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MEMORY PROCESSING IN LEARNING-DISABLED CHILDREN

by


LEONARD ISRAEL

A dissertation submitted to the Graduate  
Faculty in Speech and Hearing Sciences in  
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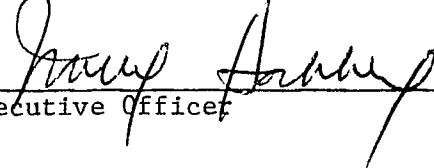
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This manuscript has been read and accepted for the Graduate Faculty in Speech and Hearing Sciences in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

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## ABSTRACT

Within the last twenty years, information processing models of memory have generated new interest in the study of children's memory. With an emphasis upon the developing role of the child in the acquisition, organization, and retention of information, we have witnessed a corresponding decline of investigations of age-related changes in the amount of material that children can retain. Focus on mnemonic strategies and organizational skills used by children to overcome memory capacity limitations has provided considerable literature about the ways children gain proficiency in memory processing.

An exception to this literature is the manner in which learning disabled children learn and remember information. Experimental data has yet to replace clinical and classroom observations of memory deficits of these children. Consequently, little is known about their information processing capabilities.

It is well-documented that clustering represents an effective organizational strategy to overcome memory capacity limitations. In free recall tasks, normal subjects routinely group (cluster) the material according to the inherent regularities of the material. By storing the material as groups, retrieval is facilitated by recalling the group and then its individual members. Clustering, therefore, renders the material more manageable and increases the amount of material which can be retained.

In this study, two experiments investigated the relationship between clustering and free recall performance by learning disabled children. In Experiment I, normal learners and learning disabled children were presented with word lists of varying structural saliency (unrelated, related-random, and related-blocked) in a multitrial free recall task. Each list contained 21 items including three buffer words which occupied

the initial and terminal positions of the lists. With the exception of the unrelated lists, the related-random and related-blocked lists were composed of 15 words in groups of five representing each of three semantic categories. A cluster was credited when two or more items within the same category appeared together in recall.

Results indicated that normal learners recalled and clustered to a greater extent than learning disabled subjects on every trial of each word list structure. While the improvement of the normal learners was characterized by significant growth across each trial, the learning disabled children tended to exhibit small, nonsignificant increments which were not subject to age-related improvement. For both the normal learners and learning disabled children, recall and clustering scores were highest on the blocked list structure.

In Experiment I, a recognition task established that the learning disabled children perceived the presence of the categories. Yet their performance was not facilitated to the same extent as it was for the normal subjects.

Experiment II sought to determine whether the clustering behaviors of the learning disabled children could be modified. A hierarchy of training cues of increasing specificity was introduced to draw attention to the taxonomic properties of the word lists. Results showed that the majority of children did not benefit from the cues. Despite the presence of the cues, recall and clustering performances in Experiment II were comparable to Experiment I. As in Experiment I, no age-related improvements in recall or clustering occurred.

In general, learning disabled performance was characterized by a delayed but qualitatively similar clustering strategy to that of normal

subjects. This deficit suggests a developmental immaturity in which efficient management of organizational strategies lack age-appropriate sophistication. Such a disturbance is compatible with reported deficits in the cognitive and psycholinguistic functioning of learning disabled children. Suggestions for evaluation and remediation of organizational skills are offered.

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## CHAPTER 1

### THE PROBLEM

Historically, models of memory were rooted in classical association theory. This behaviorist approach postulated a stimulus-response connection consisting of serially-ordered behavior. Within the stimulus-response (S-R) paradigm, remembering was considered to occur if, under specific stimulus conditions, the required response was emitted. This response then became a link in a series of contiguous associations where each succeeding link depended upon the prior establishment of the one it followed. In this manner, S-R theory was thought to account for learning and memory (Deese, 1968; Asch, 1968). In such models, all changes are quantitative and result from an increase in the strength and number of associations (Reese, 1976a). However, such an approach is rigid and superficial in its description of what occurs in learning situations. It does not suffice to consider only an external step-by-step sequential chaining of associations and to limit investigation to the amount of material that can be remembered. Descriptions must be provided for those complex mental operations mediating between the presentation of the stimulus and the emission of a response. We must get "inside" a persons's head and attempt to discover the mechanics of those internal events responsible for the arrangement and retention of information.

Jenkins (1974), who at one time identified with associationism, came to realize the inherent weaknesses and limitations of such a position with regard to a theory of memory: "we cannot deal with memory without dealing with instructions, perceptions, comprehension, inference, problem-solving... (p. 794)." Jenkins and others (Piaget and Inhelder,

1973; Hagen, Jongeward, and Kail, 1975) point out that explanations of memory development must acknowledge cognitive processes since memory and cognitive development are inherently related.

Within the last two decades there has been a gradual shift away from a quantitative perspective reflecting how much is remembered (whether the stimuli consist of digits, letters, numbers, words, etc.) to qualitative growth models emphasizing how information is remembered. It is within the latter area, with its concern for memory storage structures and control operations, that a significant proportion of the research investigating memory processing has been conducted. Within the framework of information processing models, memory emerges less as a random compilation of isolated facts than as a highly structured and interrelated system for receiving, manipulating, and recoding information for storage.

As Bruner and Anglin (1973) state:

"The individual is best viewed neither as a passive recipient of information nor as a bundle of stimulus-response connections. Rather he should be regarded as an active participant in the knowledge getting process, one who selects and transforms information, who constructs hypotheses and who alters those hypotheses in the face of inconsistent or discrepant evidence (p. 397)."

In developmental psycholinguistics or speech and hearing sciences, there has been little attention to the development of memory and the acquisition of language, or the relationship between memorial processes, language disorders, and communicative difficulties (Olson, 1973). The most frequent reference to the relationship between language and memory involves those investigations employing elicited imitation tasks (Smith, 1970; Giattino, 1971; Slobin and Welsh, 1973). Requiring the child to imitate sentences that exceed his immediate rote memory span

is presumed to tap his sentence-processing strategies. Imitated sentences are understood to be stored in memory as a representation of the sentences' semantic content.

With respect to language disorders and communicative difficulties, investigations of memory are minimal. Menyuk (1969) states that language-deviant children display poorer auditory memory abilities than "normal" language users. Her basic premise is that deviant language users are characterized by impaired information processing which prohibits the reorganization, elaboration, and storage of linguistic rules. Because of this deficit, they cannot adequately and efficiently carry out in-depth linguistic analyses, the consequence being impoverished or different rules concerning language.

Eisenson (1972) states that for a child to be proficient with oral language, he must not only demonstrate the capability to receive and identify sequential stimuli, but must be able to hold this sequence in memory to allow for integration of the content, to compare it with other stored impressions, and to assign meaning to it. He maintains that the spoken language difficulties associated with developmental aphasia are characterized by a perceptual disturbance in which the child is unable to organize, remember, and compare sensory-auditory events despite normal hearing acuity.

Researchers in autism (Baltaxe and Simmons, 1973, 1975) found that although autistic children's short-term memory capacities are probably equivalent to that of normal children, they display deficits in information processing involving the coding, storage, and retrieval of information. One such example is the limited ability to take advantage of syntactic structure in coding information and reaching meaningful

interpretations, the consequence being echolalia. This deficiency, while not language specific nor attributable to a short-term memory limitation, underlies their cognitive processing in general.

Recently, Tillman (1975) found that on free recall memory tasks adult aphasics' performance is random, unorganized, and unstable in multi-trial conditions. Their recall also did not show appreciable gains when various remedial cues were introduced.

In all of the above mentioned works, with the exception of the Tillman (1975) study, memorial strategies and coding processes were not of primary interest. During the school-age years, at a time when children have achieved virtual mastery of the language system of their community, they must now frequently acquire information for future recall. To gain an understanding of how children effectively and efficiently learn and remember, one might utilize an information processing approach which places emphasis on the memorial processes that transform and manipulate information. Free recall is a tool which permits this examination.

In a free recall paradigm, the subject reports, in any order, all items he can remember. Upon presentation of randomly ordered lists of words belonging to several categories, recall usually finds items from one category appearing together; that is, words are placed into discrete conceptual categories. This body of research in the free recall performances of children and adults has conclusively demonstrated that one strategy which effectively increases the retrievability of information is the recoding of the material into a superordinate system. This ability to organize (cluster) conceptually related material provides a clear indication that the subject is processing and operating upon that

which is fed into his system. By employing a clustering or "chunking" strategy, one can circumvent the constraints imposed upon the amount of material which can be remembered. In this manner, information beyond the subject's immediate memory capacity may be acquired, stored, and recalled.

In free recall involving lists of words, regardless of whether the to-be-remembered list of words is presented in the auditory and/or visual sensory modality, results convincingly show that a quantitative and qualitative growth pattern emerges: 1) as age increases, recall scores (per category and overall) and category organization (clustering) improve (Rossi and Rossi, 1965; Vaughan, 1968); 2) the presence of a categorical relationship in the to-be-learned list increases recall and organization (Neimark, Slotnick, and Ulrich, 1971; Kobasigawa and Middleton, 1972); 3) recall is superior on taxonomically clustered lists (blocked input condition) than for list structures of non-clustered and unrelated words (Cole, Frankel, and Sharp, 1971; Yoshimura, Moely, and Shapiro, 1971); 4) the provision of superordinate labels as retrieval cues generally facilitates recall (Scribner and Cole, 1972; Halperin, 1974); 5) training and instruction in the use of category organization results in greater clustering and higher recall in both the number of categories and the amount per category (Liberty and Ornstein, 1973; Moely and Jeffrey, 1974); and 6) self-determined categorical organization enhances recall performance (Moely, Olson, Halwes, and Flavell, 1969; Lange and Jackson, 1974).

This deliberate use of strategic behavior and mnemonic skills in memorization activities, which serve to render material more manageable, follows an age-related developmental progression. With increasing age

and maturity, children become increasingly planful and strategic in their approach to remembering. Their attempts to remember increase as does their ability to generate and use more efficient mnemonic strategies to plan and structuralize stimuli. The number and complexity of strategies also increase. In short, they become active memorizers as new operations and processing skills emerge. Within an information processing model, we can view the child as a "strategy user," a critical development in the improvement of memory (Hagen and Stanovich, 1977).

At the same time, they are becoming linguistically competent as their processing of spoken language approaches adult standards. Mastery of the phonological, syntactic, and semantic components of language is virtually accomplished during the early years of the elementary school period. As with memory, their language processing is composed of strategic behaviors (Bever, 1970; Slobin, 1973).

Along with this maturation of language in comprehension and expression is an increasing ability of language to help organize incoming information and to structure the output. Children become increasingly sophisticated in their knowledge and performance in academic skills requiring the categorization of perceptual (such as size, color, and shape) and conceptual-nominal (classification according to taxonomic structure) attributes. Underlying this ability is one aspect of the inter-relatedness of language and memory. If these attributes are perceived and coded, then, as Tillman (1975) asserts "memory enables us to retain the percepts for the necessary processing while language permits the inclusion of the percept into a system of categories (p.4)." Again, the essential feature is the developing ability to control the encoding or reorganization of information.

The manner in which this information is encoded is largely responsible for its retrieval at a later time. Stated differently, what the individual has done to make the material accessible, that is, how it is represented in long-term memory, is crucial for its retention and retrieval.

With regard to a learning-disabled population, investigators (largely in special education) have primarily concentrated efforts upon the reading, writing, arithmetic, behavioral, and attentional difficulties, and the visual and auditory perceptual weaknesses of these children and young adolescents much to the exclusion of their linguistic development and ability to handle spoken language tasks. However, recent investigations (Wiig and Semel, 1973, 1975; Wiig, Semel, and Crouse, 1973; Goldsmith, Wallach, and Beilin, 1974; Vogel, 1975) in the latter area have provided some knowledge about the cognitive and linguistic characteristics of this group. It appears that learning disabled individuals are delayed cognitively and linguistically. It further appears that the delay in developing adequate language and communication skills is accompanied by an acquisition pattern different from that of normal achieving children. However, a more precise definition of the relationship between learning disabilities and linguistic deficits has yet to be established.

While research concerning the language development of learning disabled children is minimal, research regarding the memory processing and coding strategies of these individuals is altogether lacking. Although writers frequently allude to the memory deficits (limited memory span for recalling material, usually digits, in sequential or serial order) of children diagnosed as learning disabled as a factor contributing

to their academic failure, systematic experimental research about information processing remains to be conducted. There are, therefore, serious gaps in our knowledge and understanding of the learning disabled child.

What has emerged from the limited available evidence is that these children are inferior to academically successful children on tasks of auditory and visual processing of linguistic information (Bryan, 1972) and that they do not benefit from externally organized material in free recall problems (Freston and Drew, 1974; Parker, Freston, and Drew, 1975). These initial data reflect performances different from that of non-learning disabled children (as has been noted in the research on language acquisition) and to a limited extent from that of mental retardates who display some capability to utilize available categorization in training and teaching procedures (Gerjuoy and Spitz, 1966; Gerjuoy and Alvarez, 1969; Evans, 1977). Also, difficulty of material proved a significant factor in recall scores since words of low frequency were recalled less successfully than high frequency words (Parker, Freston, and Drew, 1975).

Assessment of the memory abilities of learning disabled individuals has therefore only barely begun. The broad generalizations and inferences based on classroom and clinical observation are not yet supported by adequate, objective experimental data about how these children perform on memory-related tasks. A basic understanding of their memory as a cognitive operative system (Corsini, 1971), such as in the implementation of systematic strategies to guide recall, is lacking. Furthermore, if a processing dysfunction does exist, we lack information about the types of remedial procedures that are most effective in

intervention with the learning disabled. To date, these insufficiencies prevent the comparison of the learning disabled child against normative and proficient processing.

How the learning disabled reconstruct and represent information in memory may be better understood by an examination of the basic operation of categorization. Bruner, Goodnow, and Austin (1956) state that "to categorize is to render discriminably different things equivalent, to group the objects and events and people around us into classes, and to respond to them in terms of their class membership rather than their uniqueness (p. 1)." They add that "the learning and use of categories represents one of the most elementary and general forms of cognition by which man adjusts to his environment (p. 2)." The utilization of categorical behaviors such as the placing of an object, word, or event into a category on the basis of some shared or common properties acts to reduce both the complexity of the environment and the necessity of constant learning (Bruner, et al., 1956). Even the pre-academic child can successfully sort objects into superordinate categories (Rosch, et al., 1976). Clearly, the execution of such an ability is subject to quantitative and qualitative changes as the child grows and matures and consequently is an important facet of school success.

The question of how learning disabled children attempt to remember grows in importance when considered during the elementary school years when competent storage, recall, and retrieval processes (essential for efficient long-term memory processing) serve as prerequisites for academic achievement in curriculum tasks. That is, exploitation of efficient coding systems (such as concept formation) are barriers against school failure. But we cannot state with any authority or confidence

just how the child with a learning disability approaches the processing of information.

In short, the memory processes of cognitive functioning in learning disabled children and young adolescents is a poorly understood area. Much needs to be learned. Probing analyses of the learning disabled's ability to recognize, interpret, and organize relationships among experiences (e.g., categorization) are much needed. Since an extensive and well-documented body of literature exists on the normal development of higher-order cognitive processes (e.g., clustering), it can serve as a guide upon which judgments and comparisons may be made about the learning disabled child's performance.

#### Part One

The first part of the study was designed to investigate the relationship between organizational strategies and free recall performance by two groups of individuals: (1) a group of normal learners and (2) a group of learning disabled children. The purpose was to measure the degree of self-imposed organization on conceptually related lists of words. Differences in organization would permit quantitative and qualitative evaluation and reflect the proficiencies of both groups of subjects as active learners. Since clustering represents a central factor in memory and is a deliberate tactic in memorization, it was adopted as the measurement tool.

Memory organization may be studied by examining not only total recall and clustering performance, but also the effects of varying the saliency of list structure (unrelated, related-random, related-blocked) upon recall. Moreover, multi-trial presentation permits analysis of

changes in memory organization over a series of recall attempts and provides opportunity for variations in performance to reveal themselves. Finally, data from a recognition task reveal whether poor performance is due to inadequate acquisition and storage (availability) of the stimuli or inadequate retrieval (accessibility) from the memory store.

In view of the planful, organizing role of proficient information processors during memory activities, the following hypotheses were proposed:

1. Total recall and clustering of normal children will be greater than that of learning disabled children on all list conditions.
2. The more salient the list organization at input, the greater the clustering and resultant recall for both normal and learning disabled children.
3. Multi-trial learning will lead to greater consolidation of output for normal children than for learning disabled children.
4. Learning disabled children will have a greater number of false recognitions than normal children.

#### Part Two

To make incoming material more manageable for category clustering, the subject needs to discover appropriate category cues and to make effective use of them during retrieval. It was anticipated that the learning disabled children would not be as efficient as their normal counterparts in utilizing organizational schemes to group list items effectively during the input phase of memorization. If they do not adapt to task demands as readily as normal achievers, whether the causal factor is a lack of ability or a failure to apply abilities within their

repertoire intentionally and efficiently, their performance may nonetheless be modifiable as a result of training.

A second part of this study was designed to show how learning disabled children may be trained to make use of cues as potential mediators. To reduce possible variance due to individual differences in performance, an additive procedure was used whereby cues of increasing specificity were provided during list presentation. Increasing the saliency of the word lists and inducing subjects to employ active strategic behaviors in the storage of information may increase awareness of conceptual relationships within the word lists and maximize performance. Accordingly, it was hypothesized that the introduction of training cues would facilitate clustering.

## CHAPTER 2

## THE NATURE OF MEMORY

Theories of Memory

Information processing models have traditionally been described as consisting of several stages of storage. In an early construct, Waugh and Norman (1965) suggested a model built upon the distinction between primary and secondary memory. Primary memory was considered to be of limited capacity, in which incoming sensory input displaced previously stored information. As a consequence of this displacement, the "older" information was permanently lost. This loss of information could be delayed if maintained through rehearsal, defined as "recall of verbal items either immediate or delayed, silent or overt, deliberate or involuntary (p. 92)." Through rehearsal, the probability of the information making the transition into secondary memory was substantially increased; in the absence of rehearsal, information was lost.

An extension of this early model was offered by Atkinson and Shiffrin (1968) who proposed a system consisting of three storage structures: the sensory register, the short-term store, and the long-term store. These structures correspond to the locations where the content of memory is stored. The sensory register functions as the initial input channel whether the stimuli are auditory, visual, haptic, or linguistic. Within this component, incoming sensory information, in its literal representation, is identified and selectively screened allowing for relevant detail to be transferred to the short-term store. Information cannot be maintained in the sensory register and decay occurs within two seconds. Neisser (1967) characterized the rapidly

fading perceptual trace of visual sensory information as "iconic" memory and of auditory sensory information as "echoic" memory.

The short-term store is the individual's primary or "working" memory or operative memory where information selected from the sensory register is used. The maximum duration of sensory information entering the short-term store has generally been set at 30 seconds (although Simon [1972] speculates the range to be two to ten seconds), considerably longer than that of the sensory register but still a temporary or momentary store. This longer rate of decay, however, is directly influenced by subject-controlled coding processes serving to regulate the flow of information among the storage systems and to increase the longevity of the sensory stimuli (i.e., the processes act to delay a loss of information attributable to decay, displacement, or interference and to keep it accessible for immediate use). These voluntary, cognitive processes, constituting active self-imposed attempts to remember and retain information, and hence, to maximize performance, include rehearsal and general organizational schemes such as clustering. It has been estimated that the storage capacity or memory span of the short-term store ranges from five to nine coded pieces of information (Miller, 1956) and that this capacity remains constant whether the stimuli are digits, letters, or words (Neisser, 1967). In addition to organizing information, the short-term store functions to hold and transfer information for long-term storage and in turn receives information from long-term memory.

Unique to the rehearsal process is what Atkinson and Shiffrin (1968) refer to as a rehearsal buffer. This buffer contains a fixed number of "slots" which tend to become filled to capacity as items enter from the

sensory register. When maximum capacity is attained, entry of new items into the buffer must displace or "knock-out" currently held items. As previously mentioned, this process maximizes retention and availability of items for recall and assists in the transfer of information to long-term storage. The amount of information transferred depends upon the length of time within the buffer and the number of items being rehearsed simultaneously.

