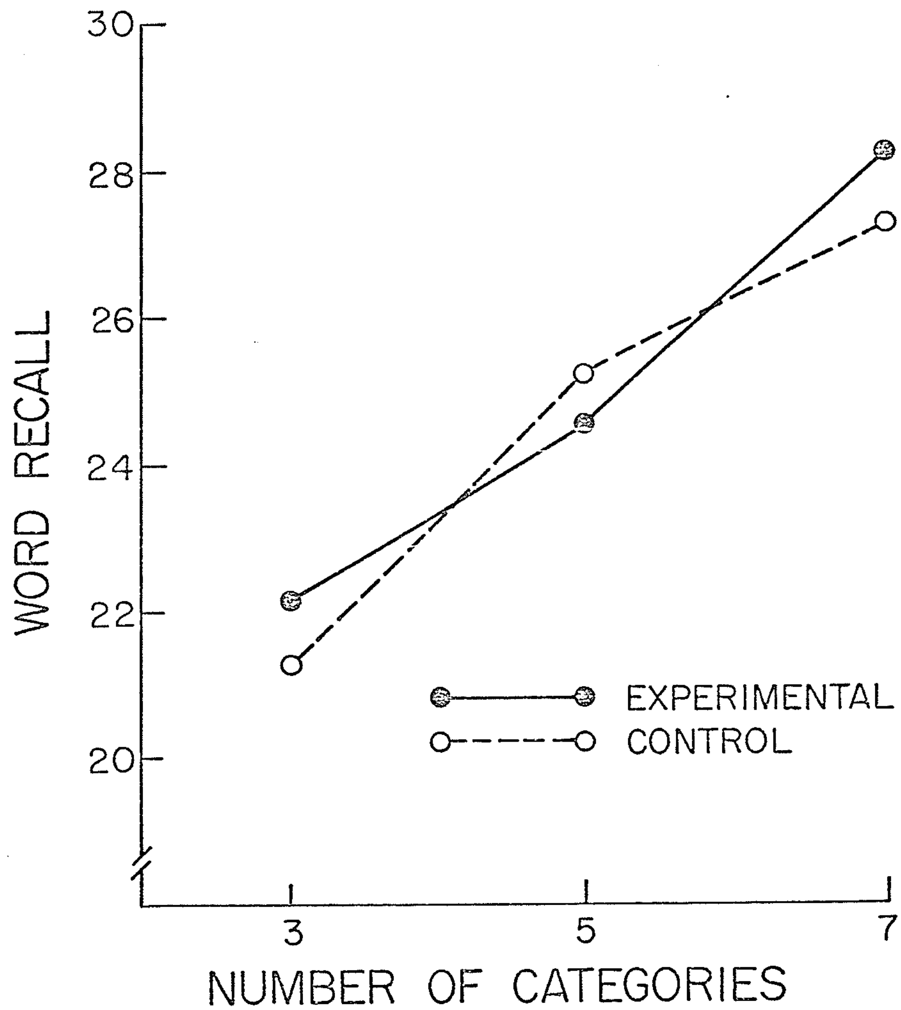

Figure 1. Mean word recall during List 1 as a function of number of categories in Experiment 1.

categories and thus corroborates the word recall-number of categories relationship originally suggested by Mandler (1967).

Levels of organization. To assess the degree of List 1 organization the adjusted ratio of clustering (ARC) of Roenker, Thompson and Brown (1971) was computed on the free recall protocols. The mean ARC scores for all groups are shown in Figure 2. As was the case in the word recall analysis, there was a significant effect due to the number of categories used by the subjects F (2, 90) = 3.93, $p < .05$, but no differences due to groups, F (1, 90) = .05, or to the interaction of groups and number of categories, F (2, 90) = .03.

In summary, performance on List 1 was generally as predicted with both word recall and levels of organization varying as a function of the number of categories used by the subjects. Specifically, the higher number of categories led to greater levels of word recall and organization. Therefore it seemed reasonable to assume that a major prerequisite of the experiment--to achieve differential levels of first-list organization--was satisfied by the experimental manipulation of the number of sorting categories used by the subjects. The lack of any large group differences in List 1 performance provided reasonable assurance of group equality at the beginning of List 2 learning.

In addition, the results of this phase of the experiment have further extended the generality of the relationship between the number of categories and word recall/organization as first established by Mandler (1967). This relationship was apparent and robust even under the group-testing procedure and the use of test booklets. Previous research in this topic area has relied upon individual testing procedures which are decidedly less economical than the present methodology.

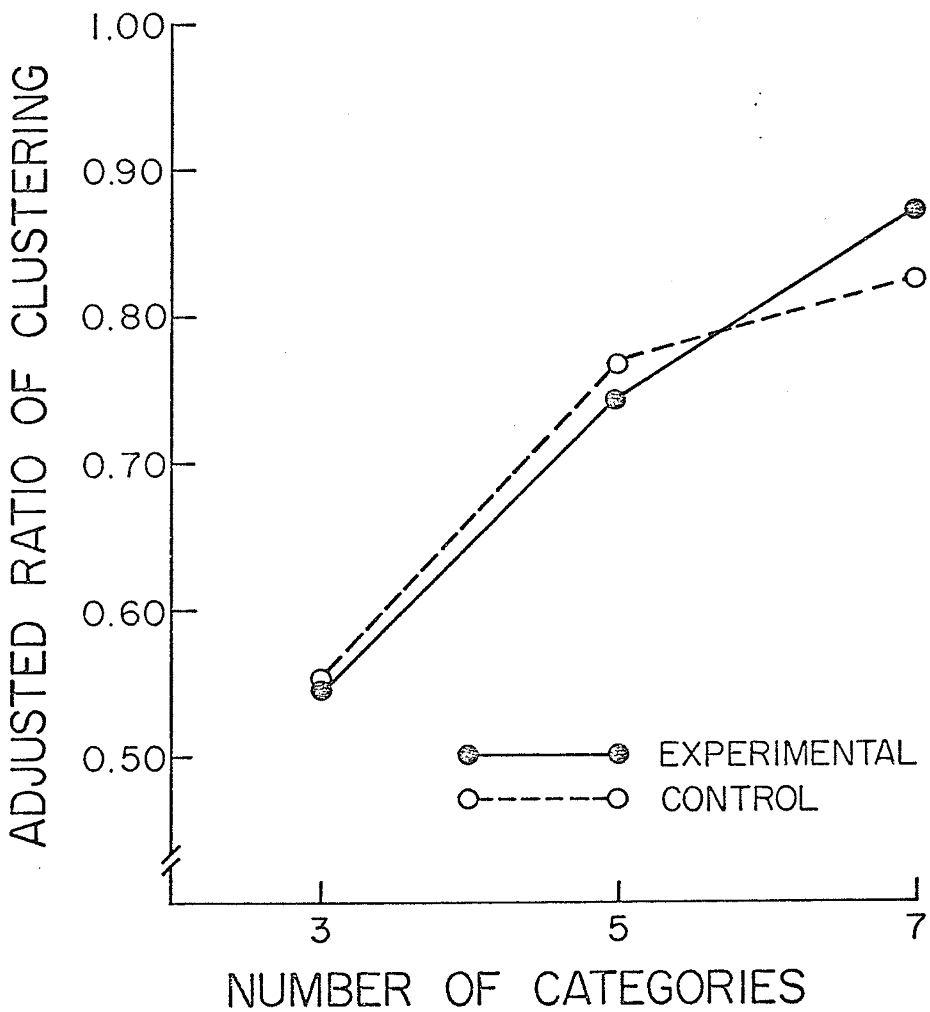

Figure 2. Mean adjusted ratio of clustering scores as a function of number of categories in Experiment 1.

Second List Performance

The data from the second phase of the experiment were analyzed according to the following complementary measures: (a) the basic transfer data consisting of the number of correct associates; (b) the proportion correct of within- and between-category pairings; and (c) the total number of overt stimulus and response errors.

Transfer. An analysis of the overall mean number of correct responses during paired-associates learning for the experimental as compared with the control groups indicated substantial negative transfer, F (1, 90) = 10.65, $p < .01$. This finding provides support for the proposition that the higher order memory units of free recall share common, functional properties with the prescribed pairings of associative learning. That is, the prior organization of the subjective memory units and the subsequent disruption of these units acted as a source of proactive associative interference and thus placed the experimental subjects at a disadvantage relative to the control subjects.

That this negative transfer was a function of the level of organization of the List 1 memory units was given by a significant groups by number of categories interaction, F (2, 90) = 3.28, $p < .05$. As shown in Figure 3 (and confirmed by Tukey HSD post hoc tests, Kirk, 1968) Group E3 with a relatively low level of initial subjective organization performed at the same level as its corresponding control, Group C3. With this low level of initial organization, the interitem connections were weakly developed and therefore could not serve as a source of associative interference.

However, Group E5, with a higher level of List organization than Group E3 (ARC scores of .78 and .69, respectively, where 1.00 is the

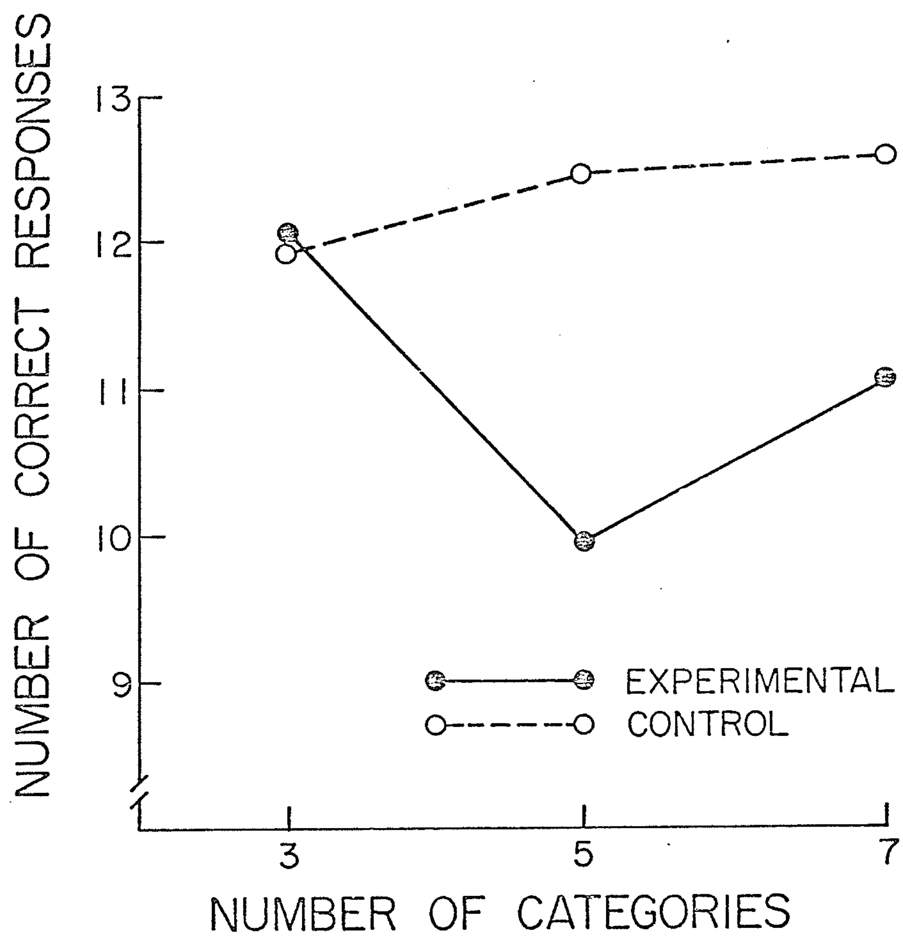

Figure 3. Mean number of correct responses during paired-associates learning as a function of number of categories in Experiment 1.

maximum attainable), recalled significantly fewer associates than its control group, C5. In this case the increased development of the intra-chunk linkages acted proactively as a source of associative interference and thus the incidence of negative transfer.

The predicted difference between Groups E7 and C7 although present, did not reach significance despite the fact that Group E7 had obtained the highest level of List 1 organization (ARC score = .85). In an attempt to account for this unexpected result, a retrospective analysis of the sorting data was made. This data indicated that although 13 out of the 16 subjects in Group E5 reached a sorting consistency of 100% only seven of the 16 subjects in Group E7 reached an identical level of sorting consistency. However, as an analysis of variance revealed no overall difference between these two groups, and Mandler (1967) found no decrement in the level of organization as a function of a reduced consistency of organization, the failure to find a significant amount of negative transfer in Group E7 remains inexplicable at this point.

The position in the learning curve where the associative interference made its impact was indicated by a significant groups by trials interaction, F (5, 450) = 4.85, $p < .01$, and is shown in Figure 4. Additional post hoc testing indicated that the groups did not differ on the initial trial of the transfer task. By Trials 2 and 3, however, associative interference was fully operative and caused the experimental groups to be at a significant disadvantage relative to the control groups. The equivalence of the experimental and control groups on Trial 1 must therefore be attributed to the facilitatory effects of item familiarization which were operative for the experimental, but not for the control, groups. Presumably, had a recognition task been used at this point

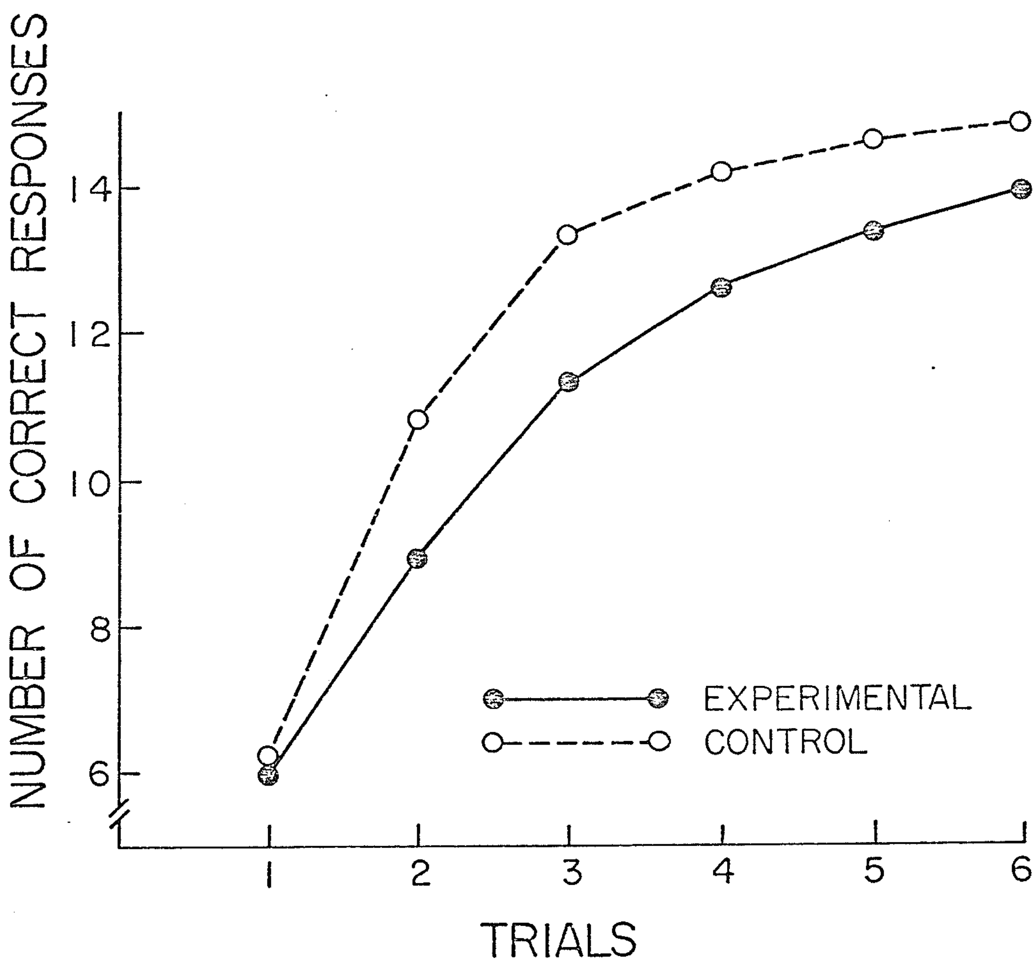

Figure 4. Mean number of correct responses during paired-associates learning as a function of trials in Experiment 1.

