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Frumkin-Feis, Yvette Joy

**VERBAL ENCODING DEFICIENCY IN LEARNING DISABLED CHILDREN
WITH VERBAL MEMORY IMPAIRMENT**

City University of New York

PH.D. 1982

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**Verbal Encoding Deficiency in Learning Disabled Children With Verbal
Memory Impairment**

by

Yvette J. Frumkin-Feis

**A thesis
presented to The City University of New York
in partial fulfillment of the
requirements for the degree of
Ph.D.
in
BASIC AND APPLIED NEUROCOGNITION**

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YVETTE J. FRUMKIN-FEIS

1982

This manuscript has been read and accepted for the Graduate Faculty in Psychology in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

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ABSTRACT

The verbal encoding ability of learning disabled children with specific verbal memory impairments (LDMI) 8 to 10 years of age, was compared to the verbal encoding ability of learning disabled (LDO) and nondisabled children (NC) without specific verbal memory impairments. In order to examine encoding ability, Wickens' technique for release from proactive interference (PI), a modification of the Peterson-Peterson short-term memory distractor task, was administered with stimuli shifting along phonetic and semantic dimensions. On the phonetic encoding task, the shift occurred in the initial consonant blends of the stimulus words, and on the semantic encoding task, the shift occurred in taxonomic category membership of the stimulus words.

Similar patterns of release from PI was found for the NC and LDO groups on the phonetic and semantic encoding tasks. However, the LDMI group did not show a release pattern following shifts in the phonetic dimensions of the stimulus words, and their pattern of release from PI following shifts in the taxonomic category membership of the stimulus words was significantly less than that of the NC and LDO groups. These results suggest that subjects in the LDMI group were less likely than subjects in the NC and LDO groups to encode and store phonetic and semantic features of the words they were trying to remember.

Tests were also administered which provided information concerning long-term associative structure and speed of associations. These tests

included verbal fluency tasks to letters and category names, a word association task, and a word clustering task. Although it was expected that these tasks would differentiate groups on the basis of encoding ability, instead, these tasks differentiated groups on the basis of academic ability. The NC group, compared to both learning disabled groups, showed evidence of better organization in long-term storage, had greater accessibility to phonetic and semantic category sets, and were quicker to respond with associations. Deficient verbal encoding ability appears to underly less successful verbal memory and reading performance and may be related to the delayed development of mature associative structures.

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INTRODUCTION

The ability to learn presupposes an ability to remember. Traditionally, the study of learning disabilities has focused on perceptual-motor abilities, visual-spatial functions, behavioral-attentional factors, and linguistic correlates of learning problems (Hallahan & Cruickshank, 1973). The study of memory in this group has occurred more recently (Bauer, 1977a, 1977b; Freston & Drew, 1974; Goyen & Lyle, 1971; Tarver, Hallahan, Kauffman & Ball, 1976; Vellutino, 1977). Investigations of learning disabled children with memory impairments (Ceci, Lea, & Ringstrom, 1980; Ceci, Ringstrom, & Lea, 1981) have found a relationship between memory impairments and deficiencies in various encoding dimensions in these children. It is this topic, the verbal encoding ability of learning disabled children with memory impairment, to which the present work addresses itself.

Encoding processes are integral to successful memory functions and play a significant role in the major theories of memory (Atkinson & Shiffrin, 1968, 1971; Craik & Lockhart, 1972). Although sometimes used elsewhere to denote mediational processes, the term encoding is used here to specify the process of translating external, to-be-recalled material into an organized form that has meaning for the individual and is amenable to retrieval at the appropriate time (Cermak, 1972). This translation is thought to occur within a number of different aspects, attributes, or conceptual dimensions (Wickens, 1970). Wickens (1970)

describes the encoding process as automatic, varied and rapid, and responsible for our quick and easy understanding of multi-meaning or ambiguous words that are often used in everyday discourse. Wickens suggested that the greater part of verbal encoding is so automatic that it can be considered unconscious, i.e., it occurs without awareness or intention. A deficiency in this process, either in terms of the speed of associations or the type of associations made, would diminish the richness of this elaborative process, lessen the amount of retrieval cues available for recall, and ultimately result in comprehension or learning problems.

Encoding along semantic dimensions has been reported for normal children as young as 7 years of age in several studies (Kail, 1976; Kail & Schroll, 1974; Kroes, 1974; Libby & Kroes, 1971; Zinobar, Cermak, Cermak, & Dickerson, 1975), however, encoding along phonetic dimensions has not been researched as thoroughly (Zinobar, et al., 1975). Many researchers have implicated semantic or phonetic verbal encoding deficiency as a contributing factor to language deficits found in learning disabled children (Denckla & Rudel, 1976; Vellutino, 1977), visual-auditory sensory integration (Blank & Bridger, 1966), and verbal recall (Ceci, Lea, & Ringstrom, 1980; Ceci, Ringstrom, & Lea, 1981; Shankweiler & Liberman, 1976, 1978).