Within the long-term store or secondary memory (Waugh and Norman, 1965; Baddeley and Patterson, 1971), where capacity is relatively unspecified and unlimited, information tends to be stored permanently (through an organized network of previously established associations which carry the potential for future access) although occasionally irretrievable or less accessible as a result of inadequacy of retrieval cues, conflict with other incoming input, or interference with other information. In addition to receiving and storing newly-interpreted information, the long-term store sends retrieved data back to the short-term store. A fundamental characteristic of long-term memory is that coherent organization of information facilitates its retrievability.

This notion of a long-term store has undergone revision. Tulving (1972) distinguishes between two separate stores, one for episodic memory and the other semantic memory. Episodic memory involves the reception and storage of information about temporally ordered (dated) events and the spatial relationships among them (e.g., "I saw a flash of light and then heard an explosion."). It therefore maintains a record of the individual's specific experiences at a particular time and place. Being context and trace dependent, it is highly susceptible to loss of information. It also pertains to memory for meaningless,

isolated items for exact input (Brown, 1975).

Semantic memory acts to receive, retain, and transmit information about words, their meaning, relations among them and rules for their manipulation, and about concepts (e.g., "I remember that sodium chloride, NaCl, is the chemical formula for table salt.") That is, it is the memory underlying the use of language and consists of facts and generalizations. Since this information is highly organized, it is cue-dependent and not easily lost. It need not involve any specific experience; for example, we know that poison is harmful although never directly exposed to it. Restle (1974) refers to semantic memory as "knowledge" and Brown (1975) adds that it includes memory for the gist or theme and allows for inferential reasoning.

Recently, there has been a movement away from models employing structural components and their contents to one emphasizing input processes and levels of analysis. In a series of theoretical papers ( Craik and Lockhart, 1972; Craik, 1973), the authors argue against the adequacy of strict multi-store memory approaches. As an alternative, they offer a conceptual framework based upon a continuum or series of levels (or depths) of processing with primary considerations on perceptually-oriented encoding operations. They suggested that the memory trace is a product of perceptual analysis and its persistence and retention a function of depth. These processing levels correspond to a hierarchy of stages ranging from shallow, superficial sensory or physical storage (sounds, visual characteristics) to a more complex and deeper semantic (symbolic) storage. The deeper the level of analysis, the more elaborate, stronger, and durable the memory trace. With greater depth and analysis, the more the individual relies upon and

makes use of past knowledge, with the result being more effective management and retention of the material.

As previously discussed, human beings are information processors. We receive, analyze, synthesize, and store information. Yet we can recall only a limited number of items unless we actively manipulate and transform the information to render it more manageable. Prior to the popularity of the information-processing model as a description of how information is remembered, a widely accepted principle was that the ability to remember was dependent upon the relationship between memory span capacity and chronological age. In this view, human memory span was considered to be "limitations in the amount of data which can be absorbed in short-term memory in a single, brief learning opportunity and then recalled immediately (Adams, 1967, 130)."

For example, Simon (1972) mentioned that digit span in immediate recall increases systematically with age at the rate of about one digit with each 1.5 years of chronological age, reaching an average of four digits at five years of age. Similarly, five-year-olds are believed to retain approximately 3.7 letters, 4.3 concrete words, and 4.2 geometric figures. Adults, meanwhile, retain approximately 7.2 letters, 5.9 words, and 5.3 geometric figures (Chi, 1976). These findings led to the conclusion that as age increases, the ability to retain a certain number of items always increases regardless of its informational content. Obviously such an explanation is simplistic and inadequate. According to the more sophisticated information processing approach, increase in memory capacity is accounted for by the use of operational strategies to organize the input. Corroborative evidence is provided by Chi (1976, 1977) who shows that age differences in memory span need not be attributed

specifically to structural limitations and rate of information loss but rather to the number, use, and availability of processing strategies and to the speed of information processing.

In a much celebrated paper, Miller (1956) argued that the relationship between organization and recall can be explained through "chunking" or recoding, a technique in which related items are grouped in some meaningful manner. That is, they are placed into a form of organization characterized by integrated and enriched information units. For example, dogs, cows, and horses can be assigned a superordinate label and recoded as "animals," or letters may be grouped into larger chunks containing a series of items, as illustrated in the easier-to-remember series NBC-CBS-ABC than NB-CCB-SABC. Similarly, binary digits may be converted into paired or decimal sequences. These consolidated units afford greater cognitive economy and are unlimited in the amount of information which may be packaged into them. Miller maintained that the immediate memory span remained constant at "seven plus or minus two" units regardless of the material. What varies then, is not the size of the memory span per se, but the size or complexity of the individual chunks. The number of chunks, however, is limited. In this unitization process, we group "old" items into "new" items thereby increasing the number of items we can effectively deal with. This consolidation of information serves to improve "memory span" and potentially assists in information retrieval. During retrieval, these units are unpacked (Moely, 1977) to produce a larger amount of information than could have originally been stored in any other way. In terms of category organization and recall, the limitation corresponds to the number of categories which can be represented rather than the number of the individual words (Posner, 1973).

Olson (1973) used this theoretical model to examine the relationship between the acquisition of language and the development of memory abilities in the child. Olson challenges the claim that an increase in the child's mean length of utterance (MLU) corresponds to a growth of the child's short-term memory span. Instead, he argues that changes in both MLU and memory span are indicative of the utilization of strategic (mnemonic) abilities which follow their own developmental course.

In summary, proponents of information-processing models view memory as an interaction between structure (short- and long-term stores) and the processes underlying the subject's active participation (rehearsal, organizational strategies) in the coding, storage, and retrieval of information. The organism's strategic control and active generation of these cognitive operations determine what is remembered and how it is remembered. Clearly, memory span data are not as useful as processing strategies to account for memory capacity. The "memorability" of information is dependent upon its organization, for without an organizational scheme, effective long-term retention and subsequent retrieval would be limited. Therefore, the likelihood of retrieving information at some later time increases in probability to the extent that the primary emphasis focuses not upon the number of features detected but rather the nature of the analysis. In other words, memory capacity is inversely related to chunking strategies and the means of coding, storage, and retrieval (Muma, 1978).

In an experimental vein, information processing theory provides basic tenets and methodological choices for studying both quantitative and qualitative growth patterns in the development of childhood memory. Specifically, the ability to store and retrieve information can be

measured on tasks involving the categorical grouping of stimuli.

### Childhood Memory

An account of memory development is provided in Soviet theory. A dialectical model of memory development (Reese, 1973, 1976 a,b; Mecham, 1977), with its stress upon environmental and contextual interaction, is an integral component of the Soviet position. This body of research (Smirnov and Zinchenko, 1969; Yendovitskaya, 1971; Smirnov, 1973) tends to view memory development as a result of social interactions, that is, as a dynamic interaction of the organism in natural settings within the immediate environment. As a consequence, changes in memory are directly attributable to corresponding changes in the child's goals throughout the developmental period. Thus, environmental conditions (play vs. work, role playing, learning in school) are held accountable for any and all modifications which occur in the child's use of mnemonic activities. Such an orientation characterizes both quantitative and qualitative indices of developmental changes in memory.

Yendovitskaya (1971) distinguishes between two distinct forms of memory: involuntary (unintentional) and voluntary (intentional). Brown (1975) offers the same dichotomy with "nonstrategic" and "strategic" respectively. According to Yendovitskaya, childhood memory during the preschool period is characterized as involuntary and highlighted by a noticeable absence of mnemonics. It is proposed that through interaction with the environment the child remembers without the specific goal of remembering anything. For example, the parent's interaction with the child might interfere with and/or shape what the child attends to and remembers at a later time. Recall, at this level,

is primarily recognition and not an exact reproduction of some material. As Yendovitskaya states: "Preschool children mainly remember a situation, words, objects, and their interrelationships in the course of fulfilling some type of activity (practical play, learning) and to the extent to which that activity is expressed in the process of performance" (p. 95). Therefore, the effectiveness of remembering in the pre-academic period increases from the development of the content and structure of the activity and is expressed in a direct relationship to the meaningfulness of the material. Subordinated to this view, is the premise that recall is additionally influenced by what the child considers to be necessary and interesting as it pertains to the process of activity. It appears then, that within the context of meaningful activities, memory is more or less automatic without being conscious and goal-directed (Smirnov and Zinchenko, 1969).

Yendovitskaya (1971) postulates that a gradual shift occurs from "nonstrategic" or involuntary memory to voluntary, premeditated memory with its deliberate attempts to memorize and remember still within the preschool years. The child's activities become more goal-oriented and increasingly a greater number of demands are placed upon the child as when parents present the child with the task of recalling something specific. However, the activity remains a part of the environment (as opposed to the laboratory), and for a successful performance the child needs to engage in practical, playful learning. At the same time, mnemonic activity (i.e., cognitive processing) is initiated whereby the child learns to provide himself the goal of remembering for its own sake. Adults no longer isolate objects and their relationships during activities and instruct the child about them. The child is now on his own to

discover these relationships and to use them when presented with a task to remember (as related to the nature of the activity). This is the beginning of voluntary memory, with its conscious formation of various means to memorize. The traditional laboratory and/or experimental investigation into subjects' ability to recall taps a form of voluntary memory.

A conceptualization of this internal behavior, within the notion of a means to an end objective, is offered by Wellman (1977a). He theorizes that it is reasonable to assume that an individual has a goal (end) in mind if: 1) the actions (means) engaged in are appropriate only to the goal, 2) the actions are adopted to meet the goal, and 3) evidence exists that the individual anticipates the goal. In short, as involuntary memorization decreases with age, there occurs a corresponding increase in the productivity of voluntary memorization.

Remembering benefits from the discovery of relationships between items and the establishment of logical connections between them. The rudiments of verbal mediation first appear during the pre-academic period, a factor crucial in establishing semantic connections and unifying the material into groupings to facilitate recall. The use of speech signals the transition from graphical-visual connections to that of verbal-logical memory (Yendovitskaya, 1971). Only when they reach school age do children demonstrate an increasingly greater mastery of the mnemonic techniques and/or devices for recall.

An analogous explanation is posited by Smirnov and Zinchenko (1969) in their description of stages (levels) of memory development. In Level I, children are not active participants since they fail to exhibit any purposeful behavior in remembering. Level II is characterized by active

participation where the child sets goals of remembering and vainly attempts to attain them while still lacking the appropriate means to accomplish them. This stage marks the initial appearance of purposeful behavior in recall. Lastly, in Level III, the child possesses the necessary mnemonics (although few in number) to recall such as rehearsal in the form of whispering to themselves and later, meaningful grouping of the stimuli.

The quantitative and qualitative development characteristics reflective of the Soviet psychology regarding memory development are best summarized by Yendovitskaya (1971). What follows is a sampling of these changes:

1. Three to Four Years

Unintentional or involuntary memory predominates. The child cannot establish goals for recall. The primary means for memorization include constant repetition of the spatial or temporal contiguity of objects while recall involves the recognition of these objects. Children can reproduce, on the average, not more than four objects out of ten to 15 objects presented to them. In experiments requiring the memorization of individual words, recall averages two words. Children appear to be more adept at memorizing connected material (fairy tales, stories) which evoke empathy, clear images, and imagination.

- II. Five Years

Intentional or voluntary memory begins to emerge. Children display the ability to accept mnemonic goal-setting by adults and to set their own goals. Initial attempts to rehearse develop as does verbal-logical memory. Recall consists, on the average, of five out of ten to 15 objects momentarily presented and four out of ten to 15 unconnected words.

### III. Six to Seven Years

Voluntary memorization and recall are fully established. Verbal mediation and mnemonic activities constitute basic means to facilitate recall. Growth in the child's verbal-logical memory is evidenced as logical semantic connections and groupings are created. Children can reproduce, on the average, seven objects or words out of ten to 15 after momentary presentation.

Memory appears to be a consequence of meaningful actions (rehearsal, organization, labeling) actively initiated by the child. As Mechem (1972, 1977) describes the Soviet position, the action must be within the child's repertoire before it can be applied to remember information. It must be well-formed and serve as its own goal before it can function as a cognitive operation towards the achievement towards a new goal such as voluntary memory. These "new" goals, which are now activities (actions), may subsequently be used to create additional and more complex activities such as problem-solving. The process continues with more complex goals becoming activities (actions) for even more complex goals. The end result is a hierarchy of actions through which the child passes as he moves from involuntary to voluntary memorization. Within the latter, it has been demonstrated that instructions to remember affect how the material will be remembered since "...the subject chooses from among the mnemonics which are currently available that he thinks is most appropriate for the material, and then engages in that activity.... This effect is not upon the mnemonic per se, but, rather upon the choice of a particular activity in which to engage (Mecham, 1972, 214)."

The dialectical approach to the study of memory development is reminiscent of Piagetian philosophy (1969) which describes memory as an

integral aspect of intellectual activity and interaction with the environment. Qualitative growth results as the child experiences developmental changes in cognitive skills and as his understanding and interests in the world change over time. The ability to retain information is therefore related to the child's general cognitive structure. Basically, there are two types of memory: memory of recognition and memory of evocation. Recognition memory operates when a previously encountered object reappears and is recognized.

A higher-order mental process is memory of evocation which is made possible by the reconstruction of the object in its absence through the formulation of a mental image which, in turn, is dependent upon the appearance of the semiotic function. For example, Inhelder (1969) sought to determine whether the processes of encoding and decoding remained the same or changed with the passage of time. In a study designed to isolate age-related qualitative differences in memory organization, children three to eight years of age were presented a configuration of ten sticks of varying lengths but arranged from the smallest to the largest. The task called for visual retention of this pattern for recognition tasks ranging from one week to six to eight months after the initial presentation.

Results, based upon the children's drawings of the original seriation, revealed that: 1) the youngest subjects (three to four years of age) did not differentiate the length of the sticks but depicted all the sticks as having equal length; 2) four- and five-year old children either paired a large stick with a small stick, created classes of small, medium and large sized sticks, or experienced limited success in drawing the correct seriation (predominantly the five year olds); and 3) correct

size graded seriations were drawn by six- and seven-year-old children. After a six- to eight-month delay, most of the drawings were produced with greater accuracy when compared to the original drawing.

Interpretations indicate a gradual organization and development of the mnemonic representation. The children always produced a drawing corresponding to their operating level (of intelligence) rather than to the configuration presented. However, the scheme of seriation was constantly modified during each substage for the entire time interval. This progress, evident after a six- to eight-month delay, points to a further development of the children's schemes, in this instance, of arranging elements in an ordered series.

In a study parallel to that of Inhelder (1969), Mehler (1971) also sought to determine those quantitative and qualitative changes underlying the development of the memory process. He hypothesized that memory developed in a manner characterized by schemata (e.g., imaginal representations) that are fairly stable throughout development plus some corrections that occur along with an increase in age. A portion of the memory trace is identical for both the child and adult (e.g., visual traces) while other features are not shared (e.g., size, color and texture).

In Mehler's (1971) experiment, 280 children between the ages 2.4 and 3.11 were shown one of five stick patterns with the intention to have them reproduce that figure in drawings. They barely managed to do so (probably because of immature motor skills) but could recognize it when presented with three choices (the original pattern, transformations in a form of rotation, and their own drawing) from one hour to three days after the initial presentation. It was observed that, as age increased,

the children's choice of the transformations decreased. For children under the age of four, the directionality (ordering of the pattern) was not encoded in memory. Mehler concluded that age-related changes in memory development were influenced by the number of additional corrections (size, color, texture) that operated on the original pattern. Like Inhelder (1969), performance paralleled level of development.

Recently, this bi-dimensional view of memory was elaborated upon (Piaget and Inhelder, 1973). These authors distinguish between memory in the "strict" sense or "wide" sense, the "strict" sense being reflective of episodic memory and the "wide" sense of semantic memory. The "strict" point of view corresponds to recognition, reconstruction, and recollection, a hierarchy of processes required to regenerate specific past experiences and/or remember ideas. Memory in the "wider" sense is viewed as the conservation of everything that has been acquired and comprehended in the past. The following quotation brings the issue into focus:

The memory is a store of information that has been encoded by way of a process of perceptive and conceptual assimilation. The information itself, however, depends on part on the code, which determines...whether or not it is put to good use.... Memory changes in the course of a subject's development do not simply reflect the level of his encoding and decoding powers: the code itself is susceptible to change.... This explains why the level of memory organization differs with age, reflecting not only the coding level of the subject, but also the transformation of the code in the course of retaining the memory... (Piaget and Inhelder, 1973, 26).

#### Language and Memory

Experience is processed. One does not simply store an event in memory according to its literal interpretation. The experiencer operates upon the perception of the event and creates a meaningful

representation thereof. The experienced event must be labeled, categorized, and elaborated upon prior to being neatly tucked away in the memory system. The experience needs to be manipulated and transformed so that an iconic image (if possible) and its linguistically coded version are stored together (Miller, 1972). Recall of the event depends upon this non-verbal iconic representation, its linguistic description, and previous knowledge.

In much the same way, sentences and discourse are processed. Several researchers (Savin and Perchonock, 1965; Boysson-Bardies, 1970; Mehler, 1971) investigated the role of linguistic transformations in the understanding and memorization of sentences and found a positive relationship between the nature and the type of the transformation and the "ease" of sentence memorization. Others (Sachs, 1967, 1974) compared memory for syntactic characteristics with memory for meaning in connected discourse. In these studies, memory for meaning (e.g., paraphrase) was significantly better than memory for the syntactic (surface) form of the sentence. These latter findings are consistent with a relatively new field of investigation in which a broader base of study concentrates upon not the memory and meaning of individual words or sentences, but upon the integration of information expressed by semantically related sentences. Within this framework, comprehension depends upon the integration of implicit and explicit information. Considered together, these sentences convey a wholistic semantic idea subsequently stored in memory. This branch of research probing the relationship between language and memory is popularly referred to as the abstraction of linguistic ideas or semantic integration. It is an area of investigation aptly described by Neisser (1967): "a sentence is more than the sum of

its parts (p. 245)."

In an experiment where a series of thematic-related sentences expressing common but partial semantic content were presented (Bransford and Franks, 1971), subjects were asked to judge whether a subsequent set of sentences were exact reduplications of those previously heard, new sentences not actually heard but related to the theme, or sentences whose meanings could not be determined from the information given. This procedure made possible an assessment of the nature of the information retained. Analysis of the data revealed that the subjects selected many semantically related sentences which had never been presented. These "new" sentences combined the semantic content of several shorter sentences that had actually been presented. In fact, these sentences received higher recognition ratings than the originally presented set of sentences, indicating that the subjects were confident that they had been heard. The most complex sentences received the highest recognition ratings. Subjects were just as confident that they had not heard sentences distorting the central theme. These findings illustrate that subjects were not merely acquiring lists of individual sentences but rather had "integrated the information communicated by sets of individual sentences to construct wholistic semantic ideas (p. 348)."

Inasmuch as these ideas contained more information than that expressed by any of the sentences actually presented and also represented integrated meaning, memory appears to be a storage of complex ideas. Similar results were consistently found with a variety of different tasks (Bransford and Franks, 1972; Perfetti and Goldman, 1973).

The conclusion that people integrate semantic information into wholistic semantic structures representing complete ideas which are then

stored in memory is only a partial explanation of the relationship among language, comprehension, and memory. In a series of experiments, Bransford Barclay, and Franks (1972) demonstrated that the abstraction of complete ideas is also a function of the person's extra-linguistic knowledge, that is, what is integrated and stored contains more information than is offered by the linguistic input alone. For example, the sentence: "three turtles rested on a floating log and a fish swam beneath them" describes the action of a fish swimming beneath the turtles. However, since the turtles were on a log, the fish also swam beneath the log. Although this information is not conveyed directly by the original linguistic input, the inference will be made derived from general cognitive knowledge of the world (e.g., knowledge of spatial relationships). Barclay (1973) provides further supporting evidence as do Bransford and Johnson (1972) who showed that one's prior knowledge of the world is frequently a prerequisite for the meaningful processing of linguistic information. In this instance, knowledge of the topic of prose passages aided subjects in creating meaningful contexts necessary to comprehend the material. When this knowledge was provided, previously incomprehensible material were rendered comprehensible.

The foregoing examples make it evident that the comprehension, storage and retrieval of the semantic product depends upon both the linguistic input information and extra-linguistic information in the form of one's existing conceptual knowledge about the world. (See Bransford and Johnson [1973] for a detailed summary of the relevant studies.)