(which would have attenuated item-familiarization effects) associative interference would have been detected (Postman, 1971a). The experimental and control groups did not differ significantly on the remaining three trials as near asymptotic levels of performance were reached.

The consistency of the results to this point strongly supports Postman's (1971a) proposition that the higher order memory units of free recall learning and the prescribed pairings of associative learning are functionally similar or continuous. These results have also suggested that the magnitude of the associative interference is approximately proportional to the level of organization of these original subjective memory units. Such findings are consistent with those of Rogers and Battig (1972) who used a varying number of trials as the vehicle for manipulating prior organization and Barton (1973) who varied the number of conceptual categories in the pre-transfer phase.

The findings to this juncture are also consistent with both the organizational and associationistic accounts of free recall to paired-associate transfer effects and therefore further detailed analyses were carried out to assess which account possessed the greater analytic value.

Category pairings. The paired-associate response data were subjected to further analyses[1] to assess the transfer valences of inappropriate and appropriate intertask memory units and to validate the utility of these concepts. An inappropriate memory unit was a paired-associates complex composed of a stimulus term and a response term which originated in different subjective categories. This pairing was labelled a between-catgory pair (BCP). An appropriate memory unit was a pairing composed of stimulus and response terms which originated in the same subjective category and therefore was labelled as a within-category pair (WCP).

The compatibility and incidence of these pairings was determined from the disposition of all items on the final sorting trial of List 1 learning. As the actual incidence of such pairings could be expected to vary with the number of categories (e.g., more WCP for the three-category condition relative to the seven-category condition) each instance was converted into a proportion (the denominator being the maximum number of such pairings possible) and then entered into the analysis with an arcsine transformation. It should be noted that since a WCP versus BCP comparison was premised upon correlated data, whereas a WCP or BCP versus a control condition was based upon uncorrelated data, three separate analyses were required. However, to facilitate visual comparisons the results were combined and are depicted in Figure 5.

The analysis of variance of the within- versus the between-category pairings yielded a significant effect due to the type of pairing, F (1, 44) = 7.54, $p < .01$ but not to the number of categories or the interaction of the two variables. This finding merely indicated that the WCP were subjected to less interference than the BCP. To assess the valence of this apparent transfer two additional analyses were performed.

The comparison of the BCP with the performance of the control groups yielded an overall effect due to the type of pairing, F (1, 88) = 5.98, $p < .05$, and also a significant pairing by number of categories interaction, F (2, 88) = 4.24, $p < .05$. These results closely parallel the previous findings concerning paired-associates recall in that there was an absence of negative transfer for Group E3 relative to C3 and noticeable but nonsignificant negative transfer for Group E7 relative to its counterpart, C7. Given the high level of prior organization of Group E7, the negative transfer of the BCP should have been maximum in

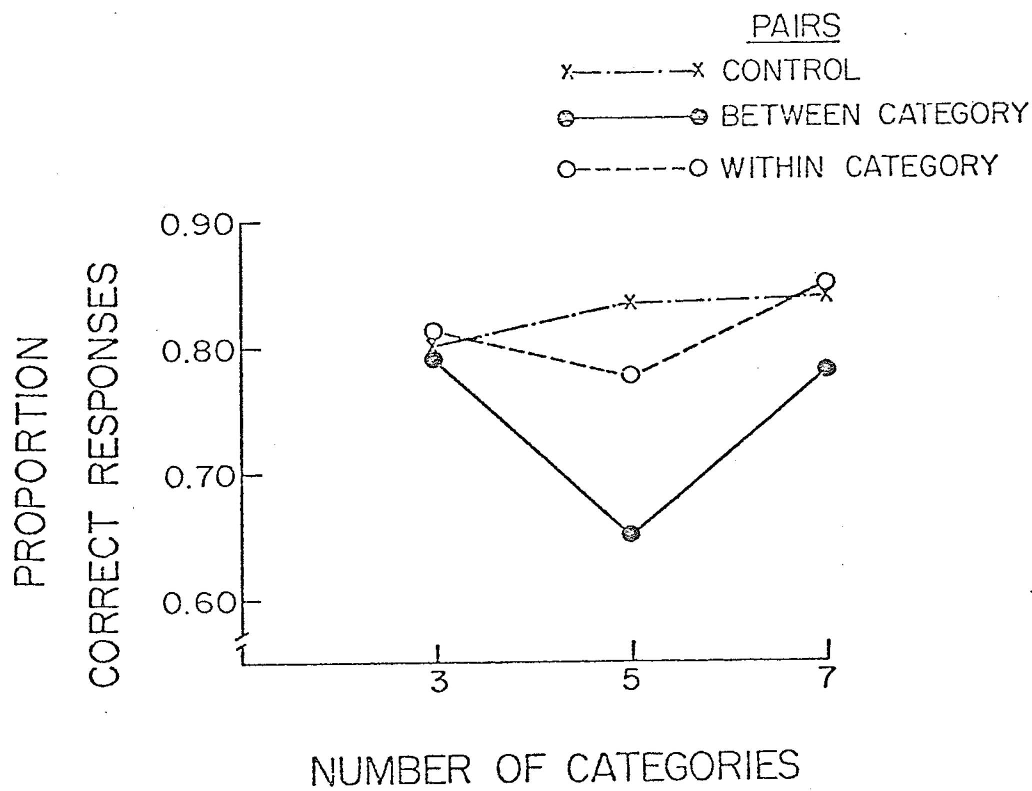

Figure 5. Proportion correct responses of control, within- and between-category pairings during paired-associates learning as a function of number of categories in Experiment 1.

this condition. Thus, the locus of negative transfer of the BCP was restricted to Group E5 relative to its control, C5.

This finding of negative transfer for the BCP is in close agreement with two free recall to paired-associates transfer studies by Barton (1973) and Barton and Young (1972). In the course of these two studies the authors systematically manipulated the number of conceptual categories which were present in the original list. From this list composed of either two, four, or 12 conceptual categories, a paired-associates list was derived. Negative transfer for the BCP was present for the four- and twelve-category condition but not for the two-category condition. Although it was interesting to note that negative transfer was maximum at the four-category condition, further speculation is unwarranted as Barton and Young neglected to provide the respective levels of organization at the completion of free recall learning.

The overall incidence of negative transfer for BCP is congruent with both organizational and associationistic predictions. The establishment of multiple interitem dependencies within each subjective memory unit during free recall learning was inappropriate with the restricted connections prescribed for the paired-associates task and thus the presence of negative transfer for the experimental group, E5 and to a lesser degree for E7.

A comparison of the WCP with the control condition failed to provide significant differences due to number of categories, $\underline{F}$ (2, 88) = .83, the type of pairing, $\underline{F}$ (1, 88) = .58 or their interaction, $\underline{F}$ (2, 88) = .57. The absence of any transfer effects at all for the within-category pairings raises some interesting issues for both the associationistic and organizational accounts.

The current associationistic version is provided by Postman (1971a). He suggested that there may be negative transfer in a free recall to paired-associates transfer task even in those instances which do not call for the disruption of previously organized memory units. That is, in certain cases, negative transfer may obtain for WCP as well as BCP. Using Postman's terminology and logic the argument proceeds as follows. During the free recall phase the subject has the opportunity to form a diversity of pathways or linkages among the items within a subjective or conceptual category. However, in the paired-associates phase of the experiment the network of interitem linkages previously formed becomes redundant as the subject must now learn a strictly segmented or prescribed pairing. In other words, the subject must now learn one association to the exclusion of all other within-category associations. Each stimulus in the paired-associates list may, due to prior exposure during the free recall phase, arouse diverse associates which interfere with the learning of the criterion associate. Thus, the negative transfer for WCP. To extend the logic further, as number of categories decrease, the items per category and therefore interitem linkages both increase and Postman would predict increasing negative transfer for WCP. The previously cited studies of Barton (1973) and Barton and Young (1972) were directed towards an evaluation of Postman's prediction. Based on both Trial 1 paired-associates responses and mean number correct responses, results indicated negative transfer of WCP for the two-category condition but not for the four- or twelve-category conditions. These results provide a measure of support for Postman's theorizing on the valence of WCP transfer.

The lack of negative transfer for the WCP found in the present investigation is not in agreement with the findings of Barton (1973) and Barton and Young (1972) nor does it provide any support for Postman's (1971a) multiple-pathway hypothesis.

According to organizational theory, the prescribed within-category pairings of the transfer task should have been appropriate with the previously formed subjective memory units. Since all items are bonded together equally in the sense that they are equally accessible and since the prescribed pairings are but one of the possible orderings of the subjective memory units, intertask compatibility should have been assured. Also, since the strength of the intrachunk relationships varied as a function the level of organization (i.e., the number of categories) then this appropriateness should have been especially valid for the seven-category condition where superior organization and fewer items per category prevailed. The appropriateness of these intertask memory units should have progressively decreased for the five- and three-category conditions. Current organizational theory would strongly favor the prediction that a stimulus and response pair from a well organized memory unit such as those found in the seven-category condition would be highly appropriate to the learning of the transfer task, and therefore a facilitory effect would obtain. However, there was a singular absence of positive transfer for the WCP.

These results, although inconsistent with current organizational theory, are not necessarily incompatible with it. It could be asserted, albeit in a post hoc fashion, that the memory units of free recall were not really compatible with the prescribed pairings of the transfer task. That is, the subjects, faced with a novel transfer task. did not capitalize on their previous organization and instead encoded the prescribed pairings in a new and unique manner. Therefore, the experimental groups performed at the same level as the control groups. Although this line of reasoning is the type of post hoc logic that Slamecka, Moore and Carey (1972) so strongly oppose, it does suggest a possible methodological variation in free recall to paired-associates transfer studies.

Extending the previous explanation, perhaps the subjects did not capitalize on the appropriate intertask memory units because they did not apprehend the possible benefits to be derived from maintaining these memory units. Therefore, sensitizing the subjects to the relationships between the first and second lists, through pertinent instructions, should enhance the recallability of the WCP in a manner analogous to part-to-whole free recall transfer (Novinski, 1972; Wood & Clark, 1969).

A study by Kearn (Note 1) which addresses itself to this issue (although it was not originated with this intent) was completed after the present investigation. In Kearn's study, subjects were advised that the items in the two phases of the experiment would be the same or different, contingent upon whether they were experimental or control subjects, respectively. Kearn employed the Mandler (1967) sort technique during the free recall phase to obtain four subjective categories with six items per category from each of his subjects. BCP and WCP were then obtained and presented to his subjects (in a between-subjects design) in the context of a paired-associates list. Consistent with previous research, the BCP led to significant negative transfer relative to the control condition. However, Kearn also found positive transfer for the WCP but only on the initial two paired-associates trials.

However, there is a methodological difficulty with the Kearn study and thus limitations to the inferences that can be drawn. As Kearn did not request recall of his subjects prior to the transfer task, it is unclear whether the obtained results are indicative of a particular level of organization or due to the subjects' awareness of the structure of the two lists. Further, why awareness of the relationship between the two lists should have led to a facilitory effect for the WCP, but not at the same time attenuated the negative transfer of the BCP, remains unresolved.

In an attempt to clarify these issues a factorial study by Stojak, Klein and McIntyre (Note 4) subsequently investigated the role of instructions and category pairings in a free recall to paired-associates transfer design. Subjects sorted 30 unrelated words into five subjective categories. Following four sorting trials and a previously unannounced free recall test the experimental subjects were exposed to the same words in the context of a paired-associates task. Standard controls for this type of a design were employed. Prior to transfer half of the experimental subjects and half of the control subjects were informed of the composition of the paired-associates list. Also, and in anticipation of a transfer set which could be operable and lead the experimental subjects to adopt a high criteria of responding (and thereby depress their performance), all subjects were enjoined to guess freely when in doubt of the correct response (cf., Slamecka, Moore & Carey, 1972).

The analysis of the number of correct responses during paired-associates learning showed an overall negative transfer effect for the experimental group, the ubiquitous groups by trials interaction, but no groups by information interaction. A finer analysis based upon the type of category pairing supported the present investigation as it indicated significant negative transfer for the BCP, and slight but nonsignificant negative transfer for the WCP relative to the control condition. However, the failure to detect a category pairing by information interaction suggested that the positive transfer of the WCP found in Kearn's (Note 1) study was probably a function of the level of prior organization--unspecified though it was!

In summary to this point, the analyses of BCP is consistent with both the organizational and associationistic theories. Negative transfer was present for these pairings and generally in proportion to the degree of organization of the subjective memory units. Conversely, the lack of transfer for the WCP does not offer support for the organizational position (which would favor a prediction of positive transfer) nor is it consistent with the multiple pathway interpretation of the associationistic position (which would favor a prediction of negative transfer). Further systematic research is obviously warranted in this area to specify those factors which govern transfer effects of the WCP.

Stimulus and response errors. The analysis of total overt errors broken into misplaced responses and stimulus intrusions was entirely consistent with the transfer data described thus far. Table 2 shows the incidence of both types of errors and also the total number of intralist errors. As the patterns of stimulus, response, and total errors are nearly identical, and in the interest of brevity, only the analysis of total errors will be reported. The main effect of groups, F (1, 90) = 15.88, $p < .01$, was a confirmation that the experimental treatment led to more errors than the control condition. Within the experimental group there was a nearly equal number of misplaced responses and stimulus intrusions, 12.44 and 12.07, respectively. Postman (1971a) considered the stimulus errors particularly diagnostic as they reflect the inability to differentiate between stimulus and response terms. The failure to differentiate the terms is a result of their prior occurrence as part of the same subjective memory

TABLE 2

Mean Number of Intralist Errors During

Paired-Associates Learning

Condition	NC	Misplaced Responses	Stimulus Errors	Total
Experimental	3	2.25	2.50	4.75
	5	5.44	5.88	11.32
	7	4.75	3.69	8.44
Control	3	1.75	1.06	2.81
	5	1.88	1.25	3.13
	7	0.81	0.69	1.50

unit. However, this lack of differentiation cannot be considered the essential factor in negative transfer. Postman (1971a), through the use of recognition tests, determined that associative interference was the overriding condition of the negative transfer. As was the case in the acquisition of the paired-associates list, Group E5 indicated the most detrimental effects due to the disruption of prior subjective memory units followed by Group E7 and finally Group E3. The standard deviations (SD) of the total number of errors provide further insight into the nature of transfer effects. For groups C3, C5, and C7 the SDs were 3.60, 3.40, and 2.25 whereas for groups E3, E5, and E7 the SDs were 3.91, 8.92, and 10.75, respectively. Thus the incompatibility of the free recall and paired-associates memory units manifests itself in both a reduction of associative performance and an increase in the variability of that responding.

In summary of Experiment 1, it appears that the integration of Mandler's (1967) concept of organization and his methodology into the free recall to paired-associates transfer design, was a viable strategy for studying fundamental transfer processes. The present design allowed for the juxtaposition of organizational and associationistic explanations of transfer phenomena and provided the means to define and clarify the concepts of inappropriate and appropriate memory units. An inappropriate memory unit was operationalized as a between-category pairing and was demonstrated to be the variable responsible for negative transfer. However, based on the present paradigm and findings, the term appropriate memory unit appears to be a misnomer and neutrality seems to be more descriptive of that aspect of transfer.