In all the above-mentioned studies, data were gathered on adult subjects. In an attempt to explore a constructive theory of sentence comprehension and memory in children, Paris and Carter (1973) presented

children ranging in age from seven to 11 years several unrelated "stories," each composed of three simple, active, declarative sentences. The first two sentences were premise statements while the final sentence was a filler item. For example:

The bird is inside the cage.  
The cage is under the table.  
The bird is yellow.

During a recognition phase, four different sentences were read to the children who were asked to judge whether they had heard that sentence in the acquisition stage. For each story, the sentences in the recognition phase consisted of a true premise (The bird is inside the cage.), a slightly altered false premise (The cage is over the table.), a permissible inference derived from the two original premises (The bird is under the table.), and an invalid false inference (The bird is on top of the table.).

Results were consistent with the findings on the adult population. Children reported having heard the true inference statements although they had not been presented during the acquisition stage. Fewer errors were made for the three remaining sentence types. Children, as well as adults therefore, actively engage in constructive and inferential processes as they comprehend and integrate linguistic material among sentences. These findings have been extended to include the integration and storage of pictorial stimuli (Paris and Mahoney, 1974) and the comprehension of prose (Paris, 1975), and more recently, age-related trends were found in inferential operations as well as in the ability to incorporate retrieval cues to draw inferences from sentences (Paris and Lindauer, 1976).

Perhaps the entire issue of memory and meaning is best described by

Bransford, et al. (1972): "People carry meanings, and linguistic inputs merely act as cues which people can use to recreate and modify their previous knowledge of the world. What is comprehended depends on the individual's general knowledge of his environment." (p. 207)

### Control Processes in Memory

The human mind knows more and thinks better as it grows older, and these changes in what it knows and how it thinks have powerful effects in what it learns and remembers, how it learns and remembers, and even perhaps when it learns and remembers (Flavell, 1971, 272).

The emphasis in this section is not upon storage structures or memory development in general, but rather upon the modifications in control operations and self-awareness which enable children to become efficient information processors, and hence, to learn and remember. At the outset, it should be noted that the repertoire of mnemonic strategies, organizational skills, and memory abilities of young children continuously expands and follows an age-related developmental pattern until stabilizing at approximately 13 years of age, and is likely the product of formal education (Super, Harkness, and Baldwin, 1977; Wagner, 1978). These changes in performance, in the intentional and deliberate application of strategic behaviors, allow the child to become increasingly planful and strategic in his approach to encoding, storing, and retrieving information. The emergence and generation of these self-employed behaviors increase in both number and complexity. The spontaneous selection of these coding processes to manipulate and transform information implies that, as information processors, we are active memorizers. By examining the child as a strategy-user, we can trace the development of his "knowing how to know" (Brown, 1975). The ensuing section offers

an analytical and in-depth review of the growth of these control processes.

### 1. Verbal Mediation

In exploring the young child's ability to engage in mnemonic activity, Flavell (1970) distinguished between two sources of potential difficulty pertaining to the mediational role of verbal symbols. In one instance, the child might exhibit a "mediational deficiency." This characterization implies that the child lacks and is unable to use a potential mediator (strategy). On the other hand, a "production deficiency" exists when potential mediators fail to be produced at a time when they would aid recall even when they are available within one's repertoire. Because of this failure to engage spontaneously in mnemonic activities, performance is defective.

An early investigation into the mediational versus production deficiency dichotomy was conducted by Flavell, Beach, and Chinsky (1966). Five-, seven-, and ten-year-old children were shown pictures of seven familiar objects arranged in a circular array and instructed to remember in the same order a subset of three pointed to by the experimenters. To observe verbal-mediator activity during a 15-second delay period, the child wore a helmet with a visor covering the eyes to prevent observation of the material but allow observation of lip movement and verbal rehearsal. During the delay period, the amount of verbalization varied as a function of age. The ability to engage in verbal rehearsal aided retention of the stimuli and led to increased recall.

In a follow-up study (Kenney, Cannizzo, and Flavell, 1967), the experimenters sought to determine whether the non-rehearsers could be induced (trained) to use a verbal-rehearsal strategy, and if so, would

performance improve. First grade children served as subjects with a procedure like that of the initial study. Results revealed that the serial recall of those children who spontaneously rehearsed the stimulus names was superior to the non-rehearsers. The non-rehearsers were then trained to rehearse verbally during the delay periods. On subsequent recall trials their recall resembled that of the spontaneous rehearsers. However, once released from specific instructions to rehearse, more than half the trained group completely stopped and recall declined.

These findings defined more precisely the status of production deficiencies. Non-rehearsers were described as exhibiting a production deficiency because verbal rehearsal was within their repertoire of memory skills yet not consciously used as a mediator. This deficiency could be overcome with training but did not carry over beyond the training period.

The applicability of the mediational and production deficiency constructs was next tested on tasks requiring non-verbal mediation (Corsini, Pick, and Flavell, 1968). Kindergarten and first grade subjects were asked to reconstruct a linear ordered pattern of wooden forms after the experimenters removed the pattern. The children were given paper forms as a means to remember the model pattern. During the trials, observation centered upon the children's use of the paper forms. Findings indicated that more first graders produced paper models than kindergarteners. Furthermore, when those subjects that did not spontaneously produce models were provided with suggestions to do so, more first graders than kindergarten subjects produced them. Accompanying this developmental trend were "production-inefficiencies" where subjects attempted to apply potential strategic behaviors but were inept in doing

so due to developmental limitations with that particular strategy (even though appropriate instructions were offered).

In sum, the data accumulated by Flavell and his co-workers on mnemonic-mediational skills indicate that 1) rehearsal is an effective strategic behavior in facilitating recall, 2) that younger children fail to invoke this cognitive process spontaneously, and 3) when evoked through training, recall temporarily approximates that of older subjects. It can therefore be safely concluded that the children in the younger age range studied displayed a tendency towards production deficiencies rather than mediation weaknesses. Similarly, the older children approach memory tasks with more intentional tactics to remember. Intermediate, between nonproduction (mediational deficiencies) and efficient production (production deficiencies), are production inefficiencies. Thus, the refinement of mnemonic mediational strategies may be viewed along a continuum of developmental progression with the end product being the spontaneous, efficient, and productive use of mature strategies.

## 2. Rehearsal and Verbal Labeling

Rehearsal, as a device to maintain the accessibility of information and to minimize forgetting, develops during the elementary school years and has been the object of extensive study. In a pioneer work (Hagen and Kingsley, 1968), two experiments were performed to explore the effects of verbal labeling on a short-term memory task involving the presentation of eight picture cards in serial order. On each trial, a card was presented and placed face down in a row after a two-second exposure. This procedure continued until all the cards were presented in a left to right fashion. Then a cue card, identical to one of the stimuli cards, was presented. The child's task was to locate the

presentation card with its matching cue card.

In the first experiment, one group of five-year-old nursery school children were instructed to label each of the stimulus cards and cue cards overtly. A second group did no overt naming. Results showed that verbal labeling failed to facilitate performance. Materials and procedures were replicated in Experiment II with six-, seven-, eight-, and ten-year-old children. Results revealed that 1) memory performance improved as a function of chronological age, 2) verbal labeling facilitated memory for the three younger groups (who did not use it spontaneously) but not for the ten-year-olds, and 3) labeling strongly facilitated recall of the most recent items.

Consideration of both experiments illustrated that labeling did not help the youngest and oldest children. The optimum range where labeling proved to be advantageous occurred at the intermediate ages. The youngest children verbalized overtly but the labels failed to mediate recall (mediational deficiency). By age ten, however, mediation was usually a covert process and therefore instructions to verbalize overtly probably interfered with covert rehearsal and as a consequence, was not facilitative. Lastly, although labeling did facilitate memory on the most recent serial positions, the gain was nullified in the performance of the ten-year-old group because of a loss of recall at the primary position. This finding was directly attributed to the interference with their preferred rehearsal practices.

The relationship between verbal labeling and rehearsal was further investigated in a study by Kingsley and Hagen (1969). Five-year-old nursery school children were administered a serial short-term memory task in which difficult to label nonsense figures were used as a stimuli.

Subjects were instructed either to pronounce the labels silently, label aloud, or rehearse the labels aloud in a cumulative sequence, e.g., fish; fish, bear; fish, bear, cat. Overt rehearsal of the labels enhanced recall performance in the primacy positions while overt labeling enhanced performance in the recency position.

The findings by Hagen and his associates indicate that short-term memory (recency performances) seem to occur automatically at all age levels (beginning at four years of age) and is facilitated by overt labeling. Primacy performance however, fails to improve with labeling but rather deteriorates when utilized by older subjects (Hagen, 1971).

The developmental characteristics of rehearsal were investigated by Kellas, McCauley, and McFarland (1975) who examined its storage and retrieval processes by the performance of eight-, ten-, and 12-year-old children on a serial recall task. For the storage phase, subjects were either instructed to rehearse or not rehearse aloud during the presentation interval. Item presentation was self-paced. Order of recall and correct responding were assessed for the retrieval phase.

Analyses indicated that 1) overt rehearsal produced increased study times, 2) older subjects rehearsed initial items more extensively than younger subjects and recalled these items earlier than younger children, 3) older children recalled more items, and 4) requiring younger subjects to rehearse out loud did not disrupt their rehearsal activity. In addition, the order of item retrieval became increasingly serial with age with younger children simply naming the items while older children rehearsed in pairs or small groups. Thus, changes in rehearsal patterns (i.e., rehearsal content) affect recall.

Corroborative evidence for this latter finding was provided by Naus, Ornstein, and Aivano (1977) on an overt rehearsal procedure designed to study the relationship between rehearsal strategies, processing time, and free recall performance. Eight- and 11-year-old children were presented 18 unrelated words. Subjects belonged to either a spontaneous covert control group (standard free recall), spontaneous overt group (normal rehearsing aloud) and an instructed overt group (rehearse aloud the presented word with any other two words from the list). Presentation rate was five or ten seconds per item.

Recall data for subjects in the spontaneous covert and spontaneous overt conditions revealed that in both, older children recalled more with the greatest difference appearing in the pre-recency portions of the word list. No age difference emerged in the recency positions. Instructed active rehearsal facilitated recall for all eight-year-olds.

Although the young group rehearsed more than the 11-year-olds, at both the five- and ten-second presentation rates, recall did not improve. This finding suggests that rehearsal content (the number of different items in each rehearsal set) is more effective than rehearsal frequency in bringing about corresponding improvement in recall performances. As found, the eight-year-old children included 1.6 different items in each rehearsal set at the five-second rate and 2.7 items at the ten-second rate. For the 11-year-olds, the values were 3.3 and 4.4 items for the five- and ten-second intervals, respectively. However, although the older children increased the number of different items rehearsed together, a corresponding change in recall was absent. It appears that an upper boundary limit (averaging 3.5 items) exists and that rehearsing a greater number of these items together fails to lead to additional

improvement in recall.

An overt rehearsal procedure was used by Ornstein, Naus, and Liberty (1975) to study the relationship between rehearsal strategies and free recall. In each of two experiments, one employing unrelated words and the other conceptually related words, a number of eight-, ten- and one-half-, 11-1/2- and 13-year-old subjects were required to rehearse out loud each stimulus item as it was presented. In both experiments, developmental changes were observed. With unrelated words older subjects exhibited an increased recall in the primacy and middle positions of the list while there were minimal differences at the recency positions. The total number of rehearsals (rehearsal frequency) of list items did not differ among age groups with initial items rehearsed more frequently than middle and terminal items. Although eight-year-olds rehearsed the middle and terminal items more frequently than the older subjects, they did not recall these items as efficiently. Examination of the rehearsal content showed a narrow and limited context with a tendency to rehearse the items either alone or in minimal combinations. The older subjects, however, demonstrated active, enriched rehearsal pattern in which several items were practiced together with each rehearsal. With conceptually related stimuli, all subjects were instructed to rehearse overtly. The 13-year-old children took greater advantage of the taxonomic information to rehearse related words together, a factor which facilitated recall and subsequently confirmed (Ornstein, Naus, and Miller, 1977) with 11-year-olds in an investigation demonstrating that rehearsal activity and recall varied as a function of list organization. Collapsing the data across both experiments, the major finding again supported rehearsal content and not rehearsal frequency as

a determining factor in the amount of recall achieved.

In sum, rehearsal is an active acquisition strategy. Children of different ages employ strategies reflective of their sophistication at rehearsal processing. The use of the rehearsal process, in terms of its internal content rather than frequency of usage, appears to be an important developmental variable which, when developed and utilized, results in enriched encoding.

### 3. Organization Processes

A popular tool to assess processing changes and a major source of data central to organization and memory is the use of a free recall paradigm. Free recall consists of an input phase in which randomly ordered stimuli are presented one after another and an output phase where measurements are taken of the number of items recalled and the degree of organization imposed upon this reproduction. No restrictions are placed on the order of recall and the discrepancy between the input and output components reflects the degree of organization. In other words, what is "free" to vary is the order in which the subjects may recall the stimulus items (Tulving, 1968). Because the order of recall is left to the subject's own discretion, the pattern of recall tends to yield clues about the individual's organizational activities.

One method of evaluating the organization of conceptually related stimuli in recall is through a measurement of the person's ability to cluster or categorize the stimulus items. When input consists of a random presentation of words having membership in several conceptual categories, recall generally is grouped according to taxonomic category. Such a tactic acts to code the material and reduce memory load and is a type of organization characteristic of mediating processes (Bousfield

and Cohen, 1953).

For example, "chair," "bed," and "lamp" are individual words characteristic of the superordinate structure "furniture." During recall, retrieval of one category member tends to activate the superordinate, which in turn, triggers the retrieval of other members belonging to the category. As such, meaningful links are established whereby the remembrance of one item acts to make it a retrieval cue for others. Clustering is a strategy typical of adult performance (Bousfield, 1953; Bousfield, Cohen, and Whitmarsh, 1958; Mandler, 1969; Drew and Altman, 1970). Performance also benefits when the input words are presented in a blocked manner, i.e., when items within the same category are adjacent to each other.

In general, the study of such processes can lead to an improved understanding of the manipulation and transformation and thus organization that is imposed on the to-be-remembered material. The remaining question is whether children also exhibit orderliness of organization in the retention and retrieval of information.

a. Recall of Categorizable Material

In an early attempt to determine the extent of clustering activities in children, Rossi and Rossi (1965) presented children ranging from two to five years of age lists made up of three words from each of four conceptual categories. Results were consistent with adult performance. All age groups clustered at above chance levels. Similarly, total recall varied as a function of age. Most significant is the finding that children as young as two years of age profited from the presence of categorizable material in the input condition. Results were replicated in subsequent studies (Rossi and Wittrock, 1967; Vaughan, 1968) while

confirmation that two-year-olds make use of relations between input items is offered by Goldberg, Perlmutter, and Myers (1974).

To gather additional criteria pertaining to this developmental progression in organization, Rossi and Wittrock (1971) instructed subjects aged two through five to recall a randomized 12-item list of familiar words composed of two pairs of words classified as rhyming (sun-fun, hat-fat), syntactic (dogs-bark, men-work) and clustered (peach-apple, leg-hand). Again, developmental trends were noted. Rhyming was dominant at age two, syntactic clustering peaked at age three, taxonomic clustering was prevalent at age four, and serial ordering (the degree of conformity between input and output) was most frequent at age five. Interpretations suggest that development progresses from concrete, perceptual functioning to abstract conceptual responding. With children ranging in age from four and one-half years to ten years, Melkman and Deutsch (1977) and Naron (1978) also observed a shift from a perceptual to conceptual mode of organization together with the youngest groups ability to utilize categorical clustering in recall.

There exists substantial evidence that memory in free recall tasks improves with age. Clustering, or the ability to categorize conceptually related material, is a powerful coding device responsible for much of this age-related improvement. Along with these developmental changes in the bases of cognitive organization, investigators have sought to determine whether other variables, aside from age, affect total recall and output categorization. Some answers to this question have been provided by altering the presentation conditions so as to enhance the possibility that subjects would discover the nature of the categorical structure of the stimuli.

To supplement a random ordering of the input list, Cole, Frankel, and Sharp (1971) structured the stimuli in a "blocked" fashion based on semantic categories. Children from the first, third, and eighth grades were presented either randomly ordered input lists or blocked lists in which members of the same category appeared together. Total recall varied as a function of age with the blocked presentation producing the best recall. Eighth graders displayed clustering to a greater extent than both younger groups. The older children, therefore, took greater advantage of the built-in categorical structure of the word lists at the time of learning than did the younger children.

As in the Cole et al. (1971) investigation, lists of conceptually related items were presented in both blocked and random fashion to children aged four to nine and ten years of age by Yoshimura, Moely, and Shapiro (1971). Recall and clustering were higher for the older than for the younger children. Likewise, the blocked picture lists enhanced recall only for the older children. These findings contrast with the Cole et al. (1971) findings with regard to the age at which blocked presentations facilitate recall. To date, experimental data are insufficient to permit conclusive decisions about the age at which blocked presentations lead to improved output performances. It appears, though, that older children have developed more effective storage and retrieval strategies when compared to younger subjects.

In a somewhat different procedure, although still addressed to the issue of the generally better performance of older children in categorized free recall, Kobasigawa and Middleton (1972) utilized a picture list depicting four categories of six items each. In addition to the typical random condition and blocked (grouped) condition, one half of

kindergarten, grade three, and grade five children were told that some of the pictures belonged together. Total recall was correlated with age while the blocked presentation facilitated organization for all grade levels. Surprisingly, telling the younger subjects about the categories had little effect on clustering. Regardless, it does seem that categorical identification at input facilitates organization and can serve as retrieval cues. Added support for the developmental trend of improved clustering and recall, in both single and multi-trial performances, and of the facilitating influence of a blocked presentation is furnished by Moely, Olson, Halwes, and Flavell (1969), Neimark, Slotnick, and Ulrich (1972), and Ornstein, Naus, and Liberty (1975).

From the foregoing, it is apparent that clustering varies with the ease with which children discover the categorical nature of the stimuli and that active and strategic memorization is a function of age. That children tend to become mature information processors only over time is a conclusion confirmed from the analyses of their recall performances. Developmental changes in the ability to devise appropriate strategies for remembering reflect changes in the child's efforts to retrieve the information.

b. Retrieval Cues

As described by Posner (1973), retrieval is "the process by which information stored in long-term memory is activated to recognize new input...(p. 40)." Organization of the material must be neatly packaged if one is to gain access to the stored information. In a classic paper, Tulving and Pearlstone (1966) distinguished between the availability (storage) and accessibility (retrieval) of information at the time of recall by presenting categorized word lists to adult subjects.

Category names were presented during input with instructions to remember only the words representative of each category. In a cued recall condition, category names (retrieval cues) were provided; in non-cued recall, category names were absent. The availability of the words at the time of recall was therefore the same for all subjects and differences between the two recall conditions could be attributable to differences in the accessibility of the stimuli. As hypothesized, cued recall was superior. They concluded that information may be stored and available or conversely encoded but inaccessible unless the appropriate category cue is provided.

Whether these retrieval cues exert the same influence upon children's recall was investigated by Scribner and Cole (1972). Children seven-, nine-, and 11-years of age were presented a 20-item categorizable word list composed of four categories. In one cue condition, subjects were given category names both at the time of presentation and at recall. In a constrained condition, category names were provided at presentation and recall with subjects required to recall all instances of a given category before proceeding to the next category. At all ages, constrained recall provided an increase in the amount recalled, even during a later probe when all restrictions were removed. At that time, the free recall performance of those subjects formerly assigned to the constrained condition revealed greater organization of output than that of the other children.

Although cuing and constraining recall make accessible the categories, in the cue condition the effective use of the categorical structure was at the subjects' discretion. In contrast, constraining recall has a stronger effect in that it removes any option regarding the

possible use of the categorical information.

Halperin (1974) assessed "retrieval deficit" (Kobasigawa, 1977) by examining performance of six-, nine-, and 12-year-old children on a 36-item word list representing nine semantic categories and presented in blocked form. The superordinate label preceded each particular category. During recall, half the subjects received these category names as retrieval cues. As with Tulving and Pearlstone (1966), the cuing was beneficial. Recall was facilitated across all ages and total category recall increased as a function of age. Again, more information was available than could be retrieved under unaided recall.