EXPERIMENT 2

The research strategies adopted in the first experiment were, for the most part, maintained in Experiment 2 which involved a free recall to serial learning transfer design. With the exception of a few differences due to the nature of the transfer task, the rationale, methodology, and data analyses paralleled those employed in Experiment 1.

Method

Experimental Design

The sorting of a list (List 1) of 30 unrelated words into a previously designated number of subjectively determined categories was followed by a free recall test and subsequently by the acquisition of a serial list (List 2) of 15 words randomly selected from List 1. Independent groups sorted List 1 into either three, five, or seven categories. Following the recall of List 1, the three experimental groups received six study-test trials on List 2, which was a fifteen-word subset of List 1. The three control groups also received six trials on the same List 2 words but for the control groups List 1 was a different, but equivalent set of words.

Therefore, the experimental design was a 2 x 3 x 6 factorial design with two independent factors (control and experimental groups; number of List 1 sorting categories) and one repeated factor (trials).

The major dependent variable was, according to the system suggested by Waugh (1963) the number of pairs of words correctly recalled in succession on each trial, regardless of their absolute serial position. A pair was considered to be correctly recalled if the response which came before it was the word which actually preceded it in the test list. For example, if the sequence ABCDE was presented and the subject responded DEABC, then the subject would have recalled three pairs, DE, AB, BC. Waugh indicated that this type of analysis was congruent with the measures typically employed in the assessment of serial learning. In addition, this dependent variable was essential to the determination of within- and between-category pairings.

Subjects

The subjects for this experiment were obtained from the introductory psychology courses at the University of Manitoba, summer session. Participation in the experiment was voluntary; however, subjects did receive a nominal course credit for their involvement. The subjects were female students between the ages of 18 and 25 and had English as their native language.

Of the 117 subjects tested, the data of 8 subjects in the experimental groups and 9 subjects in the control groups were discarded. The reasons for the exclusion of these data included: (a) sorting consistency of less than 90%; (b) failure to use the number of categories specified in the test booklet; (c) categorization based upon the physical rather than the semantic characteristics of the words; and (d) failure to recall the items in succession. Because of the constraints of a limited subject pool and time no additional subjects were tested. However, there were similar numbers of subjects in all cells for a total of 52 experimental subjects and 48 control subjects. A decision was made not to randomly discard subject data to obtain an equal number of cell entries. Rather it was decided to make use of all available data and complete the analyses based upon slightly unequal cell sizes.

Lists

The same two lists of words as described in Experiment 1 were used (see Table 1, Appendix A), but the lists were reversed in terms of their status as an experimental or control list. For the free recall phase of the experiment, a whole method of presentation was used (Bower, Clark, Lesgold, & Winzenz, 1969; Mueller & Overcast, 1975; Winograd, Conn, & Rand, 1971). The 30 words were arranged in six columns of five words each at the top of the sorting page. Below the words were the number of categories appropriate to that condition. Four random orderings of the words appeared on four sorting pages with each sorting page separated by a filler page.

To obtain the items for the serial list, the experimental list was arbitrarily subdivided into two 15 word lists. These sublists were equated as closely as possible on the same characteristics as the whole lists (i.e., frequency of usage, initial letters and word length) with the additional constraint that no two words within the same sublist started with the same letter (see Table 4, Appendix A). The 15 words within each sublist were then randomly assigned to serial position with the restriction that the initial letters of consecutive words were not alphabetically arranged. Four random orders of each list were prepared.

Procedure

The sorting and free recall phases of Experiment 2 entailed exactly the same procedure as detailed in Experiment 1. The reader is therefore referred to page 54 for the procedural details and to Appendix B for the exact instructions to the subjects.

The serial learning phase followed immediately after the free recall task and presentation of the instructions for the study-test method of serial learning (see Appendix B). Presentation for this phase of the experiment was via a Kodak Carousel Projector. A 5 sec "Ready" slide signalled the imminent start of the study phase and was followed by an individual presentation of each item of the serial list with each item in view for 2 sec. At the completion of the study phase, a "Recall" slide initiated the start of a 75 sec test phase. Six study-test cycles were given.

Each test page for the serial learning trials contained 15 blank lines arranged in a column in the centre of the page. The subjects attempted to provide in writing the serial order of the words as presented with the options of guessing or leaving the appropriate space blank.

Results and Discussion

The raw data from Experiment 2 are contained in Appendix C and the summaries of the various analyses of variance on this data are contained in Appendix D.

First-List Performance

The data from the free recall phase of this experiment were separately analyzed according to the following measures: (a) the consistency of organization between the third and fourth sorting trials; (b) the number of words recalled; and (c) the levels of organization present on the free recall protocols.

Consistency of organization. The mean percentage of sorting consistency for experimental and control groups are shown in Table 3. Analysis of variance of sorting consistency yielded no significant differences between groups, among conditions, nor due to the interaction of the two main factors. The overall average of sorting consistency was approximately 98%, which was marginally higher than that found in Experiment 1. The assumption that recall and levels of organization scores were based upon a stable and consistent sort appeared to be justified.

TABLE 3

Mean Percentages of Consistency Between the Third and Fourth Sorting Trials in Experiment 2

	Number of Categories		
Condition	3	5	7
Experimental	98.9	97.7	99.4
Control	97.9	98.1	97.6

Word recall. The mean List 1 word recall is shown in Figure 6. As anticipated, the only significant effect was due to the manipulation of subjective categories F (2, 94) = 30.70, $p < .01$. As depicted, and confirmed by a Tukey HSD test (Kirk, 1968) word recall was a positive linear function of the number of categories employed by the experimental and control subjects.

Levels of organization. As shown in Figure 7 the levels of organization as determined by the adjusted ratio of clustering score (Roenker, Thompson, & Brown, 1971) also increased as a function of the number of categories. As was the case in the analysis of word recall, the only

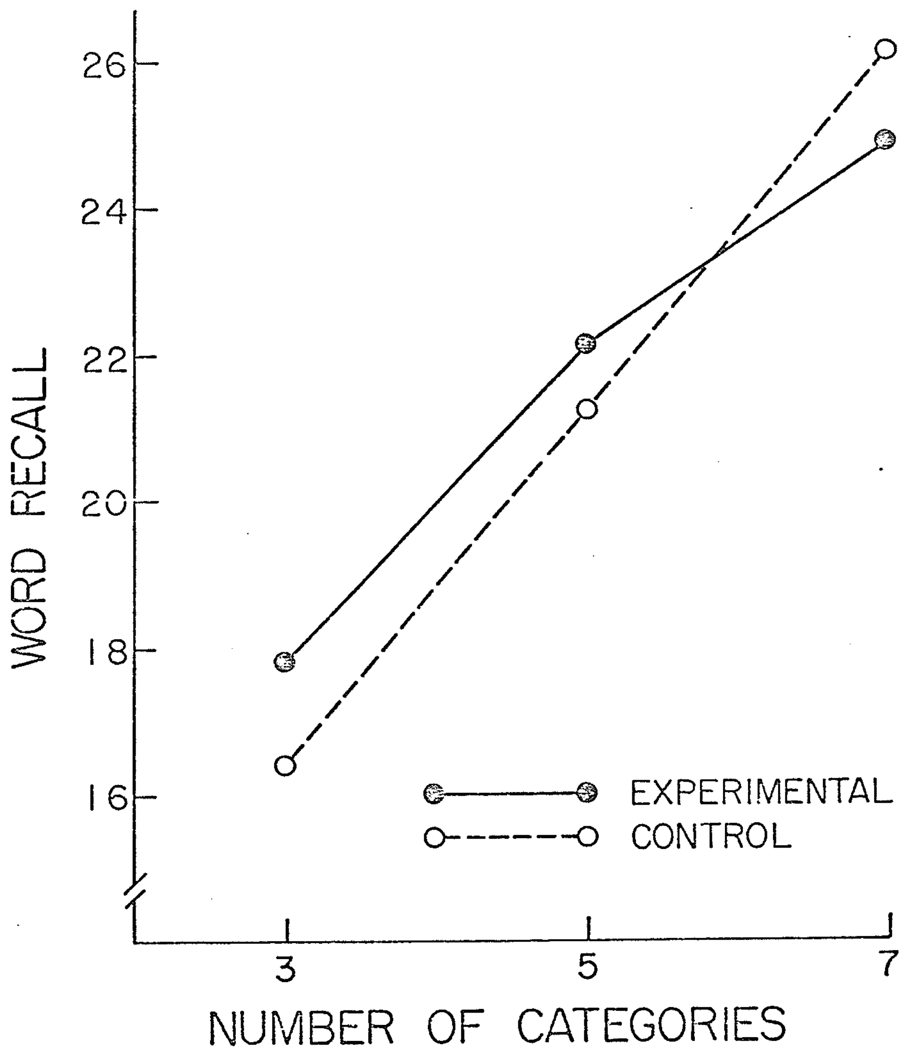

Figure 6. Mean word recall during List 1 as a function of number of categories in Experiment 2.

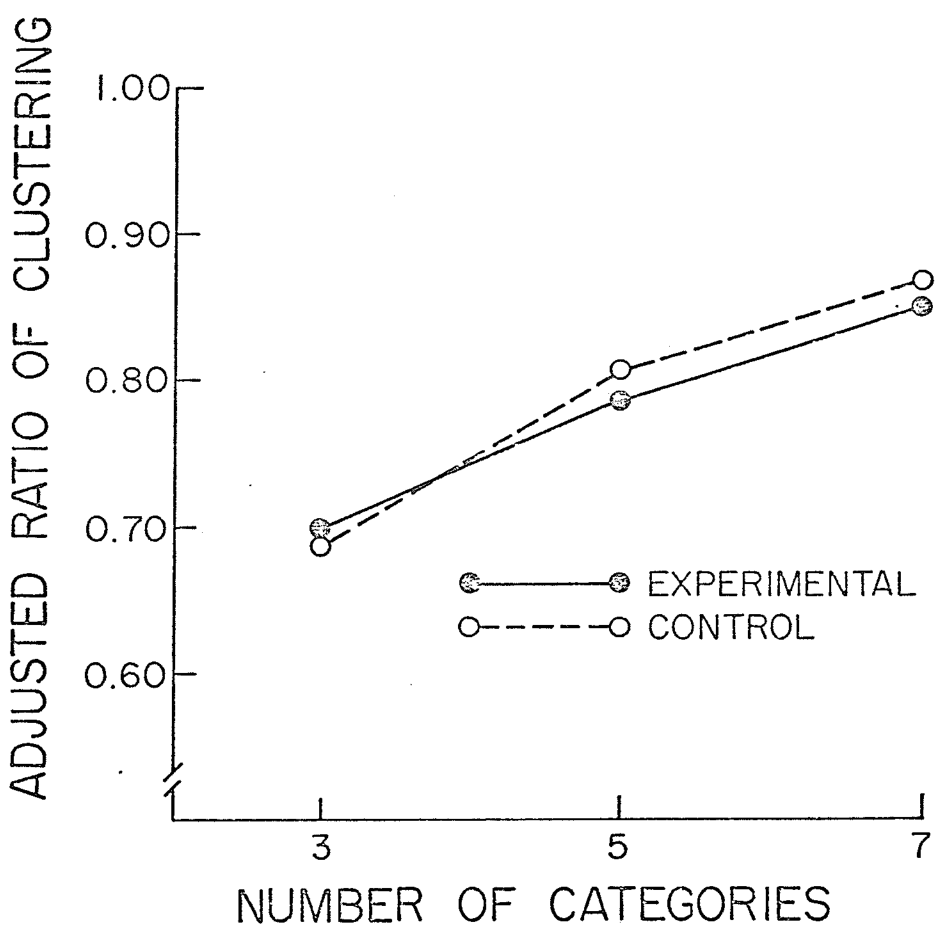

Figure 7. Mean adjusted ratio of clustering scores as a function of number of categories in Experiment 2.

significant factor proved to be the number of categories condition, F (2, 94) = 9.75, $p < .01$.

Thus, the Mandler (1967) sorting methodology has again proven its usefulness as a vehicle for systematically varying organizational levels across independent groups. In so doing, it has satisfied the first requirement of the present free recall to serial learning transfer study-differential levels of prior organization.

Second-List Learning

The following complementary measures were analyzed to provide information concerning the nature and locus of transfer processes in the context of a free recall to serial learning task: (a) the basic transfer data consisting of the mean number of adjacent pairs of words correctly recalled; and (b) the proportion correct of within- and between-category pairings derived from the previous measure of adjacent pairs of words.

Transfer. The nature of the transfer task led to a marked decrement in the performance of the experimental groups relative to their controls, as indexed by the number of adjacent pairs of words correctly recalled, F (1, 94) = 6.66, $p < .01$. The presence of negative transfer in this situation lends further support to Postman's (1971a) hypothesis which suggested a functional continuity of memory units across learning tasks. That is, if the higher order memory units formed during subjective categorization were unique and dissimilar from the memory units developed during the seriation task, then negative transfer would not have occurred. However, as negative transfer did obtain, it follows that there is a functional similarity to these memory units which is trans-situational.

The origin, locus, and development of this negative transfer was clearly demonstrated by a significant three way groups by number of categories by trials interaction, $\underline{F}$ (10, 470) = 2.34, $\underline{p} < .01$. These results, portrayed in Figure 8, illustrate that there was weak evidence of negative transfer for Group E3 relative to its control, C3; an increasing but nonsignificant amount of negative transfer for Group E5 relative to C5; and clear evidence of negative transfer for Group E7 relative to its control, C7. A post hoc analysis (Tukey HSD, Kirk, 1968) indicated that the interference was manifested on the last three serial learning trials of the seven-category condition.

Thus far, the results are straightforward and may be interpreted in the following, general way, without special emphasis at this point on an organizational or associationistic explanation. During the learning of List 1, subjective memory units were formed with several distinct levels of organization. Forcing the experimental subjects to then reorganize or modify these memory units proved to be an interference task and led to an overall decrement in their List 2 performance relative to the control subjects. The magnitude of the decrement in serial recall was directly proportional to the degree of prior organization of the items but this effect was not manifested on the initial serial learning trials. Presumably, during the initial serial learning, familiarization with the items allowed the experimental subjects to equal the performance of the control subjects. However, this item familiarization effect was of short duration and by the latter trials, especially for group E7, interference overwhelmed any facilitory effects.