Younger children, aged six, eight, and 11, were tested by Kobasigawa (1974) where the retrieval cues were pictures of places and objects related to the individual category members and available during presentation (e.g., zoo was the cue for animals). Two recall conditions were established in addition to standard free recall instructions. In a cue condition, subjects were shown picture cards and told to look at them and use them in any way to help them remember. Under a directive cue condition, subjects were reminded about the retrieval cues and told the number of items which need to be recalled for each cue.

As age increased, more children took advantage of the retrieval cues, while older subjects recalled more items than the younger cue users. The improved recall performance of the two younger age groups was attributed to the enhancing influence of the directive cue procedure. In comparison, the 11-year-olds' performance was not significantly different under both conditions, a finding suggestive that the availability of the cues during recall was sufficient to improve their recall scores.

To recapitulate, the development of retrieval skills emerges in a way parallel to that of the storage of information. Both show definitive, age-related changes in the spontaneous and deliberate attempts to employ systematic strategic techniques to learn and remember. Organizational skills and memory abilities continuously expand with age. As Hagen, Jongeward, and Kail (1975) state: "...The use of mnemonic strategies emerges over a period of years.... By ten to eleven years the child appears to have a working flexible repertoire of these strategies from which he can draw when the situation demands (p. 52)."

c. Subjective Organization

As an alternative to the use of categorizable stimuli as input, a subject may impose his own personal organization on unrelated items. This procedure is known as subjective organization. Measurements are taken of subjects' consistency in recalling items in the same sequential order over a series of trials. Each presentation is a different random order of the list. As with recall of related words, conscious restructuring of the input reflects the individual's efforts to remember it more effectively. With adults, the degree of organization increases consistently over the course of learning (Tulving, 1962).

Only a handful of studies have probed the aspect of organizational ability in children. Nelson (1969) investigated the categorical and subjective organization of five- and eight-year-old children and the extent to which this organization was influenced by training. Stimulus lists consisted of the childrens' and adults' category items (previously determined) and unrelated words. In one condition, subjects were pre-trained on either a list of category names or unrelated words. The input lists were presented for six recall trials following recall on the

training lists.

Category label training had no effect on the recall of either age group. The eight-year-old children showed improvement on the number of items recalled over each trial and also increased their category and non-category organization. Younger subjects failed to exhibit this growth. From the data, it appears that the utilization of appropriate organizing strategies is restricted to older children.

Ornstein, Naus, and Liberty (1975) found subjective organization to be minimal across grades three, six and eight and across trials, although covert rehearsers were superior to overt rehearsers in terms of organization and recall. In contrast, Glidden (1977) observed subjective organization to increase over two sessions for five- and eight-year-old children although it did not change as a function of age.

Due to these inconclusive and disparate results, definitive statements regarding age-related processing differences (as they apply to subjective organization) cannot presently be offered. The construction of a personal organizational scheme based on unrelated stimuli is probably a "higher-order" mental process than that of organizing categorizable input. In any event, it seems that subjective organization is a later-developing mnemonic activity than organizing items according to given taxonomic and superordinate structures.

#### d. Self-Imposed Categorization

Still another method for examining the use and development of mnemonic control processes allows subjects to construct their own conceptual schemes. Mandler and Pearlstone (1966) demonstrated that when adults were "free" to impose their own categorization on a stimulus array, in the form of sorting the material into the same taxonomic

groupings on two consecutive trials, they attained criterion faster, made fewer errors, and used less time per trial than a constrained group who were not free to employ individual mediational preferences. As the number of categories increased, there was a corresponding increase in the number of words recalled.

To determine whether the results were subject to changes with age, Mandler and Stephens (1967) gave seven-, nine-, 11-, and 13-year-olds a free or constrained task with high frequency familiar words. A free group was instructed to sort the words into a self-determined number of categories. Criterion was two identical sorts in succession. Subjects in a constrained group were told that they were to learn which words belonged to certain categories. The target categorization was a duplication of a partner's final sorting under the free-sorting condition. A surprise free-recall test followed attainment of the criterion.

The adult findings were replicated with children. Free-sorting subjects made fewer errors and used less time and fewer trials to reach criterion than the constrained group. They also showed a greater tendency to cluster in recall. Age differences were obtained for all these measures and for total recall.

In a related procedure, Moely, Olson, Halwes, and Flavell (1969) presented children ranging in age from five years to 11 years a randomly ordered set of categorizable pictures. After naming each picture, the experimenters left the room for several minutes. In a control condition, the subjects were free to reorganize the stimulus array in any manner. Children in a naming condition were given the category labels prior to the study period. In a teaching condition, the experimenters assisted the subjects in correctly sorting the pictures, in labeling the categories,

and in counting the number of instances in each. It was further suggested that it would be easier to remember if the various categories and their individual members were thought of. During a two-minute study period, all attempts to reorganize the pictures were recorded. Pictures were removed prior to recall.

The younger children did not spontaneously rearrange the stimulus array into taxonomic structures during the study period; they did cluster the pictures into categories when instructions and teaching were provided (although they reverted back to their nonstrategic behavior when instructions ceased). The teaching condition induced more clustering than in the naming and control conditions for kindergarteners and first graders. In contrast, the ten- and 11-year-olds spontaneously engaged in conceptualization schemes.

Employing virtually an identical methodology and age range, Neimark, Slotnick, and Ulrich (1971) also found strong support for the conclusion that the restructuring material for organizational purposes is a major determinant of age-related differences in the number of items correctly recalled and in the amount of clustering. Incorporating a paradigm of multiple recall trials, Paris (1978) observed sixth graders to construct consolidated clusters of categorized words. The efficacy of training children to use organizational devices to increase the number of categories recalled, the number of items per category, and clustering was demonstrated by Moely and Jeffrey (1974) and Hall and Madsen (1978) and transfer of training to a new task by Bjorklund, Ornstein, and Haig (1977).

In a different training experiment in organizational techniques (Liberty and Ornstein, 1973), fourth graders and college students were assigned either to free-sorting or constrained sorting groups. As in

the Mandler and Stephens (1967) sorting technique, free-sorters could adopt any sorting pattern in organizing a list of 28 high-frequency words into two to seven groups. Criterion was either two identical sorts on successive trials or six alternating sort/recall trials. Subjects in a constrained condition were forced to learn the grouping schemes developed by a "free-sorting" partner. In other words, children were forced to learn the sorts of their peers as well as those of adults, while college students were required to reproduce the sorts of younger subjects in addition to those of other college students.

In contrast to the ease with which free-sorting older subjects reached criterion, fourth graders experienced difficulty in reaching criterion within the allotted number of trials. Recall was greater for adult subjects who generally made more efficient use of the sorting categories in recall and clustering although both groups were operating with the same number of categories (5) in the last two sorting trials. However, fourth graders failed to provide explanations or names for the categories created. Most significantly, the younger subjects displayed idiosyncratic sorting patterns while the organization of the adults was similar. Children sorted less on word meaning and more on phonemic similarity or spatial position while adult patterning was semantically based.

Under the constrained sort, fourth grade recall improved when provided with the adult's organization pattern while adult performance deteriorated when supplied with the fourth grader's scheme. Again, adults used the sorting categorization to a greater extent in recall and clustering than fourth graders. However, the recall performance of the free-sorters and their same-age constrained "partner" did not differ, indicating that age, not the constraining condition, affects organizational techniques.

Developmental trends in personal category organization were elaborated upon by Lange and Jackson (1974). Six-, nine-, 12-, 15-, and 19-year-old subjects attained stable free-sorting schemes prior to a single trial of free recall. There were significant developmental changes in sorting time, in the number of sorting categories and in the average size of the categories. Younger children formed smaller categories, a greater number of categories and required more time to reach a stable grouping of items. The sorting criteria, as exemplified by subject's verbal explanations, indicated that even the six-year-olds used a high percentage of superordinate groupings to arrange their sorts. Analysis further showed that once stable sorting schemes were achieved, all subjects made reference to these arrangements during free recall and that they served to mediate their performances although younger children failed to attain the higher levels of clustering of older children.

In summary, developmental changes in the cognitive bases of organization in memory show the child to be an active learner. Systematic organization, in the form of self-imposed personal conceptualization, tends to enhance recall performance whether it be spontaneously utilized or induced. This "extra-facilitating" effect which appears when subjects are given opportunities to organize material at the time of input may be more sensitive to the individual's preferred modes of categorization than experimentally-determined schemes. It has since been demonstrated that children in the three- to four-year age range engage in mnemonically relevant activities (e.g., pointing, touching, looking) to prepare for future nonverbal memory tasks (Wellman, Ritter, and Flavell, 1975) and that this array of behaviors facilitates recall. Nevertheless, future research is in order to fully determine the extent that subjectively

derived control processes, specifically sophisticated knowledge regarding use of the superordinate, enhances both verbal clustering output and total recall.

e. Metamemory

This term refers to an individual's introspective knowledge concerning the workings of his memory system: estimation of accuracy of memory capacity, knowledge of task demands, appraisal of abilities and limitations, and strategic functioning for storage and retrieval (Kreutzer, Leonard, and Flavell, 1975). As the child acquires new and more sophisticated memory skills and becomes more intentional and strategic in his approaches to remembering, corresponding changes occur in the development of his knowledge and self-awareness of his own memory system. As Hagen (1971) hypothesized, the child begins to realize that he is an active memorizer and, in part, determines when and why intentional processing, storage and retrieval of information occurs (Flavell, Friedrichs, and Hoyt, 1970; Flavell and Wellman, 1977). Such a view dictates that the child can determine his level of performance on memory tasks and that performance can improve if these newly acquired skills are applied.

To determine if young children distinguish between memorizing and perceiving, Appel, Cooper, McCarrell, Sims-Knight, Yussen, and Flavell (1972) instructed four-, seven-, and 11-year-old children either to memorize categorizable pictures for future recall or merely to look at the stimuli without being informed of the recall test. A 90-second study period followed the stimulus presentation during which time subjects were free to inspect and manipulate the pictures. Only the 11-year-olds exhibited greater rehearsal, recall and clustering in the remember condition than in the look condition. In contrast, many of the

younger subjects in both conditions named the pictures rather than use a deliberate strategy to remember.

However, Yussen, Gagne, Gargiulo, and Kunen (1974) found with children ranging from seven- to 11-years of age, that all recalled more items when instructed to remember than when instructed to look at the stimuli. Also, seven-year-olds employed categorization schemes and fewer of the oldest children rehearsed.

The distinction between perceiving and memorizing in first graders received further study by Salatas and Flavell (1976). Employing a free recall paradigm and similar "look" and "remember" instructions, they found a clear-cut differentiation between the instructions based upon the spontaneous categorization during study time and recall performances. Metamemory questions were designed to tap the child's knowledge regarding the efficacy of categorizing stimuli for the purposes of recall and to ascertain whether young children realize that categorizable pictures are easier to remember than unrelated stimuli.

Responses showed no relationship to categorization in the free recall trials although correct answers for both questions were frequent. ("Remember" subjects gave more correct answers than "look" subjects.) Therefore, knowledge of the facilitating effect of categorization does not imply that such taxonomic groupings will be used as a conscious strategy in recall, a finding confirmed on a re-test six weeks later. For some subjects, inconsistent attempts at categorization indicated a transitional stage of development. Occasionally, children attempted to categorize the pictures on an early trial but not on subsequent trials. Others categorized on later trials but not on the first trials.

To examine developmental changes in organization, Tenney (1975) asked children in kindergarten, third, and sixth grades to compose word

lists that would be easy to remember. Each list was initiated by a key word mentioned by the experimenter. There were three sets of instructions pertaining to the generation of these lists. In one condition, the list was to consist of words belonging to the same taxonomic category while in a second condition, they were to select only words which would be easy to remember. A third group was to free associate to the key word by mentioning the first words that occurred to them. Examination of the words generated showed that kindergarteners were unaware of the inherent relationship between organization and recall. They did not spontaneously construct lists according to taxonomic membership but did when instructed. They also composed similar lists whether they were asked to free associate or compose easy-to-remember lists. With increasing age, lists were categorically structured. Some children were in a transitional stage (cf. Salatas and Flavell, 1976) where their explanations gave indications of adult strategies but their list generation did not.

In an extensive and revealing monograph, Kreutzer, Leonard, and Flavell (1975) interviewed 20 children at each of grades kindergarten, first, third, and fifth to sample their knowledge of "metamemory" through the presentation of several diverse questions and hypothetical problems concerning the storage and retrieval of information. The protocols covered in the interview included 1) the individual as strategy-user, 2) properties of the information which affect the ease with which it will be remembered, 3) strategies which facilitate recall and 4) the amount and kind of retrieval needed to satisfy the task demand. The data are summarized below according to the developmental periods covered in the study.

I. Kindergarten and First Grade: Children at these ages know some things about memory. They comprehend, for example, the everyday mnemonic expressions "remember," "forget," and "learn." They indicated that rote learning of meaningless information (e.g. phone numbers) is easily and quickly forgotten, while previously learned material is more accessible to retrieval. This age group appeared to realize that the ease of difficulty of the task, increased study time, the number of items to be remembered, and the attributes (especially perceptual salience and familiarity) of the items can all affect recall. These children displayed tendencies to adopt specific tactics when the goal of the task was retrieval. Such tactics included careful inspection of the items and a careful search when asked to locate an object (e.g., "Suppose you lost your jacket at school. Think about all the ways you would go about finding it."). During this developmental period, children commonly resorted to external mnemonic resources to achieve retrieval. For example, written notes, tape recordings, strings on fingers, and other people. In the latter, a question posed was "You're going ice-skating with your friend after school and you wanted to be sure to bring your skates. How could you be certain that you would not forget to bring your skates to school?" A common reply implied that "several heads are better than one," thereby indicating a reliance upon an external retrieval cue rather than upon their own internal processes to remember.

II. Grades Three and Five: In addition to knowing the same things as the younger group, the older children and especially the fifth graders knew them better and were more planful in their approach to remembering. The older school child was better able to understand the task in terms of its mnemonic implications and in the selection of an

appropriate tactic to meet this challenge. Responses of the third and fifth graders showed a heightened awareness to the fluctuations in memory performance as a function of the types of information and to the variability exhibited by children of different ages. These children are more efficient strategy-users, command a wider repertoire of task solutions and are aware of them, and thought of themselves as active memorizers to a greater extent than younger children. This broader range of mnemonic devices and their fruitful application included rehearsal strategies, self-testing and super-ordinate grouping patterns. Older children displayed a more insightful intuition in regard to the developmental progressions of improved memory skills. For example, third and fifth graders were more acutely aware that children of different ages engage in different behaviors during study time between the task presentation and retrieval and that these experiences can influence recall.

From this structured interview, an enormously rich amount of information was gathered. Clearly, metamemorial development, or the ability to talk about and be aware of information storage and retrieval, is a function of cognitive growth and learning experience and age, and more than likely begins its ontogenetic development in the pre-school periods (Flavell and Wellman, 1977). However, the implications and relationship of these abilities to actual memory behaviors on experimentally-defined tasks are, to date, not fully determined (Kelly, Scholnick, Travers, and Johnson, 1976). We are limited in what we know about the child's "knowing about knowing" (Brown, 1975). To understand better developmental changes in the child's mnemonic activities, the refinement of metamemorial knowledge must also receive study.

### Learning Disability: Language and Memory

Since the turn of the century, there has been a confusing overabundance of terminology to describe the child who today is labeled as learning disabled. Among the more commonly preferred terms are the brain-injured, minimally brain-damaged, neurologically handicapped, perceptually handicapped, and psychoneurologically handicapped. Reflective of the varied assortment of terms and the multi-disciplinary involvement, the construction of a universally accepted definition of such a disorder has consistently met with failure. In its place is an inclusive description of a heterogeneous group of children displaying inter-individual differences in their learning (dis)abilities.

Among the more generally accepted characteristics are average or above intellectual functioning, unimpaired physical and emotional states, and an absence of sensory impairments, mental retardation, and cultural deprivation. In spite of these areas of normal functioning, learning disabled children are believed to experience difficulty in perceiving information visually and/or auditorally. Disorders of listening, thinking, talking, reading, writing, spelling, and mathematics commonly exist. In other words, learning disabled children exhibit in some manner information processing dysfunctions in the form of receiving, organizing, and expressing information which cuts across perceptual, conceptual, language, and academic areas (Chalfant and Scheffelin, 1969). Such deficits or disruptions in one or more of these essential learning processes underscores their incapacity to learn under conventional classroom instruction and necessitates the intervention by specialized personnel, material, and educational methodology.

Undoubtedly, impairments such as these adversely affect academic learning and impede potential progress, the result terminating in a discrepancy between their expected and actual academic achievement. It is no surprise that children diagnosed as learning disabled learn at a slower error-filled pace when compared to normal functioning peers. The lack of school success can be looked upon as a developmental insufficiency in functioning. This handicapping condition is therefore the primary agent making learning a labored process.

Research on the language abilities of school-age children and young adolescents diagnosed as learning disabled is limited. Their language skills have not been as well documented as their behavioral and attentional syndromes, visual and auditory perceptual dysfunctions, and reading, writing, and arithmetic abilities.

The emerging data indicate language deficits of a diverse nature. In a study examining the use of morphological rules by learning disabled children, Wiig, Semel, and Crouse (1973) found that these children gave significantly fewer correct responses than a corresponding group of academically achieving children. Specifically, the learning disabled children experienced difficulty with third person singular, possessives (singular and plural), and adjectival inflections (comparatives, superlatives). Most significant is that their performance was characterized by idiosyncratic and unpredictable errors characteristic of a different as well as delayed developmental pattern. Morphological deficits were also observed by Vogel (1974, 1975, 1977) in a series of investigations into the oral syntax abilities of dyslexic children (defined as a specific type of learning disability). As part of her research, Vogel explored the performance of a group of second graders each who had repeated one

year of school. For this group, mean scores on eight of nine syntactic measures were lower than that of a group of academic achievers. This finding was interpreted to be indicative that "neither maturation, exposure to language over a longer period of time, nor continued education is effective in closing the gap between the syntactic ability of the repeaters and that of their younger normal classmates (1975, 79)."

Wiig and Semel (1973) evaluated the comprehension of linguistic concepts requiring logical operations in learning disabled children. The areas selected for study were comparative relationships (Is ice cream colder than coffee?), passive constructions (Don was driven home by John. Who drove?), spatial relationships (The dog fell on the cat. Who was on top?), familial relationships (Give another name for your mother's father), and temporal relationships between sequential events (Does spring come before winter?). The learning disabled children made significantly more errors than a group of academic achievers. The authors concluded that the learning disabled group exhibited difficulties (and failure) in processing and comprehending logico-grammatical sentences. In descending order of difficulty, they performed most poorly on familial relationships, followed by spatial relationships, relationships between sequential events, passives, and comparative relationships. The overall data suggest cognitive and logical processes parallel to that of younger normal children.

Employing the identical material with academically achieving grade school children, Wiig and Semel (1974a) found increases in the total number of correct responses in each of the five relationships for grades one through five, but no significant changes after grade five. These findings suggest that by age 11, sentences involving logico-grammatical

relations are mastered. It is interesting to note that the hierarchy of task difficulty coincided with the results found in their 1973 study with learning disabled children. This serves to substantiate the earlier findings that learning disabled children are delayed in the acquisition of morphological and syntactic skills and linguistic concepts.

In another investigation, Semel and Wiig (1975) assessed the comprehension and expression of syntactic structures (based upon the Northwestern Syntax Screening Test, Lee, 1969) and critical verbal elements (using the Assessment of Children's Language Comprehension, Foster, Giddan, and Stark, 1972) of learning disabled children. Analyses of their performances on the NSST (for both receptive and expressive subtests) indicated a significantly greater number of errors than a group of academically achieving children. The error pattern revealed that sentences containing questions, wh-forms, possessives, demonstratives, and relationships between direct and indirect objects proved most difficult. Performances on the ACLC were similar to those of 6.0 - 6.5-year-olds when compared to existing normative data. Interestingly, no age differences emerged in the performances of the learning disabled children. The findings provide added support for the quantitative reductions in the comprehension and expression of syntactic elements and demonstrate an inability to adequately process, analyze, and synthesize (i.e., remember) auditory language and verbal elements. The authors further suggest that delays in the acquisition of syntactic rules are not reduced by age, a result previously reported (Vogel, 1975).