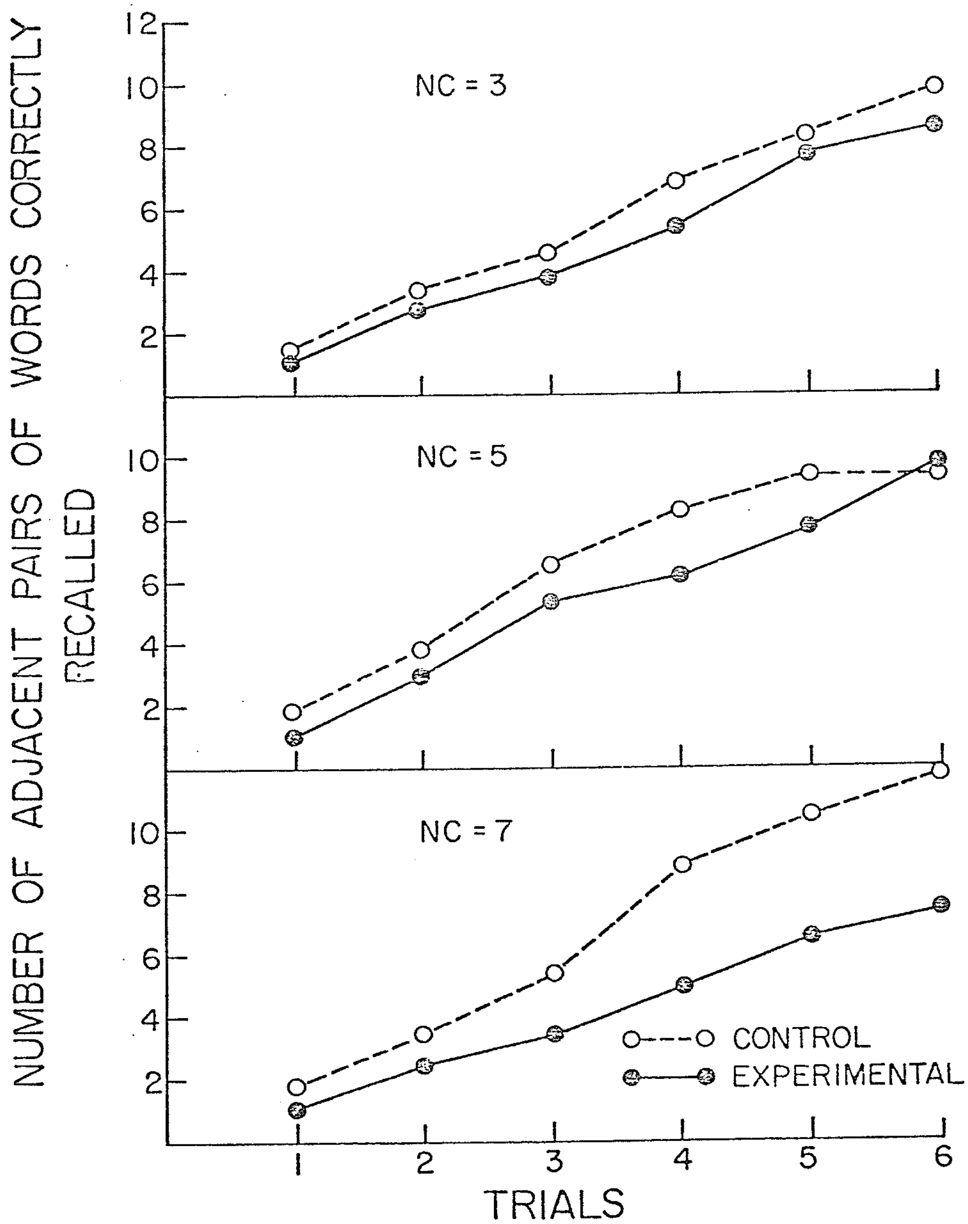

Figure 8. Mean numbers of adjacent pairs of words correctly recalled as a function of number of categories and trials during serial learning in Experiment 2.

These results can be examined in a more detailed fashion from the perspectives of the associationistic and organizational theories. The associationistic interpretation of this data poses a problem since there appears to be an absence of an enlightened, comprehensive account of associative serial learning (Bewley, 1972; Kintsch, 1977). This state of affairs will obviously prove to be critical when attempting to account for the transfer valences of within- and between-category pairings. In fact, the lack of an acceptable version of associative, serial learning accounted for the absence of specific predictions in the present investigation regarding category pairings.

Nevertheless, it is possible, by generalizing from Postman's (1971a) multiple-pathway analysis, to describe the transfer data in associationistic terminology. To illustrate, during free recall learning, the formation of higher order memory units may be characterized as the development of numerous pathways or connections among the component items. The level of organization in these higher order memory units (viz., subjective categories) should reflect the associative strength of the multiple, interitem connections. Therefore, the associative strength among the items in the seven-category condition should be greater than the interitem associative strength in the three-category condition. The learning of an exclusive or prescribed sequence in the transfer task requires the disruption of previously formed connections and eventuates in negative transfer. The level of the resultant negative transfer is, of course, proportional to the level of prior organization of the higher order memory units and thus the presence of negative transfer for the seven-category condition but not the three-category condition.

However, there are studies which suggest that subjects encode a serial list using other than interitem or item-to-serial position associations (e.g., Battig & Young, 1968; Johnson, 1972; Lesgold & Bower, 1970; Martin, 1974; Martin & Noreen, 1974; Posnansky, Battig, & Voss, 1972) and offer, as an alternative explanation, an organizational account.

As an example, Martin and Noreen (1974) worked within an organizational model and portrayed serial learning as (a) the analysis of a sequence of items into subsequences or chunks, (b) the learning of the specific items within a subsequence, and finally, (c) the learning of the prescribed seriation of the items. With the exception of the additional requirement to encode order information serial learning is in essence highly similar to free recall learning. Within this framework, the present investigation could be viewed as a whole-to-part transfer design and the resultant negative transfer a function of, and in proportion to, the prior organization. That is, the higher order memory units formed during the free recall phase are now inappropriate to the serial learning phase and the experimental subjects are unwilling or unable to abandon their initial organizational schemes. In persisting with their original, inappropriate memory units they perform at a disadvantage compared to the control subjects.

The findings to this point of negative transfer proportional to the level of prior organization are consistent with both an organizational model and, with some extrapolation, are also consistent with an associationistic theory. However, by employing a more detailed analysis of category pairings an attempt was made to determine the domain of applicability of the respective theories.

Category pairings. To assess the locus of the overall negative transfer and to ascertain the utility of the concepts inappropriate and appropriate memory unit further analyses were made on derivatives of the basic, adjacent-pair recall. Each adjacent pair correctly recalled was classified as an inappropriate memory unit (i.e., a between-category pairing, BCP) or as an appropriate memory unit (i.e., a within-category pairing, WCP). This classification was based upon the disposition of all items at the completion of the fourth sorting trial.[1] As the incidence of these pairings was unequal across categories (e.g., there was a greater probability of obtaining a WCP from the three-category condition than from the seven-category condition) all data were converted into proportion of pairings recalled and then analyzed with the use of an arcsine transformation.

As was the case in Experiment 1, the BCP versus the WCP comparison was based upon correlated data whereas the WCP or BCP versus control comparison was premised upon uncorrelated data. This situation necessitated the use of three separate analyses. However, for easy visual reference the data were integrated and are shown in Figure 9.

The analysis of variance of the within- versus the between-category pairings produced no significant effects due to pairings, F (1, 45) = 2.70, number of categories, F (2, 45) = 1.28, nor to their interaction, F (2, 45) = .89, with all p values greater than the .05 level. The absence of significant differences indicated that both types of pairings produced equal recallability and a similar level of compatibility across the two learning tasks. To assess the presence of transfer

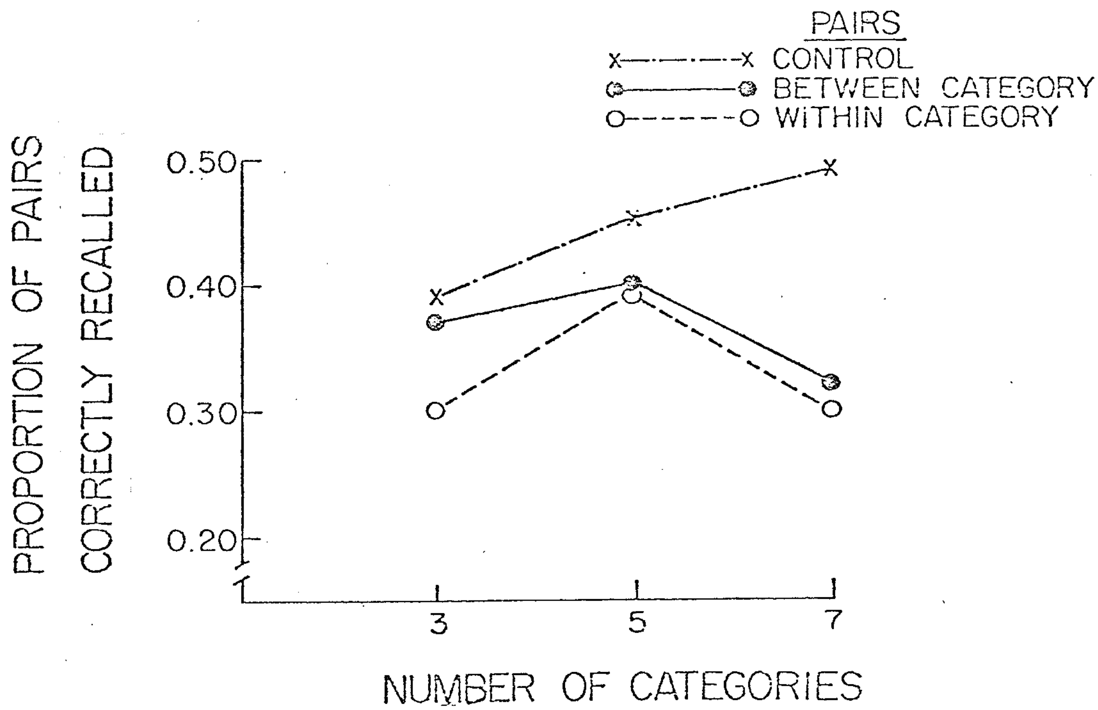

Figure 9. Proportion of correct responses of control, within- and between-category pairings during serial learning as a function of number of categories in Experiment 2.

and its valence, two additional analyses were performed.

The comparison of the BCP with the control condition produced a significant pairing by number of categories interaction, F (2, 82) = 3.19, $p < .01$. As shown in Figure 9 and corroborated by a Tukey post hoc analysis (Kirk, 1968), transfer was negligible in the three category condition, marginal but still nonsignificant in the five-category condition; however, pronounced and statistically significant in the seven-category condition.

This pattern of results was entirely consistent with the hypothesis that the negative transfer due to inappropriate memory units was a function of the level of organization of the material prior to transfer. That is, the disruption of well established, interitem connections to learn a prescribed sequence led to more negative transfer than the disruption of poorly developed, interitem connections. These results are also congruent with both the organizational and associationistic accounts of transfer phenomena.

The comparison of the WCP with the control condition yielded only a significant effect due to the type of pairing, F (1, 82) = 3.98, $p < .05$. The presence of negative transfer for the appropriate memory units is, of course, anathema to the proponents of an organizational model. The maintenance across tasks of a subset of a subjective category should have led to positive transfer and certainly not to the overall incidence of negative transfer. In fact, the negative transfer for the WCP was maximum at the seven-category condition where according to organizational theory positive transfer should have existed and been maximum.

The pattern of negative transfer for the WCP is not inconsistent with the associationistic version as advanced by Postman (1971a) and as elaborated upon in Experiment 1. Based upon the premise that a preceding item is a functional stimulus for each successive item in the series, the presentation of that stimulus would activate multiple, prior associations which were formed during the course of free recall learning. However, these previous associations are now superfluous in the sense that the subject must now learn one prescribed sequence to the exclusion of all others. The competition between the criterion sequence and the previous associations was manifested in negative transfer.

To develop this line of reasoning a bit further, Postman also suggested that the amount of negative transfer would be a function of the number of prior assocations. Therefore, maximum negative transfer should have occurred in the three-category condition and progressively decreased to the seven-category condition. No such interaction was found in the present investigation.

In summary of Experiment 2, further evidence was garnered in support of Postman's (1971a) thesis on the functional continuity of memory units across learning tasks. The presence of negative transfer in the context of a free recall to serial learning transfer design was strongly suggestive of such continuity. It was further demonstrated that the degree of negative transfer was a direct function of the level of prior organization of the subjective memory units. Such findings are consistent with those of Shapiro (1971) and Wood (1969a).

Inappropriate memory units were operationalized as between-category pairings and found to be partially responsible for the overall negative transfer--a finding consistent with both organizational and associationistic interpretations.

However, the finding of negative transfer for the appropriate memory units (i.e., within-category pairings) was clearly non-supportive of the organizational model but generally in keeping with the associationistic approach to transfer phenomena.

GENERAL DISCUSSION

The focal question in this research was whether interitem relationships which develop during the establishment of subjective memory units are functionally similar to the interitem connections formed during the course of prescribed associative and sequential learning. The logic to resolve this question demands that if the interitem relationships of subjective memory units and the products of controlled associative learning are characterized by dissimilar, non-overlapping properties then interference, in the context of transfer tasks, would not occur. However, the consistency of the findings in Experiments 1 and 2, that such subjective memory units did act as a source of proactive interference during the learning of subsequent associative and sequential tasks, is highly suggestive of an affirmative answer and provides additional support for Postman's (1971a) thesis on the continuity of intertask memory units.

The locus and actual mechanism responsible for the presence of negative transfer may be dealt with in the context of another, ancillary question that has guided this research. That question is: which theoretical formulation -- associationistic or organizational -- can best accommodate the obtained transfer data?

The associationistic position, clearly expounded by Postman (1971a), may be described as the multiple pathway hypothesis. During free recall learning the formation of subjective groupings entails the development of diverse interitem pathways or associations. Repeated exposure to the items induces an elaboration and strengthening of the connections among the component items. Presentation of one of these items as a stimulus term would therefore activate numerous associated responses from within the network of multiple, interitem pathways. In other words, these subjective memory units are identified by the development of interitem dependencies. In the context of the transfer tasks, however, the random pairings or arbitrary sequences lack congruency with the prior associative network of interitem dependencies. New, pair-wise and sequential dependencies must be established during transfer learning thereby forcing the disruption or modification of the original subjective groupings. Consequently, interference occurs, as manifested by the presence of negative transfer. The magnitude of this negative transfer is related to the level of prior learning. That is, as the associative strength of the item connections increases, more unlearning is required which interacts with the increased competition from inappropriate associations and thus the increase in negative transfer.

The organizational explanation of negative transfer, as derived from the work of Mandler (1967) and Tulving (1966), may be described as the organizational persistence hypothesis. During prior learning, component items are subjectively organized into higher order memory units or chunks. These chunks are subsequently organized into higher order cohesive units which are hierarchically arranged. Free recall learning is thus viewed as the gradual formation of potent intrachunk dependencies among the component items overlaid with an organizational plan or schema for the later, efficient retrieval of the requisite items. The difficulty is that subjects persist in maintaining their prior, now incompatible organizational schemas when confronted with the requirements of the associative or sequential transfer tasks. Strong intrachunk linkages must be abandoned to facilitate the learning of the transfer tasks but it is this inability or unwillingness to discard inappropriate organization which leads to the development of negative transfer. Of course, the greater the level of the original , now inappropriate, organization, the greater the magnitude of the negative transfer.

Thus both theoretical formulations provide viable explanations of the basic transfer data. Both theories have been developed to the level of sophistication that they can account not only for the overall incidence of negative transfer but also for the finding that the magnitude of negative transfer was a function of the level of prior organization. On the basis of the data presented to this point it is impossible to discriminate between the analytic powers of the respective theories as both theories can accommodate the available data. That the memorial presentation of subjective groupings, prescribed pair-wise associations and sequential dependencies are functionally similar is highly likely given the results of this research. Whether these relationships can best be understood in terms of organizational or associationistic concepts defies resolution at this point. However, an examination of each theory's facility in accounting for the transfer data related to appropriate and inappropriate intertask memory units may make such a resolution possible.

The integration of the Mandler (1967) sort technique into the standard free recall to paired-associates or serial learning transfer paradigms fulfilled two critical requirements. First, it allowed for the differential levels of first-list organization prior to transfer; and second, it made possible, on an a priori basis, the operationalization of the terms inappropriate and appropriate memory units as between- and within-category pairings, respectively.

The analysis of between-category pairings provided no additional information as to the relative merits of the associationistic and organizational explanations as the respective experimental predictions were identical and congruent with the obtained data. The results of Experiments 1 and 2 did indicate that the between-category pairings resulted in a performance decrement for the experimental as compared with the control groups. The magnitude of this negative transfer was generally proportional to the level of original organization in Experiment 1 and directly related in Experiment 2. Although masked by item familiarization effects on the initial transfer trials substantial interference was apparent on the latter transfer trials. The negative transfer was presumably caused by the necessity of adopting prescribed pair-wise and sequential dependencies which were incompatible with the interitem dependencies intrinsic to the subjective groupings.