A common misconception is that these deficits might disappear as the child grows older. Such is not the case. These cognitive and

linguistic processing and production deficits have been found to persist into adolescence. Utilizing a revised protocol of logico-grammatical sentences with learning disabled adolescents, Wiig and Semel (1974b) observed a quantitative reduction in their sentence comprehension. In a subsequent procedure involving the immediate recall of semantically and syntactically varied sentences (Wiig and Roach, 1975), learning disabled adolescents repeated fewer sentences verbatim than a group of academically achieving peers. These subjects also made more errors on anomalous sentences (e.g., Wasn't the fat ceiling robbed by the tired pen?), sentences containing correct and incorrect modifier strings (e.g., She has bought five large brown leather cases versus She has washed plastic red small eight cups), sentences with random word strings (e.g., walk some by hard of clearly table very), and syntactically complex anomalous sentences (e.g., the sky that the dream thought jumped cheaply). Errors of the learning disabled group were primarily word omissions and within-class word substitutions (resembling categorical intrusions since the failure to recall stimulus words led to the appearance of related words with membership in the same semantic category).

Goldsmith, Wallach, and Beilin (1974) examined the abilities of normal and learning disabled children to correct ungrammatical temporal sentences (e.g., Yesterday the boy mails the letter; tomorrow the lady walked to the store.). In all sentences the adverb appeared in either the initial or final position. Whereas the normal group changed the verb (morphological strategy) to agree with the adverb, the learning disabled children changed the adverb (lexical strategy) to make it agree with the verb tense. This suggests a qualitatively different rule system marked by a lack of age-related improvement in the learning disabled

population. Similarly, qualitative and quantitative differences exist in this group in the use of verb tense markers (Moran and Byrne, 1977), and function words (Edwards and Kallail, 1977). Wallach (1976) found additional differences in their ability to comprehend embedded relative clause constructions (e.g., The giraffe that bites the wolf kicks the hippo).

Further support for the claim that these reductions in the language processing and production abilities persist into adolescence is provided by a later study by Wiig and Semel (1975). Ratings were obtained between a learning disabled population and academic achieving peers on the accuracy and speed with which both groups 1) named verbal opposites, 2) retrieved verbal labels in response to pictures of objects, actions, numbers, and colors, 3) named members of the semantic categories of foods, animals, and toys, 4) produced grammatical sentences incorporating given stimulus words, and 5) defined words. In addition, ratings of conversational speech characteristics (melody, phrase length, articulation, sentence structure, word-finding, and word substitutions and circumlocutions) were recorded.

Tabulations indicated that the learning disabled adolescents experienced the greatest deficits on phrase length and grammaticality. The longest phrases contained an average of five words and were primarily of a simple declarative construction while the matched control group averaged ten to 12 words in a variety of sentence constructions. On the other measures, the learning disabled group exhibited reductions in the accuracy and speed of recalling verbal opposites (with-in class substitutions predominated), naming associated members of a semantic category (weakness in efficient clustering behaviors and difficulty in

retrieving semantic units from long-term memory), defining words (typically described functional attributes), and producing sentences (lacked grammatical complexity and required longer periods of time to generate).

To gather general data on the nature of the relationship among language processing and production deficits of learning disabled adolescents, Wiig, LaPointe, and Semel (1977) replicated the procedures from a previous study (Wiig and Semel, 1975). Inspection of the data indicated a performance plateau suggestive that developmental factors do not produce an improvement in their language abilities. Chronologically, they have surpassed the critical period of language development. It remains to be determined whether the deficits are amenable to intervention and remediation during early adolescence. Data were interpreted to mean that two distinct language deficit syndromes may be characteristic of a learning disabled population: 1) cognitive-linguistic processing deficits characterized by reductions in the knowledge (competence) and use (performance) of morphology and syntax and in the comprehension of linguistic concepts, and 2) dysnomia characterized by verbal paraphasias (difficulty with verbal associations and analogies) and word-finding and retrieval deficits.

The expanding picture, then, when compared to normal peers, is one in which learning disabled individuals experience delays in learning the language system with particular problems with the comprehension and production of logical relations, embedded clause structure, ungrammatical temporal sentences, production of complex sentences, acquisition of morphological rules, and word-finding and retrieval inefficiencies. Concurrent with this developmental delay is a qualitatively different

learning pattern. Finally, the deficit does not self-remediate with increasing age.

#### Memory Processing by Learning Disabled Children

The previous discussion raises the possibility that memory deficits are related to inefficient utilization of language skills. While findings with normal children have consistently found age-related increases in the application of processing skills, the generalizability of these results to children with learning disabilities is in question.

Employing a multi-trial free recall problem in a study of mediation processes, Bryan (1972) investigated the ability of learning disabled children (8.1 - 10.11 years old) to recall a list of 15 words which was presented either visually or aurally under one of three instructional conditions: forced rehearsal in which the children were instructed to say the word (or picture) aloud after seeing (or hearing) it; voluntary rehearsal where the experimenter suggested that either overtly saying the word or thinking about the word (or picture) might facilitate learning; and an attention condition in which it was explained that paying close attention would assist in learning. Results indicated that learning disabled children performed significantly poorer than a control group of academic achievers on recalling words under both the auditory and visual presentation regardless of instructions (although scores were higher for the visual modality for both groups). Thus the use of potential mediators (forced rehearsal, voluntary rehearsal, and attention) failed to assist in recall.

In a study of the free recall of word lists, Freston and Drew (1974) examined the performance of learning disabled children (mean age 10.10 years) in recalling auditorally presented stimuli of varying difficulty

and degree of organization. Word familiarity ranged from high difficulty (infrequently used words) to intermediate difficulty to low difficulty (frequent usage). Organized lists consisted of blocked conceptual categories while the unorganized lists were comprised of randomized instances of the same categories. Results indicated that list items of low difficulty proved easier than intermediate difficulty which, in turn, received more correct responses than items of high difficulty. Material organization did not influence recall performance indicating that the children did not effectively utilize the available input organization to enhance their recall performance. A subsequent study (Parker, Freston, and Drew, 1975) corroborated these findings.

However, conflicting findings have recently been reported by Suiter and Potter (1978) who found that organized pictorial groupings of categorical stimuli (four pictures per group from one category) were more effectively recalled by learning disabled children (8.6 - 13.8 years) than unorganized groups (four pictures per group but no more than two pictures from any category) when visually presented for recall. Similarly, Ring (1976) reported that both normal achievers and learning disabled children (mean age 7.7 years) profited from the presence of input organizational cues on tasks involving the recall of auditorally presented material (ungrouped and grouped tones and words [verbs]). Despite this qualitative similarity, the achieving children attained a higher total recall performance.

Lastly, Torgesen and Goldman (1977) explored the use of verbal rehearsal and short-term memory in second grade reading disabled children (in this study, learning disabled was defined as difficulty in reading performance). Utilizing a sequential recall task, the subjects were

required to indicate (by pointing) the exact sequence in which seven drawings of common objects were presented. After the presentation of the last item, a 15-second delay period was introduced before recall of the stimulus sequence. During this latency, all attempts at rehearsal were recorded. Upon completion of the recall task, the children were questioned about whether they had purposely initiated behaviors to help them remember the sequential order of the stimuli. Results indicated that the poor readers did not use verbal rehearsal to the same extent as the better readers and that a greater number of poor readers were unaware that verbal rehearsal functions as an effective and efficient mnemonic strategy. Deficient rehearsal processes were further evident on free-recall tasks (Bauer, 1977a, 1977b) and not unlike the performance of mentally retarded children (Belmont and Butterfield, 1969, 1971; Butterfield and Belmont, 1972; Brown, 1974).

Needless to say, much remains to be learned about the coding processes, organizational skills, and memory abilities of children diagnosed as learning disabled and their subsequent use in learning situations. The limited research available fails to provide a developmental comparison with normal functioning and does not fully explain the bases for their poorer learning and underachievement.

The role of clustering as a powerful index of normal memory functioning is well-known. Evidence of clustering demonstrates that the subject is actively operating upon the information. Likewise, failure to adopt a planful means of processing points to lack of mnemonic sophistication, and is correlated with a depressed performance. The present study explores the extent to which learning disabled children make use of the clustering strategy.

### CHAPTER 3

#### METHODOLOGICAL CONSIDERATIONS

In Chapter 2, it was shown that organization is a fundamental component of memory and, consequently, has been studied extensively in free recall tasks. Clustering represents an organizational strategy used by normal learners to increase the retrievability of information through the recoding of the material into a superordinate-ordinate relationship. Evidence for such recoding practices is relatively undocumented for a learning disabled population. To assess the organizational abilities of learning disabled children and to analyze their performance in comparison to normal functioning, the use of clustering in free recall was the focus of this study.

#### Stimuli

A popular means of assessing information processing in a free recall paradigm is the use of word lists consisting of randomly ordered words having membership in a number of taxonomic categories. The degree to which a subject reproduces these words during recall reflects his organizational skills, specifically that of clustering.

The words selected for use in this study were judged by the examiner and teachers to be familiar and easily identifiable by elementary school-aged children. Their corresponding pictures were black and white, hand-drawn reproductions taken from commonly used diagnostic instruments such as the Peabody Picture Vocabulary Test (Dunn, 1965) and the Templin-Darley Test of Articulation (Templin and Darley, 1960) and from therapeutic materials such as Word-Making cards (Medlin, 1977). Each was displayed on a 3" x 5" white, unlined index card.

The words were composed into three list structures differing in saliency of the list organization.

Related-random (clusterable) lists consisted of a random arrangement of related items belonging to several categories and therefore having the potential to be organized and recalled by conceptual category. No two words from the same semantic category appeared adjacent to each other in any list.

Related-blocked (clustered) lists consisted of a pre-established, massed (blocked) structure where all items from particular conceptual categories occupied contiguous input positions and were presented successively. In this manner, the experimenter externally imposed structure on the words to-be-learned as opposed to the learner, and as such, should have enhanced sensitivity to the organizational structure.

Unrelated word lists were constructed with minimal interitem associations to avoid any apparent meaningful connections. Consequently, there was no discernible underlying pattern of organization and negligible clusterability.

To insure that the relationship between organization and recall would be maintained, Miller's (1956) "magical number 7" was not violated. The number of individual words per category and the number of categories per word list were all subspan. Although the word lists themselves exceeded the limits of a short-term store, grouping the items into larger units circumvents this restraint and characteristically facilitates recall. Accordingly, a typical recall pattern is that of the appearance of a number of words from one category, followed by instances of a second category, then a third category, and so forth.

All word lists were equated for frequency of occurrence (column 1 norms) according to Thorndike and Lorge (1944). In these norms, the categories of A and AA are given to words whose frequency of occurrence falls within 50-100 per million and 100 or over per million, respectively. These ratings were used to compute the list means. Each list contained 33 syllables.

As a safeguard against serial position effects, buffer words were added to the initial and terminal positions of each list condition in Experiment I. In Experiment II, buffer words were not used with training cue lists. This exclusion in the training condition is crucial since the absence of a category cue in situations where all other items were cued might undesirably heighten the subject's awareness of these items. The buffer words were equated in terms of Thorndike-Lorge (1944) frequency but had no relationship to the categorical composition of the word lists nor were they related to any item in the unrelated list structure. They were not tabulated in recall totals. Lists are found in Appendices A and D.

### Procedures

#### 1. Modality Presentation

It has been demonstrated (Horowitz, 1969) that visual and audio-visual modes of presentation on free recall tasks are more effective than auditory presentation alone in enhancing total recall and clustering scores. To facilitate the detection of the principles of organization within the stimuli and subsequently maximize the probability of learning the material, the present studies utilized a bi-modal (auditory and visual) presentation. The use of an optimum means of stimulus presentation can lessen possible modality differences in learning style

and lead to greater opportunities in the attempt to reorganize and recall the material.

## 2. Multitrial Learning

In free recall of list items, organization is a necessary condition for successful performance. In light of the difficulties and frustrations experienced by learning disabled children on learning tasks, assessment based upon a single attempt at recalling the list items might not accurately reflect their remembering abilities. For example, low recall and clustering scores might be the result solely of slow awareness of the categorical composition of the stimuli. In such instances, increased study time, i.e., a number of learning trials, would permit more complete assessment of the subjects' capabilities. Presenting free recall lists repeatedly with a recall test following each presentation enables the subject to expand recall of words within categories and gradually form a larger and more stable organization of clustering. This procedure thus affords the experimenter an advantage of evaluating successive changes and gain across trials of both the total number of words recalled and the degree of organization. This alternating, input-recall trial paradigm is the means of stimulus presentation in Experiment I.

In the second part of the study (Experiment II), which probes the effects of supplying potentially facilitating categorical cues during input, evaluation of clustering activity was made on the basis of a single trial. In the training task, an initial measurement was obtained prior to the introduction of training. After the presentation of three lists of varying cue specificity, three additional measurements (using the initial word list) were secured.

### 3. Measurement of Clustering

To investigate the relationship between organizational strategies and free recall performance, a common coding criterion used to define the extent to which a subject structures recall is that of In-Class Repetitions (ICRs) (Tillman, 1975).

With this index, a subject must exhibit a sequence of two or more items within the same category during recall to be credited with a cluster. In other words, an ICR is earned for each occasion a succeeding word is from the same category as its predecessor with the exception that credit is not assigned to the initial word of the cluster to correct for chance pairings (Tillman, 1975).

For example, if the size of a cluster is two items, a score of 1 is credited while a "run" of three items receives an ICR score of 2, a run of four items an ICR score of 3, and so forth. In this manner, higher ICR scores reflect better and more organized recall. In Experiment I, where word lists contained 15 items representative of three different categories (plus buffer items), perfect organization would yield an ICR score of 12 while in Experiment II, a 4 x 5 matrix (five words from each of four categories) yields a perfect ICR score of 16.

### 4. Special Scoring Considerations

In calculating total recall and clustering performance, the following instances were not tabulated in recall totals:

- a. categorical intrusions which are words from the same category but not part of the stimuli list.
- b. irrelevant intrusions which are non-category words and not part of the stimuli list.
- c. repetitions.

Additionally, two scoring conventions adopted by Tillman (1975) to account for perseverative and intruded responses were included:

- a. If a categorical intrusion occurred, the intruded word destroyed the cluster.
- b. If repetitions occurred, it was not the first instance that was counted, but rather the instance which prolonged the length of the cluster.

The following chapters present the data for the study. Chapter 4 reports the performance of the learning disabled children in contrast to that of normal learners and Chapter 5 describes the outcome of training learning disabled children to cluster.

## CHAPTER 4

## EXPERIMENT I: USE OF STRATEGIES

The purpose of Experiment I was to identify the extent to which normal and learning disabled children use clustering as a strategy in learning and retrieving word lists during multitrial free recall. While it is widely reported that normal children routinely formulate a clustering strategy based upon the regularities of the word lists to enhance recall, information is minimal about how learning disabled children use clustering for storage and retrieval.

Inherent to the study was an examination of the relationship between word list composition and the amount and nature of the material recalled. Lists of varying structural saliency (unrelated, related-random, related-blocked) were presented to the subjects and assessments made of both total recall and clustering. The more efficient the processing, the greater the recall.

Low recall and clustering performance, however, could be indicative of either inefficient coding (availability) with a failure to enter memory or inadequate retrieval (accessibility) from the memory store. To differentiate between these two possibilities, an unexpected recognition task was interjected within the multi-trial presentations. If subjects correctly report positive recognitions, then accessibility rather than availability would apparently be the problem.

DesignSubjects

A total of 48 children participated in the initial study. Twenty-four males had diagnosed learning disabilities according to psychometric

and achievement test results. All but three of these children attended the Landmark School for Children with Learning Disabilities in Prides Crossing, Massachusetts. The other three children attended the Lakeside School - a school for special needs children in Peabody, Massachusetts. The learning problems of the Learning disabled group were not attributable to visual, hearing or motor handicaps, mental retardation, or emotional disturbance. No subject was on any medication. Academic retardation was at least two years below grade level.

The remaining 24 children, 8 females and 16 males, were drawn from a fifth-grade population from the Marblehead Public Schools in Massachusetts. All were receiving regular curriculum and were never enrolled in special education classes. All were regarded by their teachers as being normal academic achievers.

All subjects fell within an I.Q. range of 90 - 128 as determined by psychometric evaluation. Intellectual potential was judged to be adequate for task demands. The mean age of the learning disabled group was 10.75 years (range 9.5 - 11.5) and the mean age of the normal group was 10.69 years (range 10.0 - 11.2).

Subjects were chosen from a larger pool of children after discussion with school personnel (teachers, administrators, and/or research consultants) familiar with them. Selection criteria included recommendations from school personnel that the children would be cooperative and able to attend to the task and follow instructions. Children failing to meet these requirements were excluded from the study. No subject had received language therapy previously. All subjects were Caucasian, native English speakers.

### Stimuli and Procedures

The stimuli consist of two different word lists for each of the three list structures: unrelated, related-random, and related-blocked. Each list contains 21 items with three buffer words occupying the initial positions of the list and three at the terminal positions. With the exception of the unrelated lists which are composed of 15 unrelated items, the related-random and related-blocked lists contain 15 words in groups of five representing each of three conceptual categories. The related-random lists were composed of the categories vegetables, toys, professions, sports, receptacles, and furniture while the related-blocked lists included jewelry, parts of buildings, tools, weather, fish, and amusements.

All lists were matched for frequency of occurrence (Thorndike-Lorge, 1944) and contained 33 syllables. The lists are reproduced in Appendix A.

Each subject received two 21-item lists of each word list type for a total of six lists, four of which have potential recall by categorization and two consisting of unrelated words. The order of lists was randomized with the provision that no two lists from any of the three list structures appear together. This restriction produced the following order of list presentation: unrelated (list numbers 2 and 4), related-random (list numbers 3 and 5), and related-blocked (list numbers 1 and 6). Appendix A identifies each of the six lists.

To minimize possible order effects, there were two different orders of presentation. In condition one, 12 normal and 12 learning disabled subjects were randomly assigned to receive a presentation order of list numbers 4, 5 and 6 followed by list numbers 2, 3 and 1. The initial three lists were each presented twice with a recall attempt following

each presentation. For the remaining lists, there were four separate presentation-recall trials for each.

In condition two, the opposite procedure was established. The remaining subjects, 12 learning disabled and 12 normal subjects, were randomly assigned to receive list numbers 2, 3 and 1 for two presentation-recall trials and list numbers 4, 5 and 6 for four successive recall attempts.

Over each trial, words always appeared in a constant order. They were tape-recorded by a female speaker at three-second intervals.

Subjects were told that they would be shown and told the names of pictures. After each list was presented, they would be asked to recall orally as many words as they could in any order. As the word was spoken on the tape-recorder, the picture of that word was placed in front of the subject. It was covered by each succeeding picture.

Subjects were seen individually and allowed whatever amount of time needed to complete the task. The recall period was terminated, however, when the examiner judged that the subject was unable to recall additional items even after he was urged to continue. All subjects performed all recall attempts in a single session which lasted approximately 45 minutes. To encourage maximal motivation and retrieval, subjects were told that the task was a game in which their performance would be rated against their peers and that "winning" depended on their own efforts.

In both conditions, an unannounced recognition test was given prior to the four presentation-recall trials. Each recognition list (one for condition one and a second for condition two) consisted of 21 items; nine words which occurred in the lists (three from each list), six categorical intrusions (labeled "new") and six unrelated filler items

(labeled "neutral"). Subjects were told to indicate with a yes-no response whether the probe word was previously presented on the original lists. All words were bi-syllabic and equated for frequency of occurrence (Thorndike-Lorge, 1944). The lists are reproduced in Appendix B.

### Results

The mean scores for recall and clustering achieved by the normal and learning disabled groups are listed in Table 1. With the buffer items excluded from the tabulation, perfect recall is 15 items while perfect organization yields a clustering score (ICR) of 12. As can be seen, significant differences emerged between the groups on both recall and material organization. On each trial, the normal learners recalled and clustered to a greater extent than learning disabled children. This finding is true for each of the word list compositions.