It was originally predicted that the results of the within-category pairings would provide useful information concerning the analtyic power of the contending theoretical positions. The transfer results -- specifically the lack of any transfer in Experiment 1, and the presence of negative transfer in Experiment 2 -- is not compatible with contemporary organizational theory. According to this formulation the within-category pairings should not involve a disruption of established intrachunk connections, nor should these pairings require the formation of new pair-wise or sequential dependencies, but merely the maintenance of existing and appropriate memory units. Thus, it appears that use of the term appropriate memory units, as advocated by the organizational formulation, is unwarranted in light of these findings. When subjected to an a priori specification of the appropriateness of the memory units the predicted positive transfer relationship does not occur and the continued use of this term must be questioned.

On the other hand, the associationistic account of the transfer valences of within-category pairings fares only slightly better. The development of negative transfer for these pairings in the seriation task of Experiment 2 is consistent with this formulation as extrapolated from Postman's (1971a) multiple-pathway model. The lack of negative transfer for the pairings in the associative task of Experiment 1 is inconsistent with the theory as suggested by the following analysis.

The development of first-list subjective groupings and the resultant associative network was elaborated upon earlier. In the context of the transfer tasks, however, this network becomes redundant as the new task requirements involve the learning of prescribed pairings of items or a circumscribed sequential arrangement to the exclusion of the remainder of the original associative network. But the presentation of one item as a stimulus in a paired-associate task or as the functional stimulus in a serial learning task elicits numerous, now irrelevant associations which compete with the learning of the criterion association. Thus the presence of negative transfer in Experiment 2.

There is a refinement of the multiple-pathway hypothesis which suggests that the level of interference would be a function of the number of interitem associations formed during original learning. With more interitem associations developed in the three-category conditions and fewer in the seven-category condition negative transfer should have been a decreasing function of the number of categories. This interaction failed to develop.

In general, both theoretical formulations provide adequate accounts of the negative transfer found for between-category pairings, thus suggesting that there is a certain usefulness in maintaining the term inappropriate memory unit as an explanatory device in transfer phenomena. The associationistic position is more consistent with respect to the observed negative transfer for within-category pairings. However, the continued use by the organizational advocates of the term appropriate memory unit may be unjustified until further empirical support is available. At this juncture recognition should be given to the possibility of alternative explanations to account for the profile of results found in the present investigation. As well as a consideration of alternative theoretical explanations, it must also be acknowledged that limitations in the experimental design of the present investigation could be responsible for the pattern of results and therefore effect the inferences to be legitimately drawn. For example, a more rigorous test of the associationistic versus the organizational predictions of the transfer valence of within-category pairings should involve the factorial manipulation of both the number of interitem connections (i.e., list length) and the level of organization (i.e., the number of categories). In this manner, an assessment could be made of the relative transfer effects of the number of interitem pathways as contrasted with the levels of prior organization. As this feature was not incorporated into the present investigation such an assessment was not possible and thus the inability to unequivocally state that the obtained results were a function of the number of interitem connections, or the level of organization or their interaction. However, research to partial out the relative contributions of these variables is currently in progress.

An additional methodological variation in the present investigation may have inadvertently obscured the transfer valence of the category pairings. This design feature, which differs from the typical methodology employed to study this transfer phenomenon, was the administration of the category pairings as a within-subjects variable. That is, all subjects were exposed to both the within- and the between-category pairings as components of a single transfer list. In contrast, other studies (e.g., Barton, 1973; Barton & Young, 1972; Kearn, Note 1) have presented each pairing type to an independent group of subjects. Such a manipulation would allow for the adoption of a consistent and efficacious learning strategy whereas in the present research such consistency would have been counterproductive. That is, to optimize their performance subjects had to adopt dual strategies by discriminating between the within-category pairings and the between-category pairings. In the former situation the subjects' optimal strategy would be to capitalize on prior organization while in the latter case their best strategy would be to discard previous organization and develop new encodings for the transfer items. However, as the overall frequency of between-category pairs was greater than that of the within-category pairs, a response set (Postman & Stark, 1969) may have developed and led the subjects to encode all pairings as between-category pairs and thus the absence of positive transfer for the within-category pairs. Research incorporating a between-subjects manipulation of category pairings and post-transfer subjects' reports is also underway in an attempt to resolve this issue.

With regards to Experiment 2 the specification of the category pairings may also have eventuated a mixed list type of design and thereby obscured a valid assessment of the transfer valence of the category pairings. The use of adjacent pairs of words recalled as the basic transfer measure may have resulted in situations where the same item could be a response term of a within-category pairing and also the stimulus term of a between-category pairing. In this manner the serial list could be construed as being composed of a series of re-pairing tasks and thus the negative transfer for both types of pairings. Given this inherent limitation to the use of the serial learning task future research should utilize the paired-associate design-- preferably in conjunction with an unmixed list design-- as the more appropriate vehicle to assess transfer phenomena.

Given the original predictions, the pattern of results suggesting only a marginal superiority of the explanatory power of the associationistic interpretation over the organizational account and the design limitations in the present research, it would be premature, if not presumptious, to extol the explanatory virtues of either account. Rather, both theoretical positions appear to be equally sufficient, or if you will, equally limited in their accounts of the present transfer data. Perhaps, as suggested by Postman, a rapproachment between the respective proponents is warranted and will result in a hybrid model of major theoretical import.

Reference Notes

1. Kearn, D.L. The role of interitem dependencies in higher order memory units in free recall learning. Unpublished master's thesis. University of Manitoba, 1975.

2. Stojak, R.A. The organization of "chunks" in free recall. Unpublished master's thesis. University of Manitoba, 1971.

3. Fullerton, T., McIntyre, J.S., & Stojak, R.A. Whole-part transfer as a function of first list organization. Paper presented at the annual meeting of the Canadian Psychological Association, June 1973.

4. Stojak, R.A., Klein, L.S., & McIntyre, J.S. Effects of instructions and category pairings in a free recall to paired-associates transfer task. Paper presented at the annual meeting of the Canadian Psychological Association, Toronto, June 1976.

REFERENCES

Adams, J. *Human memory.* New York: McGraw-Hill, 1967.

Adams, J., & McIntryre, J.S. Natural language mediation and all-or-none learning. *Canadian Journal of Psychology,* 1967, *21.*, 436-439.

Allen, M., Puff, C.R., & Weist, R. Effects of associative and coding processes on organization in free recall. *Journal of Verbal Learning and Verbal Behavior,* 1968, *7,* 531-538.

Anderson, J.R., & Bower, G.H. Recognition and retrieval processes in free recall. *Psychological Review,* 1972, *79,* 97-123.

Anderson, J.R., & Bower, G.H. *Human associative memory.* Washington: Winston & Sons, 1973.

Atkinson, R.F., & Shiffrin, R.M. The control of short term memory. *Scientific American,* 1971, *225,* 82-91.

Barton, A.K. An empirical analysis of free recall to paired-associate transfer. *Journal of Experimental Psychology,* 1973, *97,* 79-88.

Barton, A.K., & Young, R.K. Transfer from free recall to paired-associate learning. *Journal of Experimental Psychology,* 1972, *95,* 240-241.

Basden, D.R., & Higgins, J. Memory and organization: Category recall and retrieval capacity. *Journal of Verbal Learning and Verbal Behavior,* 1972, *11,* 157-163.

Battig, W.F. Evidence for coding processes in "rote" paired-associates learning. *Journal of Verbal Learning and Verbal Behavior,* 1966, *5,* 177-181.

Battig, W.F. Paired-associate learning. In T.R. Dixon & D.L. Horton (Eds.), *Verbal behavior and general behavior theory.* Englewood Cliffs, N.J.: Prentice-Hall, 1968.

Battig, W.F., Brown, S.C., & Schild, M.E. Serial position and sequential associations in serial learning. *Journal of Experimental Psychology,* 1964, *67,* 449-457.

Battig, W.F., Merikle, P.M., & Schild, M.E. Anagram free-recall and recognition learning, and paired-associate transfer. *Journal of Verbal Learning and Verbal Behavior,* 1965 , *4,* 44-52

Beach, N.F. The effects of familiarization training on the learning of paired adjectives. *Journal of Verbal Learning and Verbal Behavior,* 1968, *7,* 479-485.

Bewley, W.L. The functional stimulus in serial learning. In R.F. Thompson & J.F. Voss (Eds.), *Topics in learning and performance.* New York: Academic Press, 1972.

Birnbaum, I. Free recall learning as a function of prior list organization. *Journal of Verbal Learning and Verbal Behavior,* 1968, *7,* 1037-1042.

Birnbaum, I. Supplementary reports: Prior list organization in part-whole free recall learning. *Journal of Verbal Learning and Verbal Behavior,* 1969, *8,* 836-841.

Boring, E.G. *A history of experimental psychology.* New York: Appleton-Century-Crofts, 1950.

Bousfield, W.A. The occurrence of clustering in the recall of randomly arranged associates. *Journal of General Psychology,* 1953, *49,* 229-240.

Bousfield, A., & Bousfield, W. Measurement of clustering and of sequential constancies in repeated free recall. *Psychological Reports,* 1966, *19*, 935-942

Bower, G.H. A multi-component theory of the memory trace. In K.W. Spence & J.T. Spence (Eds.), *The psychology of learning and motivation: Advances in research and theory. Vol. 1.* New York: Academic Press, 1967.

Bower, G.H. Imagery as a relational organizer in associative learning. *Journal of Verbal Learning and Verbal Behavior,* 1970, *9,* 529-533.(a)

Bower, G.H. Organizational factors in memory. *Cognitive Psychology,* 1970, *1,* 18-46.(b)

Bower, G. A selective view of organizational factors in memory. In E. Tulving & W. Donaldson (Eds.), *Organization of memory,* New York: Academic Press, 1972. (a)

Bower, G.H. Mental imagery and associative learning. In L.W. Gregg (Ed.), *Cognition in learning and memory.* New York: John Wiley & Sons, 1972. (b)

Bower, G.H. Stimulus-sampling theory of encoding variability. In A.W. Melton & E. Martin (Eds.), *Coding processes in human memory.* Washington: Winston & Sons, 1972. (c)

Bower, G.H., & Lesgold, A. Organization as a determinant of part-to-whole transfer in free recall. *Journal of Verbal Learning and Verbal Behavior,* 1969, *8,* 501-506.

Bower, G.H., Clark, M., Lesgold, A., & Winzenz, D. Hierarchical retrieval schemes in recall of categorized word lists. *Journal of Verbal Learning and Verbal Behavior,* 1969, *8,* 323-343.

Brown, J. *Recall and recognition.* New York: John Wiley & Sons, 1976.

Burke, F.J., & Battig, W.F. Facilitation of paired-associate learning by associative ratings. *Journal of Verbal Learning and Verbal Behavior,* 1968 , *7,* 695-699.

Buschke, H. Learning is organized by chunking. *Journal of Verbal Learning and Verbal Behavior,* 1976, *15,* 313-324.

Carey, S.T., & Okada, R. Part-list recall following part-whole learning. *Memory and Recognition,* 1973, *1,* 172-176.

Cieutat, V.J. Group paired-associate learning: A safeguard against E-bias. *Journal of Verbal Learning and Verbal Behavior,* 1967, *6,* 105-106.

Cofer, C.N. On some factors in the organizational characteristics of free recall. *American Psychologist,* 1965, *20,* 261-272.

Cofer, C.N. Properties of verbal materials and verbal learning. In J.W. Kling & L.A. Riggs (Eds.), *Woodworth & Schlosberg's exerpimental psychology.* New York: Rinehart & Winston, 1971.

Deese, J. Influence of interitem associative strength upon immediate free recall. *Psychological Reports,* 1959, *5,* 305-312.

Deese, J. Frequency of usage and number of words in free recall: The role of association. *Psychological Reports,* 1960, *7,* 337-344.

Deese, J. From the isolated verbal unit to connected discourse. In C.N. Cofer (Ed.), *Verbal learning and verbal behavior,* New York: McGraw-Hill, 1961.

Deese, J. On the structure of associative meaning. *Psychological Review,* 1962, *69,* 161-175.

Delprato, D.J., & Hudson, R.L. Association by contiguity--clustering in free recall. *Psychonomic Science,* 1971, *22,* 89-99.

DeRosa, D.V., Doane, D.S., & Russell, B. The influence of first-list organization upon second-list free recall learning. *Journal of Verbal Learning and Verbal Behavior*, 1970, *9*, 269-273.

Earhard, M. Storage and retrieval of words encoded in memory. *Journal of Experimental Psychology*, 1969, *80*, 412-418.

Elmes, D.G., Roediger, H.L., III, Wilkinson, W.C., & Greener, W.I. III. Positive and negative part/whole transfer in free recall. *Journal of Verbal Learning and Verbal Behavior*, 1972, *11*, 251-256.

Estes, W.K. An associative basis for coding and organization in memory. In A.W. Melton & E. Martin (Eds.), *Coding processes in human memory*. Washington: Winston & Sons, 1972.

Fisher, D.F. Effects of delay interval on word recall and clustering. *Journal of Psychology*, 1971, *71*, 67-77.

Foote, R.A., & Pollio, H.R. Role of associative organization in free recall under five different presentation conditions. *Psychonomic Science*, 1970, *20*, 205-207.

Frankel, F., & Cole, M. Measures of category clustering in free recall. *Psychological Bulletin*, 1971, *76*, 39-44.

Friendly, M.L. In search of the M-gram: The structure of organization in free recall. *Cognitive Psychology*, 1977, *9*, 188-249.

Garner, W.R. *Uncertainty and structure as psychological concepts*. New York: Wiley, 1962.

Gibson, E.J. A systematic application of the concepts of generalization and differentiation to verbal learning. *Psychological Review*, 1940, *47*, 196-229.

Glanzer, M. Storage mechanisms in recall. In G. Bower (Ed.), *The psychology of learning and motivation. Vol. 5.* New York: Academic Press, 1972.

Gorfein, D., Blair, C., & Rowland, C. The generality of free recall: Subjective organization as an ability factor. *Psychonomic Science,* 1968, *11,* 279-280.

Hasher, L. The retention of free recall learning--whole-part problem. *Journal of Experimental Psychology,* 1970, *90,* 8-17.

Herrnstein, R.J., & Boring, E.G. *A sourcebook in the history of psychology.* Cambridge: Harvard University Press, 1966.

Hovland, C.I., & Kurtz, K.N. Experimental studies in rote learning theory: X. Pre-learning syllable familiarization and the length-difficulty relationship. *Journal of Experimental Psychology,* 1952, *44,* 31-39.

Hull, C.L., Hovland, C.I., Ross, R.T., Hall, M., Perkins, D.T., & Fitch, F.B. *Mathematicodeductive theory of rote learning: A study in scientific methodology.* New Haven: Yale University Press, 1940.

Jenkins, J.J., Mink, W.D., & Russell, W.A. Associative clustering as a function of verbal association strength. *Psychological Report,* 1958, *4,* 127-136.

Jenkins, J.J., & Russell, W.A. Associative clustering during recall. *Journal of Abnormal and Social Psychology,* 1952, *47,* 818-821

Johnson, M.K. Organizational units in free recall as a source of transfer. *Journal of Experimental Psychology,* 1972 , *94,* 300-307.

Johnson, N.F. Sequential verbal behavior. In T. Dixon & D. Horton (Eds.), *Verbal behavior and general behavior theory.* Englewood

Cliffs, N.J.: Prentice-Hall, 1968.

Johnson, N.F. Organization and the concept of a memory code. In A.W. Melton & E. Martin (Eds.), *Coding processes in human memory.* Washington: Winston & Sons, 1972.

Katona, G. *Organizing and memorizing.* New York: Columbia University Press, 1940.

Kent, G.H., & Rosanoff, A.J. A study of association in insanity. *American Journal of Insanity,* 1910, *67,* 37-96.

Keppel, G. Retroactive and proactive inhibition. In T.R. Dixon & D.L. Horton (Eds.), *Verbal behavior and general behavior theory.* Englewood Cliffs, N.J.: Prentice-Hall, 1968.

Kintsch, W. Models for free recall and recognition. In D.A. Norman (Ed.), *Models of human memory.* New York: Academic Press, 1970.

Kintsch, W. *Memory and cognition.* New York: John Wiley & Sons, 1977.

Kirk, R.E., *Experimental design: Procedures for the behavioral sciences.* Belmont, California: Brooks/Cole Publishing Co., 1968.

Kofka, K. *The principles of Gestalt psychology.* New York: Harcourt, Brace & World, 1935.

Mandler, G. Response factors in human learning. *Psychological Review,* 1954, *61,* 235-244.

Mandler, G. Organization and memory. In K.W. Spence & J.T. Spence (Eds.), *The psychology of learning and motivation Vol. 1.* New York: Academic Press, 1967.

Mandler, G. Association and organization. In T.R. Dixon & D.L. Horton (Eds.), *Verbal behavior and general behavior theory.* Englewood

Cliffs, N.J.: Prentice-Hall, 1968. (a)

Mandler, G. Organized recall: Individual functions. *Psychonomic Science*, 1968, *13*, 235-236. (b)

Mandler, G. Words, lists and categories: An experimental view of organized memory. In J.L. Cowan (Ed.), *Studies in thought and language*. University of Arizona Press, 1970.

Mandler, G. Organization and recognition. In E.Tulving & W. Donaldson (Eds.), *Organization of memory*. New York: Academic Press, 1972.

Mandler, G., & Huttenlocher, R. The relationship between associative frequency, associative ability, and paired-associate learning. *American Journal of Psychology*, 1956, *69*, 424-428

Mandler, G., & Pearlstone, Z. Free and constrained concept learning and subsequent recall. *Journal of Verbal Learning and Verbal Behavior*, 1966, *5*, 126, 131.

Mandler, G., Pearlstone, A., & Koopmans, H. Effects of organization and semantic similarity on recall and recognition. *Journal of Verbal Learning and Verbal Behavior*, 1969, *8*, 410-423.

Mandler, G., & Stephens, D. The development of free and constrained conceptualization and subsequent verbal memory. *Journal of Experimental Child Psychology*, 1967, *5*, 86-93.

Martin, E. Serial learning: A multilevel access analysis. *Memory and Cognition*, 1974, *2*, 322-328

Martin, E., & Noreen, D.L. Serial learning: Identification of subjective subsequences. *Cognitive Psychology*, 1974, *6*, 421-435.

McGuire, W.J. A multiprocess model for paired associate learning. *Journal of Experimental Psychology*, 1961, *62*, 335-347.

McIntyre, J.S., Stojak, R.A., & Mostoway, W. Individual organization and release from proactive interference. *Journal of Experimental Psychology* 1973, *98*, 164-168.

McLean, R.A., & Gregg, L.W. Effects of induced chunking on temporal aspects of serial recitation. *Journal of Experimental Psychology,* 1967, *74*, 455-459.

Melkman, R. Effects of preferred and imposed number of categories on recall. *Journal of Experimental Psychology,* 1975, *104,* 280-285.

Melton, A.W., & Martin, E. *Coding processes in human memory.* Washington: Winston & Sons, 1972.

Miller, G. The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychology Review,* 1956, *63,* 81-96. (a)

Miller, G. Human memory and the storage of information. *Institute of Radio Engineers, Transactions of Information Theory,* 1956 , *2,* 129-137. (b)

Miller, G., Galanter, E., & Pribram, K.H. *Plans and the structure of behavior.* New York: Rinehart & Winston, 1960.

Mueller, J.H., & Overcast, T.D. Grouped presentation in free recall. *American Journal of Psychology,* 1975, *88,* 649-660.

Nelson, A.K., McRae, B.C., & Sturgess, P.T. Recall as a function of instructions and trials. *Journal of Experimental Psychology,* 1971, *90,* 152-153.

Nelson, T.O. Extinction, delay, and partial reinforcement effects in paired-associate learning. *Cognitive Psychology,* 1971, *2,* 212-228.

Novinski, L. Part-whole and whole-part free recall learning. *Journal of Verbal Learning and Verbal Behavior*, 1969, *8*, 152-154.

Novinski, L. A reexamination of the part/whole effect in free recall. *Journal of Verbal Learning and Verbal Behavior*, 1972, *11*, 228-233.

Ornstein, P. A. Role of prior-list organization in free recall transfer task. *Journal of Experimental Psychology*, 1970, *86*, 32-37.

Paivio, A. Mental imagery in associative learning and memory. *Psychological Review*, 1969, *76*, 241-263.

Paivia, A. *Imagery and verbal processes.* Toronto: Holt, Rinehart, & Winston, 1971.

Paivio, A. Imagery in recall and recognition. In J. Brown (Ed.), *Recall and recognition.* New York: John Wiley & Sons, 1976.

Pellegrino, J. W. A general measure of organization in free recall for variable unit size and internal sequential consistency. *Behavior Research Methods and Instrumentation*, 1971, *3*, 244-246.

Pellegrino, J.W., & Battig, W. F. Relationships among higher order organizational measures and free recall. *Journal of Experimental Psychology*, 1974, *102*, 463-472.

Petrich, J.A., Pellegrino, J.W., & Dhawan, M. The role of first list information in free-recall transfer. *Journal of Experimental Psychology*, 1975, *104*, 326-336.

Posnansky, C.J., Battig, W.F., & Voss, J.F. A new probe technique for the identification of serial learning processes. *Behavior Research Methods and Instrumentation.* 1972, *4*, 129-132.

Postman, L. Short-term memory and incidental learning. In A.W. Melton (Ed.), *Categories of human learning*. New York: Academic Press, 1964.

Postman, L. The effect of interitem associative strength on the acquisition and retention of serial lists. *Journal of Verbal Learning and Verbal Behavior*, 1967, *6*, 721-728.

Postman, L. Association and performance in the analysis of verbal learning. In T.R. Dixon & D.L. Horton (Eds.), *Verbal behavior and general behavior theory*. Englewood Cliffs, N.J.: Prentice-Hall, 1968.

Postman, L. Organization and interference. *Psychological Review*, 1971, *78*, 290-302. (a)

Postman, L. Transfer, interference and forgetting. In J.W. Kling & L.A. Riggs (Eds.), *Woodworth and Schlosberg's experimental psychology*. New York: Holt, Rinehart & Winston, 1971. (b)

Postman, L. A pragmatic view of organization theory. In E. Tulving & W. Donaldson (Eds.), *Organization of memory*. New York: Academic Press, 1972.

Postman, L. Interference theory revisited. In J. Brown (Ed.), *Recall and recognition*. New York: John Wiley & Sons, 1976.

Postman, L., & Stark, K. Studies of learning to learn. IV. Transfer from serial to paired-associate learning. *Journal of Verbal Learning and Verbal Behavior*, 1967, *6*, 339-353.

Postman, L., & Stark, K. Role of response availability in transfer and interference. *Journal of Experimental Psychology*, 1969, *79*, 168-177.

Postman, L., & Underwood, B.J. Critical issues in interference theory. *Memory and Cognition*. 1973, *1*, 19-40.

Roenker, D., Thompson, C.P., & Brown, S.C. Comparison of measures for the estimation of clustering in free recall. 1971, *76*, 45-48.

Rogers, J.L., & Battig, W.F. Effect of amount of prior free recall learning on paired associate transfer. *Journal of Experimental Psychology*, 1972, *92*, 373-377.

Runquist, P.A. Clustering in free recall following paired-associates learning. *Journal of Experimental Psychology*, 1970, *83*, 260-265.

Runquist, W.N. Interference among memory traces. *Memory and Cognition*, 1975, *3*, 143-159.

Russell, W.A., & Jenkins, J.J. The complete Minnesota norms for responses to 100 words from the Kent-Rosanoff Word Association Test. Technical Report No. 11, University of Minnesota, Contract Nonr-66216, ONR, 1954.

Schulze, N., & Gorfein, D.S. Subject strategies in part-whole transfer in free recall. *Memory and Cognition*, 1976, *4*, 311-317.

Segal, M.A., & Mandler, G. Directionality and organizational processes in paired-associate learning. *Journal of Experimental Psychology*, 1967, *74*, 305-312.

Shapiro, S. Serial organization and prior free recall. *Canadian Journal of Psychology*, 1970, *24*, 57-63.

Shuell, T.J. Clustering and organization in free recall. *Psychological Bulletin*, 1969, *72*, 353-374.

Shuell, T.J., & Keppel, G.A. A further test of the chaining hypothesis of serial learning. *Journal of Verbal Learning and Verbal Behavior*, 1967, *6*, 439-445.

Slamecka, N.J. An examination of trace storage in free recall. *Journal of Experimental Psychology*, 1968, *76*, 504-513.

Slamecka, N.J. Testing for associative storage in multi-trial free recall. *Journal of Experimental Psychology*, 1969, *81*, 557-560.

Slamecka, N.J. The question of associative groth in the learning of categorized material. *Journal of Verbal Learning and Verbal Behavior*, 1972, *11*, 324-332.

Slamecka, N.J., Moore, T., & Carey, S. Part-to-whole transfer and its relation to organization theory. *Journal of Verbal Learning and Verbal Behavior*, 1972, *11*, 73-82.

Sternberg, R.J., & Bower, G.H. Transfer in part-whole and whole-part free recall. A comparative evaluation of theories. *Journal of Verbal Learning and Verbal Behavior*, 1974, *13*, 1-26.

Sternberg, R.J., & Tulving, E. The measurement of subjective organization in free recall. *Psychological Bulletin*, 1977, *84*, 539-556.

Tulving, E. Subjective organization in free recall of "unrelated" words. *Psychological Review*, 1962, *69*, 344-354.

Tulving, E. Intratrial and intertrial retention: Notes toward a theory of free recall verbal learning. *Psychological Review*, 1964, *71*, 219-237.

Tulving, E. Theoretical issues in free recall. In T.R. Dixon & D.L. Horton (Eds.), *Verbal behavior and general behavior theory*. Englewood Cliffs, N.J.: Prentice-Hall, 1968.

Tulving, E., & Donaldson, W. (Eds.), *Organization of memory*. New York: Academic Press, 1972.

Tulving, E., & Madigan, S.A. Memory and verbal learning. In P.H. Mussen & M.R. Rosenzweig (Eds.), *Annual Review of Psychology*, 1970, *21*, 437-484.

Tulving, E., & Osler, S. Transfer effects in whole/part free recall learning. *Canadian Journal of Psychology*, 1967, *21*, 253-262.

Tulving, E., & Pearlstone, Z. Availability versus accessibility of information in memory for words. *Journal of Verbal Learning and Verbal Behavior*, 1966, *5*, 381-391.

Underwood, B.J. Stimulus selection in verbal learning. In C.N. Cofer & B.A. Musgrave (Eds.), *Verbal behavior and learning: Problems and processes*. New York: McGraw-Hill, 1963.

Underwood, B.J. Attributions of memory. *Psychological Review*, 1969, 559-573.

Underwood, B.J. Are we overloading memory? In A.W. Melton & E. Martin (Eds.), *Coding processes in human memory*. Washington: Winston & Sons, 1972.

Underwood, B.J., & Ekstrand, B.R. Effects of distributed practice on paired-associate learning. *Journal of Experimental Psychology*, 1967, *73*, (4, PT.2).

Underwood, B.J., & Erlebacher, A.H. Studies of coding in verbal learning. *Psychological Monographs*, 1965, *79*, (13).

Underwood, B.J., Runquist, W.N., & Shulz, R.W. Response learning in paired-associate lists as a function of intralist similarity. *Journal of Experimental Psychology*, 1959, *58*, 70-78.

Underwood, B.J., & Shulz, R.W. *Meaningfulness and verbal learning*. Philadelphia: Lippincott, 1960.

Voss, J.F. On the relationship of associative and organizational processes. In E. Tulving & W. Donaldson (Eds.), *Organization of memory,* New York: Academic Press, 1972.

Wallace, W.P. Consistency of emission order in free recall. *Journal of Verbal Learning and Verbal Behavior,* 1970, *9,* 58-68.

Waugh, N. Two methods for testing serial memorization. *Journal of Experimental Psychology,* 1963, *65,* 215-216.

Weingartner, H. Associative structure and serial learning. *Journal of Verbal Learning and Verbal Behavior,* 1963, *2,* 476-479.

Wickelgren, W. Rehearsal grouping and hierarchical organization of serial position cues in short-term memory. *Quarterly Journal of Experimental Psychology,* 1967, *19,* 97-102.

Wickelgren, W.A. Coding, retrieval and dynamics of multitrace associative memory. In L.W. Gregg (Ed.), *Cognition in learning and memory.* New York: John Wiley & Sons, 1972.

Wickens, D.D. Encoding categories of words: An empirical approach to meaning. *Psychological Review,* 1970, *77,* 1-15.

Wickens, D.D. Characteristics of word encoding. In A.W. Melton & E. Martin (Eds.), *Coding processes in human memory.* Washington: Winston & Sons, 1972.

Winograd, E., Conn, C.P., & Rand, J. Superiority of complete presentation to single item presentation in recall of sequentially organized material. *Journal of Experimental Psychology,* 1971, *2,* 223-230.

Winzenz, D. Group structure and coding in social learning. *Journal of Experimental Psychology,* 1972, *92,* 8-19.

Wood, G. Whole-part transfer from free recall to serial learning. *Journal of Experimental Psychology*, 1969, *79*, 540-544 (a)

Wood, G. Wholepart transfer from paired associate to free recall learning. *Journal of Experimental Psychology*, 1969, *82*, 532-537. (b)

Wood, G. Paired-associate and free recall to free recall transfer. *Journal of Experimental Psychology*, 1970, *83*, 519-522.

Wood, G. Organizational processes and free recall. In E. Tulving & W. Donaldson (Eds.), *Organization of memory*. New York: Academic Press, 1972.

Wood, G., & Clark, D. Instructions, ordering and previous practice in free recall learning. *Psychononic Science*, 1969, *14*, 187-188.

Young, R.K. Serial learning. In T.R. Dixon & D. L. Horton (Eds.), *Verbal behavior and general behavior theory*. Englewood Cliffs, N.J.: Prentice-Hall, 1968.

Young, R.K. Transfer in serial learning. In C.P. Duncan, L. Sechrest, & A.W. Melton (Eds.) *Human memory: Festschrift for Benton J. Underwood*. New York: Appleton-Century-Crofts, 1972.

Footnotes

[1]As an exploratory and precautionary measure two separate analyses were made of the category-pairings in both Experiments 1 and 2. The first analysis was based upon the disposition of all items on the last sorting trial. The second analysis of the pairings was based upon the output order of the items during the free-recall test. This dual-analysis approach was warranted by the findings of Basden and Higgen (1972) who suggested that the amount of organization and recall was dependent upon the number of categories recalled rather than the number of categories used for sortint the items. In the present investigation a maximum of seven categories was used and, as no category forgetting occurred, both analyses showed highly similar results.

An investigation into situations where category forgetting does occur (i.e., large number of categories and uncued recall) is now in progress.