#### Comparison of Normal and Learning Disabled Recall and Clustering

To compare the performance of the learning disabled versus normal groups, the number of items and ICRs in recall were analyzed across the four trials condition (i.e., Trials 3 to 6). These multi-trial measurements serve as better estimators of growth and document the differential growth rates more effectively than the two trial design where not enough information is learned. The performances of both groups of subjects (Table 1) are displayed in Figures 1 and 2. Use of this repeated presentation-recall design as an index of performance becomes crucial when one compares the initial attempts by learning disabled and normal achievers to recall and cluster.

Unexpectedly, with the exception of mean recall on Trial 3 of the related-random lists, no differences appear in their initial performances and hence the groups cannot be distinguished. However, on subsequent

TABLE 1

Comparison of Learning Disabled vs. Normal Performance

<u>Task</u>	<u>Trial</u>	<u>Normal</u>		<u>Learning Disabled</u>	
		<u>Mean</u>	<u>Standard Deviation</u>	<u>Mean</u>	<u>Standard Deviation</u>
Unrelated Recall	1	4.75	1.54	4.00	2.00
	2	5.92	2.08	4.33	2.32
	3	2.79	1.41	2.25	1.70
	4	5.13	2.09	2.58	1.82
	5	6.63	2.14	3.88	2.15
	6	8.13	2.97	4.54	2.23
Related-Random Recall	1	4.38	1.74	3.63	2.22
	2	7.54	2.28	5.25	2.54
	3	4.17	1.63	2.71	1.71
	4	6.92	2.34	3.92	2.66
	5	8.63	2.45	4.63	2.30
	6	10.21	2.17	5.88	3.35
Related-Blocked Recall	1	5.17	2.10	4.04	2.91
	2	9.21	2.02	4.83	3.09
	3	4.75	2.86	3.29	2.87
	4	8.96	2.73	4.29	2.88
	5	9.29	2.96	5.83	3.55
	6	10.83	2.88	6.21	3.36
Related-Random Clustering (ICRs)	1	1.63	1.14	1.46	1.70
	2	2.88	1.54	1.92	1.38
	3	1.17	1.20	.83	.87
	4	3.00	1.96	1.33	1.34
	5	4.38	2.36	1.54	1.35
	6	4.54	2.47	2.13	1.90
Related-Blocked Clustering (ICRs)	1	2.38	1.47	1.83	1.63
	2	5.17	1.71	2.21	1.96
	3	2.38	2.22	1.50	1.82
	4	5.71	2.70	2.08	1.82
	5	5.92	2.89	3.04	2.58
	6	7.00	3.23	3.29	2.56

attempts to recall and cluster, highly significant differences emerge which clearly differentiate the learning disabled children from their normal counterparts. This finding demonstrates that multi-trial learning enabled normal achievers to consolidate their output to a greater degree than learning disabled children. For example, the mean clustering scores of Trial 3 on the related-random lists indicate a nonsignificant difference of .34 words while Trial 6 reveals a highly significant difference of 2.41 words ( $t = 3.81, p < .001$ ). Even more enlightening is the comparison of Trial 3 versus Trial 6 clustering performance on the related-blocked lists. Here, there is an initial difference of a nonsignificant .88 words but a most significant 3.71 words by Trial 6 ( $t = 4.41, p < .001$ ).

The same pattern holds for total recall whereby only .54 words separate the two groups on the third trial of the unrelated word lists but 3.59 words distinguish performance by Trial 6 ( $t = 4.73, p < .001$ ). Similarly, a nonsignificant 1.46 words which fail to differentiate performance becomes a highly significant 4.62 words by Trial 6 ( $t = 5.12, p < .001$ ) with related-blocked input.

Thus while the initial attempts to recall and cluster appear low for both groups, the normal subjects improve rapidly while the learning disabled subjects' performance remains more stable with only small increments observed. With few exceptions, the sizes of the steps are manifestly significant for the normal group. That is, with the exclusion of the nonsignificant growth rates on recall (Trials 4 to 5 on the related-blocked list) and clustering (Trials 4 to 5 on the related-blocked list and Trials 5 to 6 on the related-random list), improvement with each trial is highly significant ( $p < .001$ ) no matter what class of material

FIGURE 1: Mean recall of learning disabled and normal subjects as a function of list condition

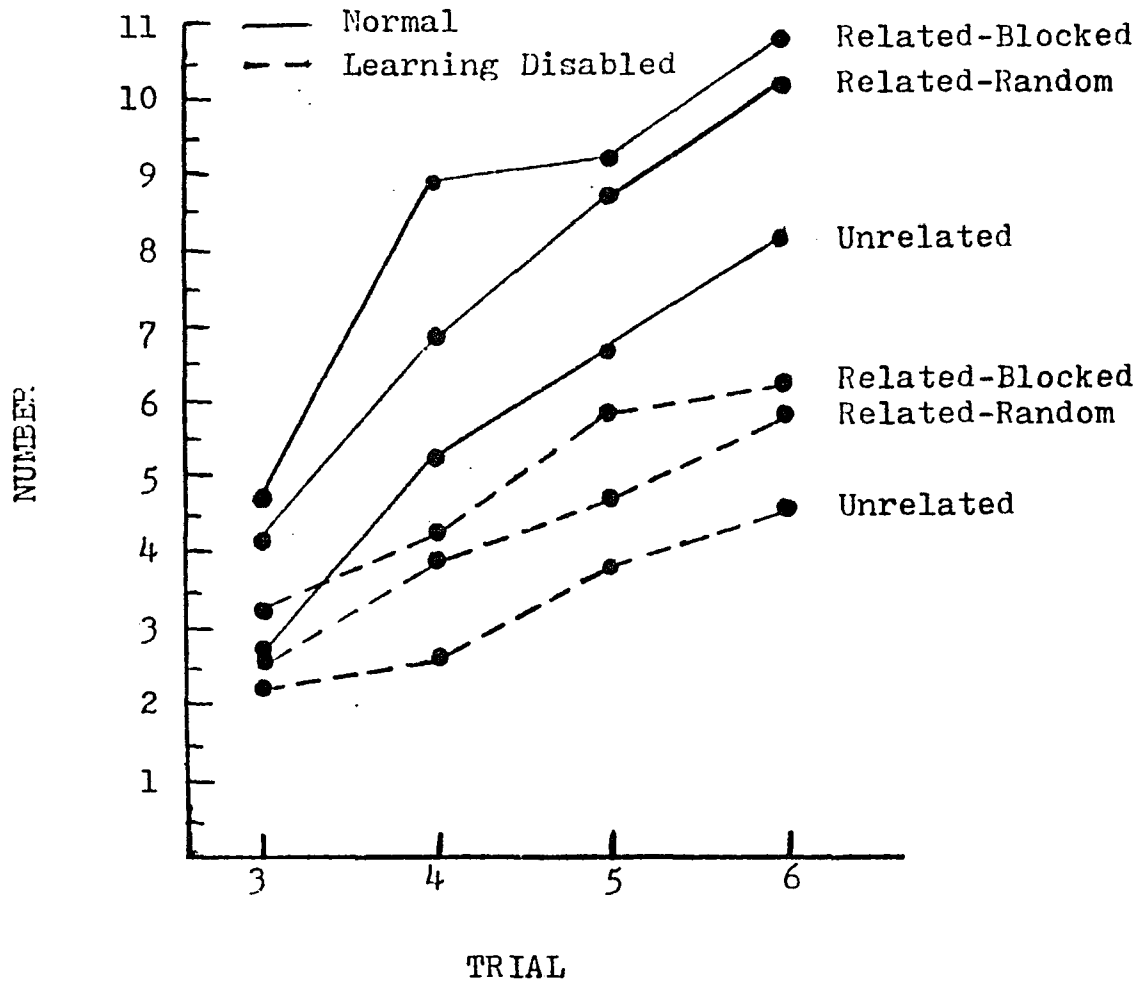
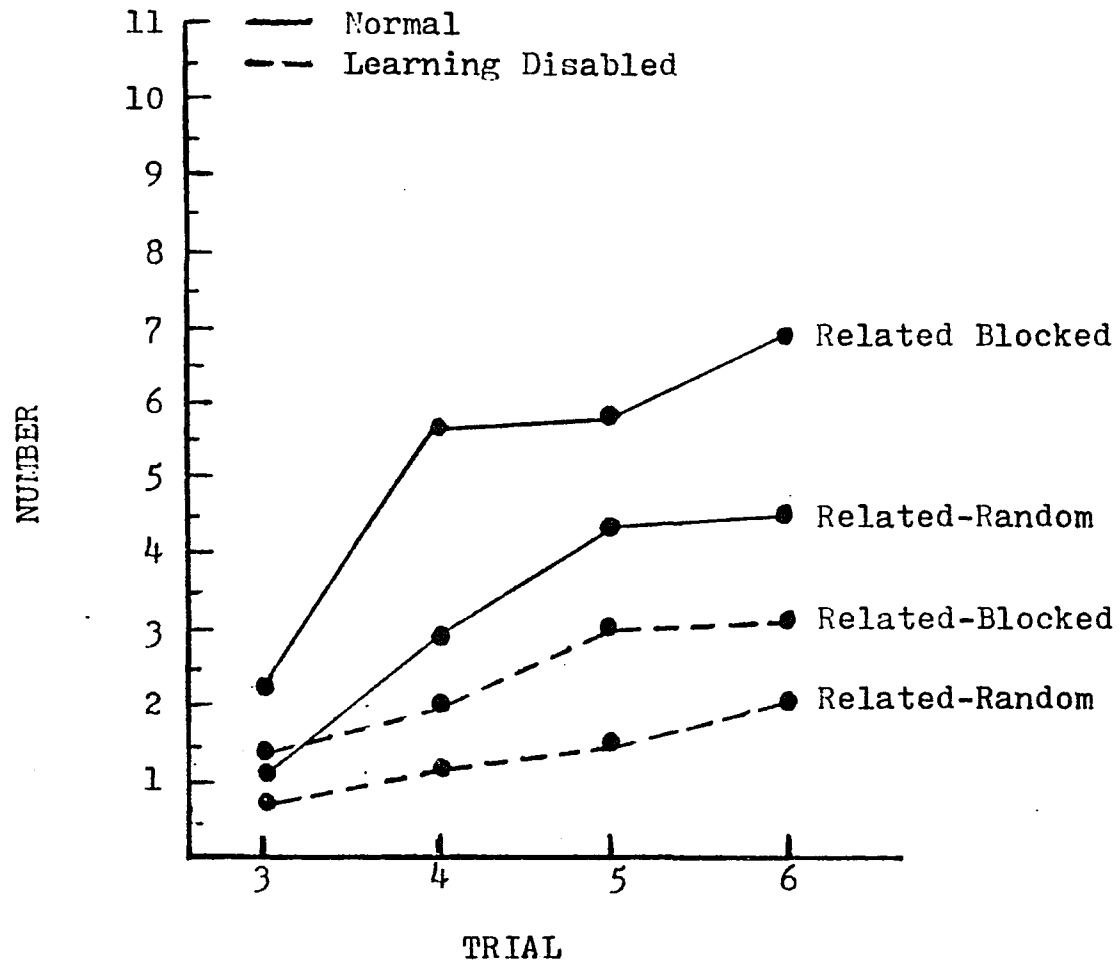


FIGURE 2: Mean clustering of learning disabled and normal subjects as a function of list condition



is assessed. For the learning disabled children, it is frequently the case that single additional trials do not yield significance. For example, with the unrelated and related-blocked stimuli, the growth in recall reached significance ( $t = 3.15, p < .01$ ;  $t = 3.42, p < .01$ , respectively) only between Trials 4 and 5. All repetitions were significant (Trials 3-4,  $t = 2.35, p < .05$ ; Trials 4-5,  $t = 2.13, p < .05$ ; Trials 5-6,  $t = 3.05, p < .01$ ) on the related-random material. Improvement in clustering attained significance on only two occasions, between Trials 5 and 6 with related-random stimuli ( $t = 2.93, p < .01$ ) and Trials 4 and 5 with related-blocked material ( $t = 2.93, p < .01$ ).

#### List Material Effects

Preliminary repeated measures of analyses of variance established that the normal and learning disabled subjects performed differently not only where the patterns of interaction (related-random versus related-blocked) are different but where the learning disabled subjects gave no evidence of responding differentially whether the stimuli were related-random or related-blocked. Accordingly, the two groups were considered distinct at the outset and subjected to independent sample t-tests as reported below.

Differences in mean growth in recall and clustering over all six trials of each word list structure are represented in Table 2. The data reveal more significant improvements for the normal subjects within each list type. Whereas normal growth within the related-random list ( $\bar{x} = 6.97$ ) was superior to unrelated stimuli ( $\bar{x} = 5.56$ ;  $t = 4.49, p < .001$ ) and the related-blocked list ( $\bar{x} = 8.03$ ) to the related-random material ( $t = 3.32, p < .01$ ), learning disabled performance yielded significance ( $t = 2.54, p < .05$ ) for only the related-random ( $\bar{x} = 4.33$ ) -

TABLE 2

Comparison of Mean Growth in Recall and Clustering of Learning  
Disabled and Normal Performance as a Function of List Composition

<u>Task</u>	<u>Recall</u>		<u>Clustering</u>	
	<u>Normal</u>	<u>Learning Disabled</u>	<u>Normal</u>	<u>Learning Disabled</u>
Unrelated	5.56	3.60	—	—
Related-Random	6.97	4.33	2.93	1.53
Related-Blocked	8.03	4.75	4.76	2.33

unrelated ( $\bar{x} = 3.60$ ) list comparison. Again, these growth patterns tend to differ in their magnitude with normal performance surpassing that of the learning disabled group within and among each class of material. Individual learning disabled performances are summarized in Appendix F.

The data (Table 2) also reveal that all contrasts between the two groups on their mean total recall and clustering are highly significant for each of the list materials: unrelated,  $t = 5.13$ ,  $p < .001$ ; related-random,  $t = 5.24$ ,  $p < .001$ ; and related-blocked,  $t = 5.36$ ,  $p < .001$ . This trend also holds on the basis of ICRs: related-random,  $t = 4.19$ ,  $p < .001$  and related-blocked,  $t = 5.16$ ,  $p < .001$ .

Inspection of the mean differences between the third and sixth recall trials for each list condition further illustrates the superiority of normal performance (Table 1). With unrelated stimuli, normals gained 5.33 words and learning disabled subjects 2.29 words. On the related-random word lists, normal recall grew 6.04 words compared to 3.17 words by the learning disabled group. With the related-blocked material, normals added 6.08 words, a growth rate similar to that of the related-random condition. Learning disabled subjects gained 2.92 words over the same set of trials which is less than their growth exhibited on the related-random lists. Overall, learning disabled children grew in total recall at approximately one-half the rate of the normals, although inter-comparisons across list structures failed to reach significance for either group.

A similar finding is observed in the growth of cluster scores. With related-random input, normals displayed a gain of 3.38 ICRs as compared to only 1.29 ICRs of the learning disabled group. With related-blocked material, normals added 4.62 ICRs while the learning disabled

subjects added 1.79 ICRs. Thus the organizational tendencies of the learning disabled group, as stated as a growth function, is about one-third (38%) the rate of normals. While the cluster growth of the normals was significant ( $t = 2.44, p < .05$ ), it did not reach significance for the learning disabled group.

Another vehicle for documenting the differences between the groups is to look for growth between the third and sixth trials and to express any improvement as a ratio of ICRs to total words. For normals, Trial 3 performance with the related-random material resulted in a 28% cluster rate and 44% by Trial 6, a growth of 16%. In contrast, the learning disabled subjects progressed from 31%, a performance slightly better than the normals, to only 36%, a 5% differential and one-third less than their normal peers. With related-blocked input, normals improved 15% with a beginning cluster rate of 50% and a Trial 6 performance of 65%. The learning disabled group advanced from 46% to 53%, a net improvement of only 7% and approximately one-half the rate of their normal counterparts.

#### Consolidation of Clusters

Further magnification of this difference is seen through examination of the length of the "runs" of clusters whereby the longer the run the more information packed into the cluster and the higher the ICR value. With a criterion of two used as the minimal standard to identify a cluster, a tally across all four trials on the related-random lists produces 104 clusters for the normal group as compared to 66 for the learning disabled group. On the related-blocked lists, 56 clusters were exhibited by normals while 63 are attributable to learning disabled

performance. The greater number of clusters for the learning disabled subjects is deceptive in terms of quantitative interpretation. However, as shown below, when consideration is directed to the number of longer runs demonstrated, it becomes increasingly apparent that the learning disabled children were not as efficient and effective in processing the input as their normal peers.

When a criterion of three defines a cluster, normals formed 51 such groupings as compared to 26 for the learning disabled subjects on the related-random lists. Similarly, 58 clusters were present on the related-blocked lists for the normals and 40 for the learning disabled group. When a run of four is considered, normals responded with 18 such groupings and learning disabled subjects with seven with the related-random structure. With the related-blocked input, 66 clusters appeared for normal performance while only 21 for learning disabled behavior.

Lastly, only six learning disabled children recalled all members of a category on at least one occasion with one of these subjects responding in this manner on three separate recall attempts. In total, eight perfect clustering performances were attained within any one category. In contrast, 19 normal subjects produced a total of 28 perfect clusters by recalling all members of a single category in a consecutive manner. Within this group, one subject achieved a ceiling performance where each of the three categories comprising a word list were recalled perfectly.

A related procedure is to calculate the total value of the ICRs. With related-random stimuli, normals went from 69 ICRs representative of 21 categories on Trial 3 to 168 ICRs from 65 categories on Trial 6, a 2.5 and three-fold increase respectively. Learning disabled subjects advanced from 39 ICRs in 18 categories on Trial 3 to only 83 ICRs and

32 categories by Trial 6, an approximate two-fold improvement. On the related-blocked lists, normals progressed from 85 ICRs and 31 categories on Trial 3 to 234 ICRs and 66 categories by Trial 6, a three-fold and two-fold growth rate respectively. With the same material, learning disabled subjects advanced from 58 ICRs and 23 categories on Trial 3 to a Trial 6 performance of 123 ICRs and 41 categories, a two-fold increase on both measures.

Thus, when more stringent criteria are applied to establish minimal clusters in correcting for chance pairings of category members and to serve as indicators of successful performance, normals tend to cluster more information and are unpacking this content during recall to a significantly greater degree than learning disabled children. While both groups clustered more over successive trials, normals added category members twice as fast as learning disabled subjects.

The basic inability of the learning disabled children to expand and consolidate the size of clusters remains evident by looking at its growth over the four trials. For example, on Trial 3 of the related-random lists, eight normals failed to cluster, 15 children exhibited 1 to 3 ICRs and the remaining subject had a score of 5 ICRs. In comparison, ten learning disabled subjects failed to initially cluster while the remaining 14 subjects ranged from 1-3 ICRs. By Trial 6, only one normal child still failed to cluster, five children had 1 to 3 ICRs and the remainder of the group exceeded 3 ICRs with a maximum of 12. However, six learning disabled subjects failed to demonstrate a single ICR while 12 learning disabled children attained 1 to 3 ICRs. Only six learning disabled subjects exceeded a score of 3 ICRs with upper limit of 6.

A parallel index of this deficit performance is the calculation of words recalled which fail to appear on subsequent trials. The most usual performance is to continue to recall on succeeding trials words which appear on preceding trials. On the related-random lists, normal children added 145 words between Trials 3 and 6 and learning disabled children 73 words. Over this same time, normal subjects failed to recall 93 previously recalled words and learning disabled subjects 92 words. While normal subjects gained more words on succeeding trials than losing previously held words, learning disabled subjects actually lose previously held words more often than they acquire new words. This appears to be a consequence of a failure to consolidate category groups.

#### Age Differences in Performance

To discount the possibility that the observed deficit performance might be accounted for by a poor showing of the younger learning disabled subjects, a within-group analysis was conducted. With a median of 10.85 years distinguishing younger versus older subjects, no age-related improvements in recall or clustering are noticeable. Collapsing the data from all the lists and summing across each of the four recall trials, the older group recalled 10, 53 and 37 more words on the unrelated, related-random, and related-blocked conditions respectively and exhibited 19 more ICRs on the related-random stimuli and 26 ICRs on the related-blocked condition. However, ratios of ICRs to total words reveal near identical performances. On the related-random input, older subjects attained a ratio of 2.90 while the younger subjects achieved a ratio of 2.93. Similarly, a 1.92 ratio characterizes the older group on the related-blocked material as compared to 2.05 of the younger group.