APPENDICES

APPENDIX A: LISTS

A MATCHED SAMPLE OF WORDS AND THEIR FREQUENCY OF USAGE

SELECTED FROM TULVING (1964)

TABLE 1

List One		List Two	
Word	Frequency	Word	Frequency
answer	AA	action	AA
accent	16	axle	9
butler	18	bridle	18
bandage	14	buyer	16
center	AA	country	AA
dipper	4	ether	4
express	AA	effort	AA
entry	17	daddy	4
finding	15	fluid	15
forest	AA	flower	AA
gambler	4	ginger	13
hermit	16	hamlet	15
hollow	A	hero	A
issue	AA	island	AA
infant	22	insult	21
jewel	41	jury	26
kitchen	AA	knowledge	AA
lady	AA	labor	AA
mantle	4	miser	4
movie	29	motive	26
ocean	AA	office	AA
paper	AA	passage	AA
quarter	AA	question	AA
rumor	18	receipt	20
scandal	13	satin	15
teacher	AA	thirty	AA
voter	17	virgin	17
value	AA	valley	AA
weather	AA	window	AA
warrant	20	wrinkle	20

TABLE 2

PAIRED-ASSOCIATES LIST 1 ARBITRARILY SELECTED FROM LIST IN TABLE 1

butler	-	center
gambler	-	bandage
kitchen	-	entry
infant	-	hermit
express	-	voter
finding	-	mantle
issue	-	teacher
dipper	-	weather
jewel	-	answer
rumor	-	value
warrant	-	forest
paper	-	movie
quarter	-	accent
hollow	-	lady
ocean	-	scandal

TABLE 3

PAIRED ASSOCIATE LIST 2 ARBITRARILY SELECTED FROM LIST IN TABLE 1

warrant	-	movie
finding	-	lady
mantle	-	hollow
issue	-	weather
jewel	-	dipper
rumor	-	teacher
quarter	-	paper
express	-	forest
voter	-	butler
scandal	-	answer
bandage	-	infant
gambler	-	value
entry	-	kitchen
hermit	-	ocean
accent	-	center

TABLE 4

SERIAL LISTS 1 AND 2 ARBITRARILY SELECTED FROM LIST IN TABLE 1

Serial List 1	Serial List 2
hamlet	thirty
daddy	labor
insult	country
valley	motive
miser	axle
office	question
action	buyer
knowledge	virgin
ginger	passage
ether	window
jury	island
flower	fluid
wrinkle	effort
bridle	satin
receipt	hero

APPENDIX B: INSTRUCTIONS

FREE RECALL, PAIRED-ASSOCIATES, AND SERIAL LEARNING INSTRUCTIONS

Free Recall

"It is very important that you follow instructions to the best of your ability. If, after I finish reading the instructions, you do not understand your task please tell me. Also, if you do not follow the instructions during the task, please tell me after the experiment as the interpretation of the results may be affected.

Now, this is a study of how people organize words. Upon my signal, you will turn to the given page (NOTE: the booklets are numbered on the bottom, right-hand edge). At the top of the page you will see a list of 30 words and below this list you will also see a given number of sorting categories. Your task is to sort the words by writing them into the given categories using any set of rules, or on any basis you wish, with one exception. Do not, I repeat, do not sort the words on the basis of any physical characteristics of the words (i.e., do not use the alphabet, or count the number of letters, or syllables in the words). Rather, try to relate the words within each category in some meaningful way. You will have adequate time to organize the words into the given categories. Use all the categories and try to balance or roughly equal the number of words in the categories. When instructed, you will then turn to the given page and attempt to replicate the way in which you organized the words. The words at the top of the page will be the same but in a new order. To repeat, try to organize the words in the same manner as you did previously. That is, words you placed together on the first sort, you place together on the second sorting trial. We will do this a third, then a fourth time and remember each time you are trying to organize the words in the same way you did on the previous attempt.

Are there any questions?"

At the completion of the fourth sorting trial the Ss will be informed "Turn to page eleven and recall as many words as you are able in any order you wish. Start at the top blank and fill in each blank in succession with one word. Do not leave any spaces."

Paired-Associates Learning

"As mentioned previously, it is important that you follow the instructions to the best of your ability. Please inform me if you do not understand any part of the instructions.

In the second part of the experiment you are going to learn pairs of words which will be projected one at a time on the screen in front of you. Your task is to connect or associate the word on the left with the word on the right of each pair. There are 15 pairs of words, preceded by the word "Ready". Once you have seen all 15 pairs, I will show you, one at a time, the left hand words only. Your task will be to write down the word which was associated with the word shown (i.e., the right-hand word). If you are not sure of the word you may guess. We will be going through the procedure several times of first showing you the word pairs and then testing to see how many associates you remember. The order in which the pairs and test words follow each other is not always the same and therefore you must learn the pairs of words as pairs and not the order in which they follow each other.

Please turn to page 13 and notice the 15 blank spaces. After the 15 pairs of words have been presented the word "Recall" will be shown on the screen. This is your signal to prepare to write down the associate of each word as it appears on the screen. Write it quickly as each word will be shown for only a very short period of time. If you cannot think of the associate guess or draw a line through the space. Drawing a line through the space will help you keep your place in the list. Please do not attempt to go back in the recall list and make any corrections. Concern yourself only with the word being projected.

Always try to get as many of the pairs correct as you can on each trial. This task has proven to be difficult so try not to become discouraged.

Any questions?"

Serial Learning

"As mentioned previously it is important that you follow the instructions to the best of your ability. Please inform me if you do not understand any part of the instructions.

In the second part of the experiment you will be learning a list of fifteen words which will be projected on the screen in front of you. Your task is to recall the words in the order in which they were presented to you. First you will see a slide with "Ready" on it, followed by the fifteen words projected one at a time. Then the slide "Recall" will be your signal to write down as many of the words as you can remember <u>in the same order</u> as presented. We will go through the list several times in this manner.

Now, please turn to page 13 and notice the 15 blanks. Since the order the words follow each other will always be the same you must make sure and write them down in the order they were presented. If you remember that the first word is 'dog' and the third is 'ten' but you cannot remember the second word, then either guess at the second word or draw a line through that space. Do not write words presented near the end of the list and then go to words from the beginning of the list. Always recall the words in the same order as presented. It is important that you try to remember as many words as possible on each and every trial, regardless of whether you have remembered all of the words or only a few of them on previous trials.

Are there any questions?"

APPENDIX C: RAW DATA

EXPERIMENT I

PERCENTAGE CONSISTENCY OF ORGANIZATION BETWEEN THIRD

FOURTH SORTING TRIALS

Number of Categories

Experimental Group	3	5	7
	100	100	100
	97	100	100
	100	100	97
	100	100	95
	100	100	100
	100	100	100
	100	100	90
	100	100	93
	100	100	100
	99	100	97
	100	100	100
	93	93	93
	100	100	99
	92	90	100
	91	100	90
	97	90	
Control Group	100	100	100
	93	100	100
	97	100	100
	92	93	92
	100	100	100
	94	100	100
	100	100	100
	100	100	100
	93	100	97
	100	100	100
	100	97	100
	97	94	100
	100	100	100
	97	100	90
	100	100	100
	100	100	100

EXPERIMENT I

WORD RECALL FROM FREE RECALL PHASE

Number of Categories

Experimental Group	3	5	7
	17	27	29
	21	24	30
	14	21	28
	30	27	22
	17	27	21
	18	24	22
	18	16	29
	22	30	26
	22	25	27
	20	29	30
	23	30	29
	28	20	30
	19	25	26
	23	29	27
	23	28	30
	24	21	28
Control Groups	25	26	28
	22	24	26
	22	28	26
	18	23	27
	29	23	28
	22	20	30
	21	27	29
	25	28	30
	25	27	29
	27	17	30
	20	23	29
	20	30	29
	20	22	27
	21	23	25
	23	23	30
	15	28	29

EXPERIMENT I

ADJUSTED RATIO OF CLUSTERING SCORES

	Number of Categories		
Experimental Groups	3	5	7
	0.176	0.943	0.893
	0.912	1.000	0.898
	0.725	0.842	1.000
	1.000	0.441	0.675
	1.000	0.314	0.681
	0.798	1.000	1.000
	1.000	1.000	0.946
	0.599	1.000	0.686
	1.000	0.686	1.000
	0.630	0.947	1.000
	0.534	1.000	1.000
	0.759	0.735	0.950
	1.000	0.819	0.748
	0.133	0.841	0.697
0.207	0.207	0.889	0.948
	0.784	0.385	0.705
Control Groups	0.590	0.940	0.944
	1.000	0.337	1.000
	0.918	1.000	0.741
	0.337	0.503	0.639
	0.480	0.721	0.778
	0.763	1.000	0.897
	1.000	0.942	1.000
	0.794	1.000	0.850
	0.223	0.887	0.836
	1.000	0.583	1.000
	0.626	1.000	0.835
	0.417	0.949	0.895
	0.821	0.621	1.000
	1.000	0.294	0.678
	0.624	0.857	0.450
	0.500	0.891	1.000

EXPERIMENT I

WORD RECALL DURING PAIRED ASSOCIATES LEARNING

EXPERIMENTAL GROUP: NUMBER OF CATEGORIES = 3

Trials

1	2	3	4	5	6
5	13	15	15	15	15
7	6	11	12	12	15
6	13	14	15	15	15
5	10	11	13	14	15
9	14	14	15	15	15
8	12	13	15	15	15
7	7	9	9	10	14
9	12	14	15	15	15
11	13	15	15	15	15
8	10	14	14	15	15
7	11	14	15	15	15
7	9	11	13	15	14
6	10	12	11	15	15
5	13	14	15	15	15
5	6	6	10	11	12
3	7	11	13	15	15

EXPERIMENT I

WORD RECALL DURING PAIRED ASSOCIATES LEARNING

EXPERIMENTAL GROUP: NUMBER OF CATEGORIES = 5

Trials

1	2	3	4	5	6
3	8	6	9	13	14
4	7	9	6	7	10
8	12	14	15	15	15
7	10	11	10	12	12
4	1	5	6	6	9
4	10	12	15	15	15
6	6	10	13	13	14
9	6	11	14	15	15
7	10	13	14	15	15
2	3	4	6	3	5
2	9	10	14	14	15
8	10	14	15	15	15
9	8	11	14	14	15
2	1	7	9	11	14
5	7	13	15	15	15
4	10	10	13	14	14

EXPERIMENT I

WORD RECALL DURING PAIRED ASSOCIATES LEARNING

EXPERIMENTAL GROUP: NUMBER OF CATEGORIES = 7

Trials

1	2	3	4	5	6
5	8	14	15	15	15
6	12	15	15	15	15
6	7	6	5	7	8
5	4	7	10	11	12
6	12	11	14	15	15
5	13	13	15	15	15
10	10	15	14	12	15
10	13	15	15	15	15
7	8	9	10	13	13
6	11	14	15	15	15
0	3	5	8	11	12
3	4	8	11	12	14
9	11	14	15	15	15
5	10	12	13	15	15
4	7	11	12	12	12
8	13	15	15	15	15

EXPERIMENT I

WORD RECALL DURING PAIRED ASSOCIATES LEARNING

CONTROL GROUP: NUMBER OF CATEGORIES = 3

Trials

1	2	3	4	5	6
6	7	13	13	13	14
5	11	13	15	15	15
6	13	15	15	15	15
6	9	11	15	15	15
0	5	8	10	11	14
5	13	14	15	15	15
4	8	10	11	14	15
4	11	13	15	15	15
9	14	15	15	15	15
4	7	13	14	15	15
8	13	14	15	15	15
5	7	12	13	13	13
7	9	12	15	15	15
9	10	13	14	15	15
5	10	13	14	15	15
7	15	15	15	15	15

EXPERIMENT I

WORD RECALL DURING PAIRED ASSOCIATES LEARNING

CONTROL GROUP: NUMBER OF CATEGORIES = 5

Trial

1	2	3	4	5	6
9	12	15	15	15	15
8	13	15	15	15	15
5	9	13	15	15	15
2	7	10	11	13	13
12	14	15	15	15	15
12	13	14	15	14	15
4	8	11	14	15	15
5	7	10	13	15	14
10	12	14	15	15	15
7	14	15	15	15	15
10	13	15	15	15	15
4	9	12	13	14	14
4	11	12	11	14	15
9	13	15	15	15	15
1	9	13	14	15	15
6	14	15	15	15	15

EXPERIMENT I

WORD RECALL DURING PAIRED ASSOCIATES LEARNING

CONTROL GROUP: NUMBER OF CATEGORIES = 7

Trials

1	2	3	4	5	6
6	14	15	15	15	15
3	9	11	13	15	15
10	13	15	15	15	15
8	13	15	15	15	15
4	7	11	15	15	15
6	11	15	15	15	15
6	9	15	15	15	15
5	13	14	15	15	15
7	12	14	14	15	15
13	15	15	15	15	15
7	12	15	15	15	15
6	13	15	15	15	15
5	14	14	15	15	15
4	6	11	11	12	14
10	13	15	15	15	15
1	6	10	12	11	14

EXPERIMENT I

OVERT STIMULUS (S), RESPONSE (R) AND TOTAL (T)

ERRORS DURING PAIRED ASSOCIATES LEARNING

Number of Categories

	3			5			7		
Experimental Group	S	R	T	S	R	T	S	R	T
	0	0	1	19	6	25	1	5	6
	3	4	7	7	3	10	0	2	2
	4	0	4	8	2	11	19	22	41
	3	4	8	5	4	9	14	11	25
	0	2	2	8	11	19	1	3	4
	2	0	2	2	3	5	1	0	1
	10	6	16	5	7	12	0	4	4
	0	5	5	4	4	8	1	1	2
	2	1	3	3	2	5	3	5	8
	0	3	3	12	23	35	5	1	6
	0	2	2	4	5	9	1	0	1
	2	0	2	3	3	6	5	3	8
	2	2	4	2	0	2	0	2	2
	1	1	2	7	11	19	1	3	4
	8	1	9	3	2	5	4	13	17
	3	5	8	2	1	3	3	1	4
Control Group	2	5	9	1	2	3	0	0	1
	0	1	1	0	1	2	0	3	3
	0	0	0	2	4	6	0	0	0
	3	1	8	5	6	14	0	0	1
	1	0	3	0	2	2	0	2	2
	0	1	1	1	1	3	0	2	2
	1	2	4	2	3	5	0	0	0
	0	1	2	0	4	5	2	0	3
	0	0	1	1	2	3	0	3	8
	3	4	7	0	0	0	0	0	1
	1	0	1	2	0	2	0	0	1
	1	11	12	3	2	6	0	0	0
	0	0	0	1	0	1	0	1	2
	4	0	4	0	0	0	4	1	5
	1	2	3	2	3	5	1	0	1
	0	0	1	0	0	1	4	1	5

EXPERIMENT 2

PERCENTAGE CONSISTENCY OF ORGANIZATION BETWEEN

THIRD AND FOURTH SORTING TRIALS

	Number of Categories		
Experimental Group	3	5	7
	100	94	100
	93	100	100
	100	100	100
	100	94	100
	100	94	100
	93	97	100
	100	100	100
	100	97	100
	100	100	96
	95	100	97
	100	100	100
	100	95	100
	100	100	100
	100	100	100
	100	95	100
	100	97	100
	100	95	97
Control Group	100	100	100
	100	100	90
	97	100	100
	100	100	100
	100	97	100
	97	97	100
	100	97	100
	90	94	93
	97	100	94
	100	97	94
	94	97	100
	100	95	100
	100	100	100
	94	100	97
	97		100
	97		94
	100		
	100		

EXPERIMENT 2

WORD RECALL FROM FREE RECALL PHASE

	Number of Categories		
Experimental Groups	3	5	7
	23	21	20
	12	28	25
	18	28	30
	22	22	27
	17	12	29
	13	27	25
	14	14	26
	16	26	30
	20	25	17
	17	23	27
	17	29	26
	12	17	24
	16	23	23
	22	23	29
	15	17	24
	22	24	20
	28	15	20
		23	
Control Groups	17	24	26
	21	17	26
	20	20	27
	16	27	27
	10	20	26
	26	24	24
	19	19	25
	22	13	27
	8	23	22
	12	28	28
	10	22	26
	13	19	29
	16	25	30
	12	17	25
	17		28
	25		21
	14		
	18		

EXPERIMENT 2

ADJUSTED RATIO OF CLUSTERING SCORES

	Number of Categories		
Experimental Groups	3	5	7
	0.923	0.421	0.533
	-0.180	1.000	0.671
	0.349	1.000	1.000
	0.438	0.705	1.000
	0.541	0.613	1.000
	-0.058	0.943	0.468
	0.533	0.125	0.937
	0.522	1.000	1.000
	0.469	1.000	0.761
	1.000	1.000	0.823
	1.000	1.000	1.000
	0.625	0.227	1.000
	0.403	0.791	0.845
	0.590	0.721	1.000
	0.717	0.570	0.929
	0.525	0.602	1.000
	1.000	0.741	0.817
Control Groups	0.779	1.000	1.000
	0.907	0.785	0.495
	0.541	1.000	1.000
	0.111	0.939	0.819
	0.130	0.737	0.485
	0.726	0.792	0.930
	0.109	0.808	1.000
	0.752	0.316	0.520
	0.091	1.000	0.756
	1.000	0.945	0.770
	0.136	0.844	1.000
	0.849	0.457	1.000
	0.625	0.352	0.733
	0.657	0.776	1.000
	0.892		0.635
	0.725		
	1.000		

EXPERIMENT 2

NUMBER OF ADJACENT PAIRS OF WORDS CORRECTLY RECALLED

EXPERIMENTAL GROUP: NUMBER OF CATEGORIES = 3

Trials

1	2	3	4	5	6
4	6	5	9	14	14
0	0	2	3	5	8
0	2	3	5	8	6
1	0	1	0	2	1
3	8	10	13	13	14
2	4	6	9	11	14
0	1	2	4	7	7
3	4	3	1	5	5
2	7	6	11	11	11
0	2	4	8	11	14
0	2	3	3	7	7
2	2	4	6	8	7
1	0	1	4	4	3
2	4	4	5	5	8
2	0	4	3	6	11
0	4	2	7	6	4
1	2	3	6	7	8

EXPERIMENT 2

NUMBER OF ADJACENT PAIRS OF WORDS CORRECTLY RECALLED

EXPERIMENTAL GROUP: NUMBER OF CATEGORIES = 5

Trials

1	2	3	4	5	6
1	1	2	3	3	3
3	5	10	11	14	14
2	5	10	14	14	14
1	0	5	3	9	14
1	1	3	4	4	4
0	3	2	4	6	12
0	3	6	4	3	2
2	6	4	5	11	11
0	5	14	14	14	14
2	3	4	11	11	14
0	4	8	2	7	11
1	2	3	3	5	8
2	0	6	6	1	3
2	3	4	8	10	14
1	4	4	4	7	14
0	2	3	8	9	11
2	3	2	1	2	6
0	2	5	3	8	10

EXPERIMENT 2

NUMBER OF ADJACENT PAIRS OF WORDS CORRECTLY RECALLED

EXPERIMENTAL GROUP: NUMBER OF CATEGORIES = 7

Trials					
1	2	3	4	5	6
0	1	1	3	4	3
2	0	0	1	2	4
1	1	4	7	12	14
2	3	7	6	6	11
0	1	2	5	7	14
1	4	22	5	11	13
2	3	4	7	7	0
2	4	5	7	7	8
2	2	3	3	6	2
0	1	2	1	3	4
1	4	1	3	1	3
1	2	0	2	2	4
1	2	3	3	5	5
1	7	12	14	14	14
0	0	2	5	7	7
1	1	3	3	5	9
2	4	6	8	7	14

EXPERIMENT 2

NUMBER OF ADJACENT PAIRS OF WORDS CORRECTLY RECALLED

CONTROL GROUP: NUMBER OF CATEGORIES = 3

Trials

1	2	3	4	5	6
1	1	2	4	6	9
2	4	7	9	8	8
2	1	3	4	5	7
2	2	2	8	14	14
1	3	0	2	5	7
2	5	10	12	14	14
2	5	12	9	14	14
2	5	5	10	12	9
1	2	1	5	4	6
1	3	4	4	6	7
0	1	2	2	4	4
2	6	2	3	7	4
0	2	1	3	5	4
2	2	6	8	11	14
4	5	8	12	8	14
1	4	3	6	5	5
0	1	2	6	5	4
4	9	10	14	14	14

EXPERIMENT 2

NUMBER OF ADJACENT PAIRS OF WORDS CORRECTLY RECALLED

CONTROL GROUP: NUMBER OF CATEGORIES = 5

Trials					
1	2	3	4	5	6
1	2	7	0	6	11
2	4	4	5	9	1
0	0	0	0	2	4
4	9	14	14	14	14
1	3	3	6	11	9
4	7	11	14	14	14
1	1	2	2	6	4
0	1	1	3	3	4
2	4	6	6	5	7
1	4	14	14	14	14
3	7	11	12	14	14
3	5	8	11	12	11
4	8	9	14	14	14
1	0	0	4	6	5

EXPERIMENT 2

NUMBER OF ADJACENT PAIRS OF WORDS CORRECTLY RECALLED

CONTROL GROUP: NUMBER OF CATEGORIES = 7

Trials					
1	2	3	4	5	6
1	2	2	2	7	9
1	2	3	6	5	9
2	4	10	14	14	14
2	3	5	8	12	14
4	4	5	7	7	11
1	5	5	10	14	14
0	1	2	6	8	11
0	1	1	4	14	14
2	1	6	10	12	14
1	4	5	11	14	14
1	4	4	9	7	10
4	10	14	14	14	14
1	0	2	5	8	12
1	3	6	14	12	14
6	8	12	14	14	14
1	2	2	6	3	4

EXPERIMENT 2

PROPORTION OF WITHIN CATEGORY PAIRS (WCP), BETWEEN CATEGORY PAIRS (BCP) AND CONTROL (C) RECALL DURING PAIRED ASSOCIATES LEARNING

Number of Categories								
	3			5			7	
WCP	BCP	C	WCP	BCP	C	WCP	BCP	C
SORT DATA								
.60	.61	.27				.33	.10	.57
.13	.25	.45	.83	.70	.44	.33	.49	.31
.13	.37	.26	.92	.67	.30	.17	.44	.69
.00	.10	.50	.25	.42	.07	.33	.35	.52
.61	.73	.21	.06	.24	.95	.42	.42	.45
.54	.53	.69	.25	.35	.39	.00	.14	.58
.29	.23	.67	.08	.24	.76	.25	.14	.33
.00	.35	.39	.50	.44	.19	.00	.14	.40
.83	.56	.23	.83	.71	.14	.50	.18	.54
.83	.46	.30	.56	.55	.36	.83	.73	.58
.13	.33	.15	.67	.40	.73	.40	.19	.42
.17	.39	.29	.33	.19	.73	.25	.28	.83
.03	.19	.18	.50	.49	.60	.33	.51	.33
.08	.38	.51	.50	.37	.75			
.52	.19	.61	.42	.39	.19			
.17	.33	.29						
.11	.38	.21						
RECALL DATA								
.56	.58	.27	.83	.69	.44	.33	.10	.57
.00	.67	.45	1.00	.63	.30	.50	.47	.31
.00	.25	.26	.33	.44	.07	.17	.44	.69
.00	.08	.50	.17	.00	.95	.33	.35	.52
1.00	.83	.21	.25	.35	.39	.42	.42	.45
.33	.33	.69	.17	.00	.76	.00	.14	.58
.00	.58	.67	.50	.42	.19	.33	.17	.33
.83	.57	.39	.83	.71	.14	.00	.26	.40
.00	.39	.23	.75	.65	.36	.00	.04	.54
.33	.17	.30	.67	.40	.73	.83	.73	.58
.33	.50	.15	.33	.20	.73	.44	.22	.42
.11	.38	.29	.67	.40	.60	.17	.08	.83
			.50	.30	.75	.17	.33	.33
			.42	.33	.19			

APPENDIX D: ANALYSES OF VARIANCE

EXPERIMENT I

ANALYSIS OF VARIANCE OF LEVELS OF CONSISTENCY

DURING SORTING TASK AS A FUNCTION OF GROUPS

(EXPERIMENTAL-CONTROL) AND

NUMBER OF CATEGORIES (3, 5, 7)

Source of Variation	df	MS	F
Groups	1	7.04	.13
Categories	2	40.82	.76
Groups x Categories	2	11.94	.22
Within Cell	90	53.59	
Total	95		

EXPERIMENT I

ANALYSIS OF VARIANCE OF WORD RECALL AS A

FUNCTION OF GROUPS AND NUMBER OF CATEGORIES

Source of Variation	*df*	*MS*	*F*
Groups	1	5.51	.48
Categories	2	288.26	25.14*
Groups x Categories	2	8.19	.71
Within Cell	90	11.46	
Total	95		

*$p < .01$

EXPERIMENT I

ANALYSIS OF VARIANCE OF ADJUSTED RATIO OF CLUSTERING AS A FUNCTION OF GROUPS AND NUMBER OF CATEGORIES

Source of Variation	df	MS	F
Groups	1	.0026	.05
Categories	2	.22	3.93*
Groups x Categories	2	.0017	.03
Within Cell	90	.05	
Total	95		

*$p < .05$

EXPERIMENT I

WORD RECALL ON PAIRED ASSOCIATES TASK AS A FUNCTION OF GROUPS, CATEGORIES AND TRIALS

Source of Variation	df	MS	F
Groups	1	246.75	10.64*
Categories	2	27.89	1.20
Groups x Categories	2	75.91	3.27*
Subjects within Groups	90	23.17	
Trials	5	954.36	443.78**
Groups x Trials	5	10.42	4.84**
Categories x Trials	10	1.17	.54
Groups x Categories x Trials	10	1.77	.82
Trials x Subjects Within Groups	450	2.15	
Total	575		

*$p < .05$

**$p < .01$

EXPERIMENT I

ANALYSIS OF VARIANCE OF RESPONSE ERRORS DURING PAIRED ASSOCIATES LEARNING AS A FUNCTION OF GROUPS AND CATEGORIES

Source of Variation	df	MS	F
Groups	1	170.66	12.30*
Categories	2	21.96	1.58
Groups x Categories	2	28.44	2.05
Within Subjects	90	13.87	
Total	95		

*$p < .01$

EXPERIMENT I

ANALYSIS OF VARIANCE OF STIMULUS ERRORS DURING PAIRED ASSOCIATES LEARNING AS A FUNCTION OF GROUPS AND CATEGORIES

Source of Variation	*df*	*MS*	*F*
Groups	1	219.01	21.05*
Categories	2	27.88	2.68
Groups x Categories	2	20.32	1.95
Within Subjects	90	10.40	
Total	95		

*$p < .05$

EXPERIMENT I

ANALYSIS OF TOTAL ERRORS DURING PAIRED ASSOCIATES LEARNING AS A FUNCTION OF GROUPS AND CATEGORIES

Source of Variation	df	MS	F
Groups	1	635.51	15.88*
Categories	2	91.54	2.29
Groups x Categories	2	92.66	2.32
Within Subjects	90	40.01	
Total	95		

*$p < .01$

EXPERIMENT I

ANALYSIS OF VARIANCE OF BETWEEN CATEGORY PAIRS VERSUS WITHIN CATEGORY PAIRS AS A FUNCTION OF NUMBER OF CATEGORIES

Source of Variation	df	MS	F
Category	2	576.57	1.52
Subject within Groups	44	379.16	
Pairing	1	1157.71	7.54*
Category x Pairing	2	213.63	1.39
Pairing x Subject within Groups	44	153.45	
Total	93		

*$p < .01$

EXPERIMENT I

ANALYSIS OF VARIANCE OF BETWEEN CATEGORY PAIRS VERSUS CONTROL PAIRS AS A FUNCTION OF NUMBER OF CATEGORIES

Source of Variation	df	MS	F
Category	2	172.78	2.09
Pairing	1	494.17	5.98*
Category x Pairing	2	350.67	4.24*
Within Cell	88	82.67	
Total	93		

*$p < .05$

EXPERIMENT I

ANALYSIS OF VARIANCE OF WITHIN CATEGORY PAIRS
VERSUS CONTROL PAIRS AS A FUNCTION OF
NUMBER OF CATEGORIES

Source of Variation	df	MS	F
Category	2	197.94	0.83
Pairing	1	140.14	0.58
Category x Pairing	2	135.97	0.57
Within Cell	88	239.89	
Total	93		

EXPERIMENT 2

ANALYSIS OF VARIANCE OF LEVELS OF CONSISTENCY DURING SORTING TASK AS A FUNCTION OF GROUPS AND CATEGORIES

Source of Variation	df	MS	F
Groups	1	14.94	2.30
Categories	2	3.76	.58
Groups x Categories	2	11.01	1.69
Within Subjects	95	6.49	
Total	100		

EXPERIMENT 2

ANALYSIS OF VARIANCE OF WORD RECALL AS A FUNCTION

OF GROUPS AND CATEGORIES

Source of Variation	*df*	*MS*	*F*
Groups	1	2.60	.14
Categories	2	571.97	30.70*
Groups x Categories	2	16.05	
Within Subjects	94	18.63	
Total	99		

*$p < .01$

EXPERIMENT 2

ANALYSIS OF VARIANCE OF ADJUSTED RATIO OF CLUSTERING

AS A FUNCTION OF GROUPS AND CATEGORIES

Source of Variation	df	MS	F
Groups	1	.0016	.02
Categories	2	.74	9.75*
Groups x Categories	2	.01	.15
Within Subjects	94	.07	
Total	99		

*$p < .01$

EXPERIMENT 2

ANALYSIS OF VARIANCE OF NUMBER OF CORRECT PAIRS DURING SERIAL LEARNING AS A FUNCTION OF GROUPS, CATEGORIES AND TRIALS

Source of Variation	df	MS	F
Groups	1	296.51	6.66*
Categories	2	27.95	.62
Groups x Categories	2	59.56	1.33
Subjects within Groups	94	44.52	
Trials	5	909.14	200.67**
Groups x Trials	5	11.87	2.62*
Categories x Trials	10	5.79	1.27
Groups x Categories x Trials	10	10.59	2.34**
Trials x Subjects within Groups	470	4.53	
Total	599		

*$p < .05$

**$p < .01$

EXPERIMENT 2

ANALYSIS OF VARIANCE OF BETWEEN CATEGORY PAIRS VERSUS
WITHIN CATEGORY PAIRS AS A FUNCTION OF
NUMBER OF CATEGORIES

Source of Variation	df	MS	F
Category	2	518.71	1.28
Subjects within Groups	45	404.75	
Pairing	1	275.97	2.70
Category x Pairing	2	91.58	0.89
Pairing x Subjects within Groups	45	102.06	
Total	95		

EXPERIMENT 2

ANALYSIS OF VARIANCE OF BETWEEN CATEGORY PAIRS VERSUS ADJACENT CONTROL PAIRS AS A FUNCTION OF NUMBER OF CATEGORIES

Source of Variation	df	*MS*	*F*
Category	2	199.22	1.39
Pairing	1	419.71	2.92
Category x Pairing	2	458.43	3.19*
Within Cell	82	143.71	
Total	87		

*$p < .05$.

EXPERIMENT 2

ANALYSIS OF VARIANCE OF WITHIN CATEGORY PAIRS VERSUS ADJACENT CONTROL PAIRS AS A FUNCTION OF NUMBER OF CATEGORIES

Source of Variation	df	MS	F
Category	2	660.60	2.64
Pairing	1	995.91	3.98*
Category x Pairing	2	325.29	1.30
Within Cell	82	250.23	
Total	87		

*$p < .05$.