### Recognition

To determine whether their poor total recall and clustering performance could be attributable to a breakdown in short-term processing, attention next turns to the results of the recognition task.

Of the 21 items presented for recognition, 9 are classified as Yes (appearing on original lists) and the remaining 12 as No (not on original lists). Collapsing the data across both the learning disabled and normal groups, the two learning disabled groups made a total of 42 false recognitions and the two normal groups a total of 19 false recognitions. The breakdown of these incorrect judgments are as follows:

1. category members that appeared on the original lists but not recognized: learning disabled, 11; normals, 2.
2. unrelated words that appeared on the original lists but not recognized: learning disabled, 9; normals, 7.
3. "filler" items - neutral words not on original lists but judged to have appeared: learning disabled, 4; normals, 1.
4. categorical intrusions - semantically-related items to the original words not on original lists but judged to have appeared: learning disabled, 18; normals, 9.

For the entire population, an analysis of variance ( $F_{3,44} = 2.48, p > .01$ ) produced no significant effects on the number of incorrect judgments.

The response pattern of the learning disabled children strengthens the view that their failure to recall and cluster to the same extent as the normal achievers can be primarily attributed to a difficulty in the accessibility of the information. Of the 42 false recognitions, approximately 43% were categorical intrusions, an indication that the categorical composition of the word lists had been perceived. This is qualitatively similar to the approximately 48% of the error judgments on categorical intrusions made by the normal subjects. In fact, 17 of the 24 learning disabled subjects exhibited at least one incorrect judgment

regarding the appearance of semantically similar words which did not appear in the original lists. This access into the categories tends to establish that they were encoded and held in memory even when subjects were limited in ability to retrieve the material.

From a quantitative perspective, 49% of the errors appear to be due to a weak encoding or a failure to enter memory. Although these items may have been perceived, they were not remembered. However, of the 11 failures by learning disabled subjects to recognize that category members appeared on the original lists, approximately 36% were made by two subjects. Inspection of the data reveals that these two subjects accounted for 12 of the 42 incorrect judgments or 29%. Of these 12 errors, 4 pertained to category members, 4 to unrelated items, 2 to intrusions, and 2 to fillers. Of the remaining 30 false recognitions exhibited by learning disabled subjects, 16 were intrusions, 7 category members, 5 unrelated, and 2 fillers. Again more than 50% of these errors were intrusions.

Although the learning disabled children showed a basic awareness of the appearance of the original items, it did not adequately function to assist in the retrieval of the words from the memory store. The data more firmly support the notion that learning disabled subjects are restricted in their memory capacity more by a retrieval deficit rather than by inefficient coding. This factor, where the information appears to have been placed in memory but not spontaneously used to aid recall, appears responsible for their low performance on the recall and clustering of the word lists.

### Summary and Interpretation

The results demonstrate that learning disabled children were functioning in a manner similar to that of the normal achievers but at a reduced level. Whereas normal output in the multitrial free recall shows regular and steady increase in the number of items and ICRs recalled on each succeeding trial, the learning disabled group recalled less and clustered less frequently. Although both groups perceived the categorical nature of the word lists (as also witnessed on the recognition task) and did reorganize the input, these behaviors exerted a minimal influence and failed to facilitate performance for the learning disabled children to the same extent as for the normals. With the amount of organization low and with little improvement over time, the primary difference is one of magnitude where normals were adding words and clusters at a faster rate. As a result of minimal use of organizational strategies, learning disabled subjects were less proficient in consolidating groupings and expanding the size and number of the categories over repeated trials, all of which act to depress overall scores. Again, the differential rate of change over the four trials, in terms of increasing the number of items recalled and increasing the organization of this recall, remains fairly constant and near the level of their first trial performance.

In addition to these quantitative differences which confirm the hypotheses stated in Chapter I, inspection of Tables 1 and 2 shows that material organization had a strong facilitative effect on recall and clustering. Both groups profited from the increased saliency of the organizational structure although not to the same degree. Increasingly higher recall and clustering is noted for both groups across each trial

in each of the three input list conditions with the best performance occurring on the related-blocked list and followed by the related-random and unrelated list compositions respectively. Thus the presence of a relationship between items during input facilitates recall and clustering. The more pronounced the organization, the more advantageously it is used along with a corresponding reduction on the demand for the individual to introduce organization spontaneously.

For Experiment II, the related-random list composition was selected as the input. With its conceptually based framework, the subject needs to discover the inherent organizational pattern to structure his output. This tendency to transform the input reflects the subjects' capacity to discern the relatibility of items and to use strategic plans to recall and cluster. As a guideline to judge successful performance with training, the normative data from Experiment I will serve as an indicator of proficiency and as a desired goal to be attained.

## CHAPTER 5

### EXPERIMENT II: TRAINING

In the initial experiment, learning disabled children did not recall or cluster as efficiently as their normal counterparts. Is their processing deficiency attributable to a lack of ability or rather a failure to implement effectively operations within their repertoire? Can they profit from the presence of training cues? To reveal how learning disabled children learn to make use of organizational schemes, a hierarchy of training cues of increasing specificity was introduced during input. The functions of these cues are to shift attention towards the conceptual properties existing among the word lists, to assist in storing a representation of this structure, and to aid in the development of a better retrieval plan to guide recall. In essence, they should promote a categorical encoding of each stimulus with a consequence of orderly output. By prompting subjects to use organizational techniques to facilitate recall, the utility of training may be evaluated.

#### Design

##### Subjects

The same 24 learning disabled children who participated in the first experiment were subjects in the training component of the study. Based upon their performance in Experiment I, normals were excluded from participation in this phase.

##### Stimuli and Procedure

Each cue was intended to heighten the subject's awareness to the superordinate structure of the word lists. Trial 1 provides a pretraining

estimate of the amount recalled and the degree of the clustering. Cue 1 establishes an associative relationship between a categorical picture and the stimulus items (Appendix C) while the identification of the category by the examiner in Cue 2 consolidates awareness. Cue 3 is the most salient dimension because the subject is actively engaged in a sorting process of his own preference and hence is cognitively involved in decision making. In addition, he was free to rehearse the pictures from the sortings before they were removed prior to recall. Three additional Trials (Trials 2-4) were included to assess the degree of generalization to which subjects spontaneously apply the principles of organization developed during training and to compare their performance to the four trials condition of Experiment I. All subjects were exposed to these seven conditions as follows:

Trial 1: A list of 26 words was presented for recall. The list consists of four categories of five words each arranged in random order and enclosed by a triad of buffer words occupying the primacy and recency portions of the list.

Cue 1: A random array of 20 words (four categories of five words each) was presented for recall. Each stimulus picture was centered on an 8" x 11" cardboard placard. In addition to each category member, a picture illustrative of the superordinate label appeared in the upper right section of the placard. For example, a picture of a cage represented the category animals. No attention was drawn to this pictorial cue. After each stimulus was presented, it was placed in front of the subject and covered by each succeeding picture. Prior to recall, the stimuli were removed from view. The cues are presented in Appendix C.

Cue 2: The procedure was identical to Cue 1. However, in addition to the stimulus word and pictorial cue, the category name accompanied the presentation of the category item. For example, "dog - which is an animal."

Cue 3: Stimulus cards and presentation were of the same form as in Cue 2, but on presentation, subjects were instructed to sort the stimuli into groups according to the pictorial cues. For assistance, four pictorial cues identical to those appearing on the stimuli cards were present on the table. As each stimulus was presented, the child was required to organize them into appropriate categories. All errors in placement were immediately corrected and then recorded. A perfect sort into the four columns was required prior to recall. The stimuli remained visible during sorting to provide an opportunity for rehearsal but were removed prior to recall.

Trials 2-4: The procedure for Trial 1 was replicated using the original list.

Word lists were equated for frequency of occurrence (Thorndike and Lorge, 1944) and excluding the buffer words in Trials 1-4, each contained 34 syllables (Buffers were monosyllabic and also matched for their frequency). List structure was related-random with the provision that within each group of four words, one instance from each of the four categories was represented. Prior to the presentation of Cue 3, a practice set of pictures was utilized to familiarize each subject with the general nature of sorting. A single trial of free recall followed an audio-visual presentation of each list. All subjects performed the task in a single session which lasted approximately 30 minutes. The word lists are reproduced in Appendix D.

To insure the validity of the cues in the form of equal clusterability and recall, normative adult list learning data were obtained. Seventy-five undergraduate students in the Speech-Language Pathology and Audiology Program at Northeastern University were equally and randomly assigned to one of three list presentation orders: Group one received an order of Cue 1, Cue 2, and Cue 3; Group two, a grouping of Cue 2, Cue 3, and Cue 1; and Group three, an order of Cue 3, Cue 1, and Cue 2. In this free recall pretesting, each list contained three pre- and three post-list buffers. All were monosyllabic and equated for frequency of occurrence (Thorndike and Lorge, 1944). The nature of these buffers are presented in Appendix E.

Analyses of variance for both total words recalled and total clusters (ICRs) revealed no significant differences among the three groups or among the three cues. For the three cue lists, the mean number of words recalled was 10.85 words and the mean clustering score was 6.01 ICRs. In addition, no significant effects of presentation order were found.

In sum, analysis of normative adult learning of the cue lists revealed that the lists are balanced for clusterability and ease of recall. These results establish the validity of the cues to be used in the training component of this study.

### Results

The mean scores for recall and clustering achieved by the learning disabled children are presented in Table 3. Perfect recall is 20 items while perfect organization yields a clustering score of 16.

The introduction of cuing shows an immediate effect upon recall whereby a significantly greater number of words are recalled on Cue 1 than on Trial 1 ( $t = 3.55, p < .001$ ). However, despite the presence of

TABLE 3Learning Disabled Performance with Training

<u>Variable</u>	<u>Mean Recall</u>	<u>Mean Clustering</u>
Trial 1	6.79	2.13
Cue 1	8.88	4.04
Cue 2	9.29	4.58
Cue 3	10.80	5.21
Trial 2	7.67	2.88
Trial 3	9.29	3.75
Trial 4	9.42	3.58

three training cues of increasing specificity, their effects were not immediately generalized so that the gain in mean words recalled between Trials 1 and 2 failed to reach significance. The single step improvement between Trials 2 and 3 was, however, significant ( $t = 3.75$ ,  $p < .001$ ) with a maximal growth of 1.62 words while a nonsignificant .13 words separates Trials 3 and 4.

Within the training lists, each of the three cue conditions yielded more words recalled than its predecessor. Whereas the growth between Cues 1 and 2 is not significant, it does achieve significance between Cues 2 and 3 ( $t = 2.21$ ,  $p < .01$ ). Yet only the recall of Cue 3 surpasses the highest recall attained within Trials 1-4 which were recalled without the benefit of cues.

In comparison, the cues were not functioning as effectively in clustering. Within the cue lists, the appearance of cues did not lead to significant differences in cluster scores and therefore the three word lists are not discriminable on the basis of ICRs. Over Trials 1-4, growth is observed although of lesser magnitude than that of recall performance. Between Trials 1 and 2, some improvement occurred ( $t = 2.07$ ,  $p < .05$ ) while the greatest single increase of .87 ICRs existed between Trials 2 and 3 ( $t = 2.35$ ,  $p < .05$ ). Overall growth was best between Trials 1 and 3 ( $t = 4.28$ ,  $p < .001$ ) with a slight regression appearing by Trial 4 ( $t = 3.13$ ,  $p < .01$ ) due to a loss of .17 ICRs. As with recall, clustering behaviors fail to yield significance between Trials 3 and 4. Even its initial effects, as measured by the difference in clustering between Trial 1 and Cue 1, is not as strong ( $t = 3.34$ ,  $p < .01$ ) as with recall ( $t = 3.55$ ,  $p < .001$ ) although it progressively yielded more ICRs between Cue 2 ( $t = 5.32$ ,  $p < .001$ ) and Cue 3 ( $t = 6.36$ ,  $p < .001$ ).

The failure of the cues to enhance performance is further substantiated by looking at the number of words recalled but failing to appear on subsequent trials. As mentioned in Experiment I, it is common to continue to recall on later trials words which were recalled previously. Between Trials 2 and 3, subjects acquired 29 new words but lost 41 words which had been recalled on Trial 2. Only 13 new words were added on Trial 4 while 58 words recalled on Trial 3 were forgotten. The same trend developed in Experiment I continues with the learning disabled children losing previously held words more often than they acquire new words. This loss, which tends to keep overall performance low, again appears to be a consequence of a failure to consolidate category groups.

Another indication of the limited value of cuing in generalization arises through inspection of the subjects' failure to recall at least one word from each of the categories comprising the word lists. Prior to presentation of the cue lists, a total of 20 categories were not recalled on Trial 1. Within the cue lists, a steadily improving performance is noted whereby only 14, 12, and 10 categories were not detected on Cues 1, 2, and 3, respectively. Despite this exposure to training, the number of categories that failed to be mentioned on post-training Trials were comparable to that of Trial 1: 19 categories were not mentioned on Trial 2, 15 on Trial 3, and 13 on Trial 4.

When individual differences are inspected, we find a wide range of performances. Summing for each subject his recall and ICR scores over each of the seven conditions, the five best subjects attained recall scores of 100, 78, 77, 75, and 74 words recalled while the sums for the five lowest subjects are 31, 32, 33, 40, and 42 words. On the basis of ICRs, the five highest scores are 55, 41, 37, 37, and 36 and the five

poorest 7, 9, 10, 11, and 17 ICRs. In four of the five performances, subjects exhibited either high recall and clustering or low recall and clustering. Individual learning disabled performances are presented in Appendix F.

In an attempt to account for these extreme differences, the subjects' performance on the Digit Span subtest of the Wechsler Intelligence Scale for Children (Wechsler, 1971) was considered. The mean score for those subjects with high recall was 8.4 digits (range 6-11) which is similar to the 7.4 digits (range 6-9) of the group exhibiting low recall. Similarly, their digit span performance fails to distinguish them on the basis of ICRs. The high clustering group achieved a mean of 8.0 digits (range 6-9) as contrasted to the 7.4 digits (range 6-9) of the low group. Over the entire experimental group, digit span was not an accurate estimator of behavior since the most anomalous digit spans did not correspond with the most anomalous performances.

Digit span behaviors do, however, clearly discriminate learning disabled children from academic achievers. On the digits forward section, normals recalled an average of 7.33 digits and learning disabled subjects 5.13 digits ( $t = 4.29, p < .001$ ). On the digits backward component, normals remembered 5.00 digits as compared to the 3.67 digits of the learning disabled children ( $t = 2.75, p < .01$ ). Overall totals are highly significant ( $t = 4.81, p < .001$ ). These differences in recalling information in the order presented would appear to reflect the superiority of the normal learners in the use of strategic behaviors to enhance performance.

As in Experiment I, no age-related improvements in recall or clustering are observed. Older learning disabled subjects (median 10.85

years) recalled 35 more words within the cue lists than the younger subjects but 16 fewer words between Trials 1-4. An identical pattern emerges on the basis of ICRs whereby the older group exhibited 30 more ICRs within the cue lists but 32 less ICRs overall. Hence, spontaneous improvement in recall and organizational ability is not associated with a corresponding increase in chronological age.

#### Summary and Interpretation

The benefits accrued from the introduction of cues designed to highlight the taxonomic properties of the word lists were minimal for the learning disabled subjects. Although the cues yielded incremental performances where averages on each trial tended to increase, this improvement was dependent upon the behavior of only a few subjects as opposed to being a regular occurrence.

Within the cue list stimuli, more words were being recalled with regularity than clustered where no improvement occurred. Between Trials 1 and 2, transference of the training was not observed for recall but did lead to minor improvement in clustering. This result might be the consequence of interference from proactive inhibition where the subjects were "learning to learn." To counteract this effect, single step improvements between adjacent recall attempts should provide an indication of the nature of growth following training.

For recall, substantial gains are achieved by Trial 3 where performance seems to crest since a significant increment of words fails to appear at the next repetition. Over the same set of trials, less improvement is noted in clustering with a peak evidenced on Trial 3 and a regression on Trial 4.

A comparison of recall and clustering scores in Experiment II to Experiment I performance demonstrates the minimal influence of training to modify clustering behaviors. Inspection of overall growth patterns reveals that the growth in words and clustering in Experiment II is no different from the growth in Experiment I without the training. With the related-random list composition serving as the source of comparison, Experiment I performance improved by 3.17 words between Trials 3 and 6 as contrasted to only a 2.63 differential over the four trials in Experiment II. This 2.63 in words gained with cues even falls short of the normals poorest performance of Experiment I where they grew by 5.34 words on the unrelated list material and where a regularity of growth is observed independent of list material.

With clustering, a negligible .15 ICRs differentiate the growth in Experiment I (1.30 ICRs) from the growth in Experiment II (1.45 ICRs). This 1.45 gain in ICRs with cues is less than one-half the growth of the normal subjects (3.47 ICRs) in Experiment I.

Comparison of the growth rates between any two adjacent trials of the related-random input of both Experiments again indicates that the growth functioning of Experiment II is not superior to the growth of Experiment I. There is no single change in improvement in Experiment II that is significantly larger than a one-step change in Experiment I. The closest change in total words is between Trials 2 and 3 of Experiment II where growth is maximal ( $\bar{x} = 1.63$ ) and Trials 4 and 5 of Experiment I where we observe the smallest growth ( $\bar{x} = .71$ ;  $t = 1.81$ ,  $p > .08$ ). Similarly, the closest change in clustering between maximal performance of Experiment II ( $\bar{x} = .88$ ) and the smallest growth of Experiment I ( $\bar{x} = .21$ ) is  $p > .14$  ( $t = 1.53$ ). These performances appear on the same trials as

with total words.

A discussion of the conclusions and inferences drawn from both Experiments as well as therapeutic implications is presented in the following chapter.

## CHAPTER 6

### GENERAL DISCUSSION

Results of this study support clustering as a major determinant of performance. When required to process a supraspan amount of information in free recall, subjects impose structure during encoding and adopt retrieval schemes on the to-be-remembered words to improve their memorability and potentially facilitate performance. Clustering represents a method to remodel and unitize the items on the basis of common features into organized "chunks." With repeated exposure to the word lists, these chunks or groups tend to become enlarged and consolidated. Consequently, retrieval is typically guided by the categorical organization of the items and is characterized by a lawfulness and orderliness. Subjects recall the members of one category before entering into another category.

Literature on the use of the clustering strategy has shown that the growth and spontaneous application of this behavior develops during the elementary school years and is influenced by cognitive maturity and general learning aptitude. In the present study, the performance of normal achievers was superior to that of learning disabled children. The learning disabled subjects spontaneously and systematically used organizational structures, but to a lesser extent than did the normal learners and consequently were not as efficient in the use of the clustering strategy to overcome limitations of memory. As a group, they were not as sophisticated or proficient rememberers as the normal achievers. At the same time, the data do not indicate a complete absence of the clustering strategy to facilitate recall.

In Experiment I, subjects were asked to discover the categorical nature of the word lists. The data indicate that the normal subjects engaged in more effective and efficient task strategies in remembering the word lists. As an illustration, the performances of both groups are characterized by regular and systematic improvement in the number of words clustered and recalled on every trial of each list condition. However, where the improvement with each repetition was highly significant for the normal subjects, it was most commonly the case that additional repetitions were not statistically significant for the learning disabled subjects.

The data also reveal that the performance of the groups on the initial attempts to recall and cluster are indistinguishable. With repeated exposure to the word lists, the normal subjects progressively used clustering to expand and consolidate their groupings. Such behavior was minimal among the learning disabled subjects. Frequently, only one or two members of a category were recalled and, as a consequence, recall and clustering remained significantly lower than in normal performance. Generally, the learning disabled children increased total recall at approximately one-half the rate of normal subjects while clustering tendencies were one-third the rate.

In an attempt to overcome this limited performance, Experiment II included training cues designed to help the learning disabled subjects apply the clustering strategy more effectively. Specifically, the function of the cues was to facilitate a more deliberate approach to the storage and retrieval of the word lists by heightening their awareness to the conceptually based organization of the lists.

This focus on clusterability and inducement to group the items was,

however, not sufficient to trigger the strategic planning necessary for optimal recall and clustering for the learning disabled group. While training resulted in improved recall generally, it did not produce comparable gains in clustering. Although more words were recalled and clustered with regularity on all trials (with the exception of a nonsignificant drop-off in clustering on trial 4), the gains in clustering were of less magnitude than with the recall of the words. Overall, the effects of training were most commonly characterized by small but nonsignificant single-step improvements.

The finding that the cues failed to modify the strategic activities of the learning disabled children and were not instrumental in causing prolonged and significant changes in the amount recalled and clustered is further strengthened through a comparison of the maximal growth rates achieved by this group. Despite the assistance provided, no growth rate between any two adjacent trials of Experiment II was significantly larger than a comparable change on the related-random list of Experiment I. In addition, the overall growth in words recalled and clustered by the learning disabled subjects in Experiment II was not different from that of Experiment I. These growth patterns of Experiment II fell short of even the smallest gains noted for the normal subjects in Experiment I.

The results did show, however, that the learning disabled children were aware of the cues and of their difficulty in recalling the word lists. At the conclusion of Experiment I, several learning disabled subjects spontaneously offered reactions to their performance. Their comments suggested a problem in either the implementation or execution of a task appropriate plan. For example, "you need a mind-reader up there," "my memory's gone whack-o," and "I forget real fast. I got a bad remembery." In all likelihood, these comments were representative

of the majority of the learning disabled children and cogently dramatize the difficulties experienced by the group.

To determine whether they were consciously aware of the necessity to do something deliberate to enhance performance, subjects were asked to evaluate their own performance by reflecting upon how they went about learning and remembering the word lists of Experiment II. Responses indicated a rudimentary realization of "knowing how to know" (Brown, 1975) - that active strategic intervention would facilitate remembering. For example, several children responded in a manner characteristic of rehearsal operations: "I said them back to myself over and over," "I was thinking all the way back," and "I said them to keep them in my head." All but five subjects indicated a reliance upon the presence of Cue 1, "the other picture in the corner," and Cue 2 (name of superordinate) to help them remember the word lists. As one boastful child said, "It made it much easier. If it wasn't there, I could still do it." Or, as another replied, "without the clues it would be more complicated for kids." All of these comments seem to indicate a knowledge that the words could be placed in some grouping pattern to enhance performance. Yet, the performance was not enhanced.

The importance of organization was also reflected by comments that categorization of the words would be a useful tool in remembering: "I was thinking of what category they go in," "I was putting and thinking of them in categories," "they go in groups," "animals go with animals, fruit go with fruit," and "categories are the common thing to do."

Only four children responded in a manner indicative of a performance which lacked structure and guidance. This is evidenced by the statements that they remembered "as they came to mind," "in no special way,"

"nothing special," and "I don't know!" Yet for two of them, the training resulted in improved clustering scores. It appears that although they lacked the means to explain categorization (or did not realize that it should be mentioned), they employed it as a strategy to remember.

As a group, individual comments were not accurate indicators of performance. It is possible that although the presence of the cues was acknowledged and aided in some organization, the majority of children may not have recognized their full impact in maximizing organization and assisting in retrieval. The failure to take complete advantage of the cues is reminiscent of the performance of younger children who were not inclined to make use of potentially facilitative cues (Kobasigawa and Middleton, 1972).

Despite comments reflecting an awareness that organization was a necessary component to effective remembering, the comparable results of both experiments show that organizational practices were not efficiently incorporated as retrieval devices. In fact, two children whose performances did not benefit from training said that while they thought of the categories during list presentation, they did not at the time of recall. In general, the performances of the learning disabled children provide minimal support for the application of efficient organizational principles.

In addition to the childrens' comments, an awareness that the words belonged in categories is witnessed in several ways. In Experiment I, the list material effects offer a positive indication that some reconstruction of the input did occur. Here, the categorizable lists were recalled with greater success than the unrelated list and with the pre-clustered list providing the highest recall and clustering scores.

Access into the categories can also be observed by the 19 categorical intrusions which surfaced during recall, a number comparable to the 17 exhibited during recall by normal subjects. In Experiment II, an astonishingly high 92 in-class intrusions occurred with two-thirds of these errors accompanying the cued lists.

On the recognition task, 43% of the total errors were composed of categorical false recognitions. In contrast, 25% of the errors were failures to recognize members of categories which appeared on the original lists. However, a failure to recall words did not mean that they were unavailable in memory. An average of 23 words which were not recalled on the related-random and related-blocked lists were judged by the learning disabled children during recognition to have been part of the original lists. That is, they were perceived but the children were less adept than normal achievers at gaining access to what had been stored. Together with their commentary about grouping the words into categories, it appears that retrieval posed a greater problem than inefficient encoding.

Remembering requires more than just becoming aware. Awareness of the categories alone is not enough to foster consolidation of the clusters and does not automatically imply that all category members will be encoded and accessible for retrieval. This awareness needs to be converted into an effective plan of action while choosing the mnemonic most suited to maximize organization. Something must be done with the material once it is identified.

The processing and unification of the incoming stimuli imply a conscious and intentional governing of the means to memorize (Yendovitskaya, 1971). Clustering is a deliberate cognitive activity

where the number and size of groupings are determined by how the information is handled during its encoding and how it is used at the time of retrieval. A basic assumption is that successful performance depends upon sensing relatedness among the words as they are received and recognizing the need for strategic intervention to render the material accessible for retrieval. Underlying this ability is the automatic attachment of superordinate headings to the incoming stimuli once the relatedness has been discovered. As previously indicated, the development of this cognitive operation and its efficient execution is related to age, cognitive development, and learning proficiency.

For the normal subjects in this study, the task was approached in a dynamic and goal-directed manner. That they were effectively processing the material and consolidating their groupings according to superordinate classifications is evidenced by a 15% improvement in clustering between Trials 3 and 6 on the categorizable word lists of Experiment I.

In contrast, a 5-7% increase characterized learning disabled behaviors. Their performance suggests a deficit in implementing the knowledge they have about the semantic connections of the word lists. Consequently, they did not become increasingly planful and strategic over successive trials. Even the inducement to modify their clustering activities with cuing in Experiment II did not lead to a refinement in processing and higher recall and clustering scores.

There are several possible explanations as to why recall and clustering were not significantly altered. It might be said that the learning disabled children did not realize that strategic planning could assist in overcoming capacity limitations. This does not appear tenable since clustering did occur although on a reduced scale when measured against normal patterns.

Another claim might be that the learning disabled subjects were functioning in a slower manner than the normal subjects and required longer periods of time to effectively process the material. The additional trials should have provided this time and allowed for significant improvement. Such was not the case. The learning disabled children appeared to have reached a plateau in their recall and clustering by Trial 3.

In addition, their recall and clustering reveal a steady (but rarely significant) increase across trials in contrast to a random, unstable performance which marks the absence of organizational planning (Tillman, 1975). Further support that some planning occurred stems from the fact that most of the children reported that the cues assisted in grouping the words although no attention had been directed to them nor had instructions to use them been provided. Despite the invitation to be goal-directed and future-oriented (Flavell and Wellman, 1977), analyses weakly indicate their use as prompts to aid in the storage and retrieval of the word lists.

The ability to categorize individual items into superordinate taxonomies is an attainment of the concrete operational period (Piaget and Inhelder, 1969) and should have an impact on mnemonic knowledge and behavior. This was not true of the learning disabled performance which was characterized by a reduced efficiency in the use of the clustering strategy.

The less than optimal use of clustering by the learning disabled children points to an incomplete development of the strategy to assist memory. Such a deficit suggests a developmental immaturity in which the characteristics necessary for efficient management of task strategies

lack age-appropriate sophistication. Consequently, their performance resembles that of younger children (Kobasigawa, 1977; Moely, 1977) who have not yet attained higher levels of cognitive functioning. Like younger children, an improved ability to retain information is related to developmental changes in cognitive skills.

The use of clustering as a strategy to enhance recall is an outcome of cognitive growth. For the learning disabled, the findings suggest a delayed but qualitatively similar learning strategy to that of the normal subjects. This deficit in their memory functioning represents one instance of a more general processing dysfunction (Chalfant and Scheffelin, 1969) in which difficulties are encountered in approaching learning in active, strategic ways. Such a disturbance may easily impede learning and scholastic aptitude in general.

From these results, inferences can be made about how the effects of such disabilities may interfere with other areas of learning. However obscure, the absence of formal and informal test data on the language characteristics of the learning disabled population in this study makes the relationship of these processing deficiencies to higher levels of cognitive and psycholinguistic functioning even more speculative.

Any situation requiring processing skills represents a potential source of difficulty. One could speculate that the limited ability of the learning disabled children to strategically impose organization on material might be, in part, responsible for their poor reading skills which were not commensurate with chronological age. As Gibson and Levin (1975) suggest, mastery of reading skills may be dependent upon an awareness of cognitive processes and an inclination to approach reading in a

strategic manner. They posit that reading involves the processes of "strategic search, organization for remembering, the discovery of rules and order, and the economical use of them.... It requires the ability to transfer knowledge of rules and economical strategies to new material (p. 11)."

Clearly, a more precise definition of the relationship between learning disabilities and reading and linguistic development is needed. There are far too many questions for which there are no answers. Further research on the development of language and cognitive strategies in learning disabled children should expand our knowledge and understanding of these children.

Given the inefficiency of the learning disabled children in the organization and retention of the word lists, what evaluation and remediation objectives would be appropriate? The performance differences observed in the learning disabled children as compared to the normal achieving children suggest that assessment should consider not only the quantity of material learned but, more importantly, the mode of learning. Since product-oriented assessments (Muma, 1978) fail to yield qualitative interpretations on how children approach problem-solving tasks, focus should also be directed on the processes responsible for the learning of the material.

In this regard, the adequacy of memory span measurements as accurate predictors of cognitive processing needs to be questioned. Although extremely popular and widely used (Martin, 1978) because of their quickness and simplicity in administration and scoring, the use of digits, syllables, and unrelated words constitute a superficial assessment of processing skills. These measurements fail to consider some important

underlying processes which enable the retention and repetition of a series of ordered events.

Although WISC digit span scores differentiated normal subjects from learning disabled subjects in this study, they were not significantly correlated with their free recall performance. On the blocked lists, where both groups attained their highest clustering scores, comparisons of digit span recall and growth in clustering yielded a correlation of only  $r = .12$  for the normal subjects and  $r = .02$  for the learning disabled children. In addition, they proved to be poor estimators of successful recall and clustering performance. Within each group, high digit span scores were not necessarily attained by subjects exhibiting high levels of recall and clustering. Similarly, a limited digit span capacity was not always related to poor free recall performance. These findings tend to illustrate the shortcomings of memory for digits as an assessment approach in the clinical diagnosis of processing abilities. As Martin (1978) suggests, an alternative practice in the assessment of individual differences in processing would be to supplement capacity span measures with free recall tasks.

This study revealed that the spontaneous use of clustering in free recall by learning disabled children resembles the performance of younger normal children. As such, it suggests that a basic goal of remediation be an alteration in learning style.

The learning deficiencies indicate a need for the learning disabled child to be made aware of the interdependency among storage and retrieval and the means by which information can be organized in a form conducive to long-term retention and retrieval. They must come to realize the utility of strategic intervention and apply it in learning situations.

Once adept at handling information in an optimal manner within specific learning experiences, the strategic behavior requires strengthening and maintenance over time to prevent its dissipation and possible regression by the child back to an immature level of functioning. To become generalized to the demands of novel situations, the relationship of these organizational operations to the new tasks needs to be discovered. Since these cognitive skills are prerequisite to success in learning (Campion and Brown, 1977), attempts should be made to develop them. Based upon the present findings (and with an awareness that more than the presence of three cues in a single session is needed), suggestions for training the development of the clustering strategy can be offered.

For children whose behavior lacks organizational structure, therapy might emphasize the attributes of individual items and the interrelations that exist among them. Such an approach involves drill and repetition over numerous sessions with exercises designed to demonstrate how members from individual categories can be grouped and reorganized to accommodate the introduction of additional members. This basic act of categorization needs to become habituated before it can begin to function as an effective mnemonic technique. As Bruner et al. (1956) state, "any cognitive operation involving the grouping and regrouping of materials into equivalence classes is rendered more comprehensible once one has a better grasp of the nature of categorizing (p. 10)."

Where the ability to categorize has developed but fails to lead to efficient storage and/or retrieval, or where it is minimally represented as a strategic operation, therapy might concentrate upon the use of organization as a means to become better memorizers. By directing instruction at the facilitative use of mnemonic operations, it might

serve to bring the strategies into consciousness and strengthen the inclination to employ them to enhance recall.

If it could be found that training leads to a modification of clustering behaviors, then perhaps it might have an effect on cognitive operations which facilitate the processing of linguistic information (e.g. passive constructions). Until future research examines this possibility, the efficacy of training to cluster remains of unknown value in the clinic.

These exercises for the development and use of clustering as a coding operation are only suggestive. Their effectiveness to promote prolonged changes in the efficient utilization of strategic functioning is untested. Optimistically, they will lead to alterations in the way learning disabled children approach learning situations. Realistically, whether the developmental lag can be overcome is not known at this time.

APPENDIX A

Lists Used in Experiment I:

<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
*cigar	*puddle	*license	*penny	*perfume	*spoon
*bridge	*goggle	*hook	*trophy	*flag	*funnel
*easel	*trunk	*dollar	*clock	*thimble	*tatoo
watch	antenna	carrot	mask	bed	snow
bracelet	ribbon	top	candle	purse	lightning
pin	circle	onion	statue	golf	wind
necklace	straw	ball	razor	rug	sunshine
ring	calendar	policeman	bone	tennis	rain
door	broom	doll	stamp	desk	whale
chimney	flashlight	priest	bandage	wallet	seal
radiator	brick	corn	sponge	hunting	octopus
closet	fork	puzzle	branch	sofa	dolphin
stairs	chain	bean	tunnel	bag	shark
wrench	match	driver	flower	football	opera
drill	bench	pea	comb	suitcase	museum
scissors	lock	clown	magnet	lamp	park
ax	fence	sailboat	button	pocket	movie
nail	needle	pilot	string	hockey	zoo
*siren	*tree	*map	*globe	*tweezers	*saddle
*faucet	*compass	*garbage	*lantern	*hill	*gate
*sign	*target	*moustache	*fountain	*river	*signal
Jewelry		Vegetables		Sports	Weather
Parts of Buildings		Toys		Receptacles	Fish
Tools		Professions		Furniture	Amusements
Frequency:					
39.0	36.0	38.2	35.9	38.2	38.7

\* Buffer Items

## APPENDIX B

## Recognition Lists of Experiment I:

Lists 2, 3, 1

metal	- neutral
closet	- parts-building
needle	- unrelated
spinach	- vegetable-new
marble	- toys-new
treasure	- neutral
driver	- profession
flashlight	- unrelated
lawyer	- profession-new
necklace	- jewelry
blanket	- neutral
scissors	- tool
record	- neutral
carrot	- vegetable
earring	- jewelry-new
hatchet	- tool-new
puzzle	- toys
ticket	- neutral
ceiling	- parts-building-new
mountain	- neutral
circle	- unrelated

Lists 4, 5, 6

picture	- neutral
tennis	- sports
candle	- unrelated
basket	- receptacle-new
thunder	- weather-new
machine	- neutral
dolphin	- fish
bandage	- unrelated
porpoise	- fish-new
sofa	- furniture
feather	- neutral
movie	- amusement
toothbrush	- neutral
pocket	- receptacle
mattress	- furniture-new
concert	- amusement-new
sunshine	- weather
ladder	- neutral
baseball	- sports-new
garden	- neutral
button	- unrelated

Frequency:

36.5

36.5

## APPENDIX C

## Pictorial Cues Used in Experiment II:

<u>Category</u>	<u>Cue</u>
animals	cage
fruit	basket
vehicles	wheel
birds	nest
clothing	hangers
insects	fly swatter
instruments	musical notes
food	place-setting
footwear	shoe-lace
drinks	glass
writing implements	pad
things to read	bookcase

## APPENDIX D

## Lists Used in Experiment II:

<u>Trials 1-4</u>	<u>Cue 1</u>	<u>Cue 2</u>	<u>Cue 3</u>
*bush			
*shell			
*key			
pail	horn	book	bicycle
gun	mosquito	pigeon	grape
radio	hat	moccasin	bear
elbow	bread	coffee	pencil
stove	fly	newspaper	car
arrow	cake	parrot	elephant
can	sweater	tea	pen
leg	accordion	boot	apple
fan	coat	duck	lion
bucket	egg	letter	wagon
toe	wasp	juice	cherry
whip	piano	sandal	paint
bottle	dress	milk	zebra
television	bee	eagle	crayon
hand	harmonica	magazine	lemon
knife	butter	slipper	carriage
refrigerator	glove	comics	wolf
barrel	cracker	shoe	train
nose	hornet	owl	orange
spear	drum	beer	chalk
*prize			
*thread			
*brush			

\* Buffer Items

Categories:

weapons	instruments	reading material	fruit
containers	clothing	drinks	writing utensils
body parts	insects	birds	vehicles
appliances	food	footwear	animals

Frequency:

46.2	47.8	47.4	47.3
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## APPENDIX E

## Buffer Words Used in Pre-Testing of Cue Lists:

	<u>Cue 1</u>	<u>Cue 2</u>	<u>Cue 3</u>
Pre-list	cork leash patch	tack mop beard	tape badge soap
Post-list	net wood cane	pipe grass tray	scale lake bulb
Frequency:	36.2	35.8	36.2

APPENDIX F

Individual Learning Disabled Performance in Experiments I and II

Subject	WISC Perf.	WISC Verbal	WISC Full	WISC			Exp. I		Exp. II			
				Digits Forward	Digits Backward	Digits Total	Trials 1-6 Mean Recall	Trials 1-6 Mean ICRs	Trials 1-4 Mean Recall	Trials 1-4 Mean ICRs	Cue Lists Mean Recall	Cue Lists Mean ICRs
1	112	102	107	4	4	8	4.33	1.83	7.75	3.25	9.33	3.67
2	96	96	96	7	4	11	5.17	2.25	11.25	3.00	11.00	6.33
3	104	98	101	5	4	9	4.22	1.92	5.00	2.00	6.67	3.00
4	87	105	96	5	4	9	5.00	1.50	16.00	8.00	13.00	7.67
5	102	103	102	4	5	9	5.17	2.50	8.50	3.25	12.00	8.00
6	105	105	105	4	4	8	2.56	1.25	4.00	1.25	5.33	.67
7	105	95	100	7	5	12	2.22	.83	6.25	2.00	11.33	4.67
8	114	104	109	8	4	12	4.33	1.67	11.50	3.50	8.67	4.33
9	132	115	126	6	2	8	4.33	2.67	12.25	5.75	11.33	6.00
10	108	96	101	7	2	9	5.39	2.67	7.00	2.00	8.67	3.67
11	111	81	95	2	6	8	2.22	.58	3.75	.25	5.33	2.67
12	89	94	91	4	2	6	2.22	.92	4.50	.50	8.00	3.00
13	111	101	106	6	2	8	5.17	2.67	9.25	4.00	12.33	7.00
14	96	96	96	5	4	9	6.17	3.08	8.75	2.75	10.67	5.00
15	87	105	96	4	5	9	3.11	1.17	10.00	4.75	9.33	4.33
16	104	101	103	4	4	8	4.61	1.67	9.25	3.25	10.33	3.00
17	129	106	119	3	3	6	7.28	3.83	11.50	5.50	10.33	4.67
18	101	92	96	4	4	8	2.89	1.25	7.50	2.75	9.00	4.67
19	106	112	110	5	3	8	4.22	2.17	11.00	4.25	10.33	5.33
20	99	83	90	4	2	6	2.44	.83	3.00	.75	7.00	2.33
21	100	94	96	8	4	12	7.89	5.25	9.25	3.50	12.33	6.00
22	109	96	102	6	7	13	3.78	1.75	5.75	1.75	11.67	5.67
23	101	94	97	7	2	9	2.89	.83	6.75	3.00	8.67	4.00
24	101	112	107	4	2	6	3.38	1.25	9.25	3.00	9.00	5.00

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