The purpose of this research is to examine several components of the verbal encoding process of learning disabled children. Of primary concern are semantic and phonemic processing since semantic processing is an important aspect of verbal recall (Hyde & Jenkins, 1973; Till, Diehl, & Jenkins, 1975; Waters & Waters, 1976) and memory structure (Loftus &

Loftus, 1976), while phonetic processing is prominent in the acquisition and implementation of reading skills. It is hypothesized that learning disabled children with demonstrable verbal memory impairments are more likely to exhibit deficiencies in verbal encoding processes than learning disabled children without verbal memory impairment and normal children without verbal memory impairment.

Recent estimates of the prevalence of learning disabilities are reported to vary from 3 to 16 percent of the school-age population (Lynn, 1979). The increase in these estimates over the last several decades may be related to greater societal concern about this problem, and consequently leads to a greater awareness and identification of these children. This relatively high incidence may also be related to the increased survival rates of "at risk" infants. For example, the survival rate of premature infants has increased tremendously in recent years (Anderson & Raff, 1979), but the incidence of delays in linguistic and perceptual development is much higher in this group relative to the population as a whole (Korones, 1972).

A well accepted, concise definition has been provided by the National Advisory Committee on Handicapped Children in their annual report to Congress in 1968:

Children with special learning disabilities exhibit a disorder in one or more of the basic psychological processes involved in understanding or using spoken or written languages. These may be manifested in disorders of listening, thinking, talking, reading, writing, spelling or arithmetic. They include conditions which have been referred to as perceptual handicaps, brain injury, minimal brain dysfunction, dyslexia, developmental aphasia, etc. They do not include learning problems which are due primarily to visual, hearing, or motor handicaps, to mental retardation, emotional disturbance, or to environmental disadvantage. (p. 4)

There has been a growing dissatisfaction in recent years among researchers and practitioners in the field concerning subject selection of learning disabled children (Lynn, 1979; Weaver, 1978). Contradictory findings and unsuccessful attempts at replications of studies have been attributed to inconsistencies in subject criteria. Even if researchers adhere to standard conventions of learning disabilities, there may be great diversity in the types of academic and cognitive disorders displayed by children included in this broad definition (Boder, 1973; Rourke, 1968). While research described in the next section refers to subjects as dyslexics, reading impaired, poor readers, developmentally disabled, or brain damaged nonreaders, in general, the subject criteria used complies with the above definition of learning disabilities.

BASIC RESEARCH

Perceptual Hypotheses

Initial investigations of the causes, correlates and/or types of learning disabilities were directed toward uncovering the basic deficiencies which characterize the population. Early phenomenological researchers implicated perceptual-motor difficulty. The work of Werner and Strauss (1939) with brain damaged children provided the impetus for others to study perceptual-motor functions in children considered, at that time, to be minimally brain damaged with normal intelligence (Hallahan & Cruickshank, 1973). Frostig's Developmental Test of Visual Perception (1964), used for assessing and treating the perceptual-motor disturbances of learning disabled children, is typical of the work in this area. Emphasis was placed on spatial relations, eye-hand coordination, and figure-ground discrimination, with the assumption that these types of disabilities were paramount in learning difficulties.

Interest in attention capabilities followed the findings of inferior performance on figure-ground and embedded figures tasks (Frostig & Maslow, 1969). In a review of studies examining attention deficits in children with learning disabilities, Tarver and Hallahan (1974) concluded that distractibility was characteristic of this group, especially on incidental learning and on perceptual tasks requiring decentralization of perception. They also noted deficits in the ability to maintain attention over prolonged periods of time on vigilance tasks and in the

ability to rapidly shift attention between visual and auditory modalities.

Orton (1925) viewed mis-perceptions in reading as a result of improper establishment of cerebral dominance for speech. This prompted researchers to study abnormal laterality patterns and linguistic functioning. Although eye and hand dominance have not been found to be related to reading disorders, lateral awareness for self and external space has been associated with this disorder (Belmont & Birch, 1966; Kephart, 1960; Zangwill, 1962). On a dichotic listening task, poor readers showed a left ear preference and overall inferior performance compared to normals (Zurif & Carson, 1970). These researchers link perceptual problems to anomalous speech lateralization and delayed left-right orientation.

Tests of intersensory integration (Birch & Belmont, 1964; Senf, 1969; Senf & Feschbach, 1970; Zurif & Carson, 1970) have shown significant differences between reading disabled and nondisabled groups in the matching of visual and auditory stimuli, furthering the view of learning disabled children as deficient in the area of perception. However, these researchers have been criticized by others who maintain that these perceptual tasks have a definite linguistic component (Blank & Bridger, 1966; Vellutino, 1977).

Linguistic Hypotheses

Early investigations of language functions focused on receptive and expressive speech. De Hirsch (1975) studied "anticipatory schemas" and found that reading disordered subjects were diminished in their ability

to predict the end of a sentence after hearing the beginning. Kirk and colleagues (Kirk, McCarthy, & Kirk, 1961, 1968) developed indices to test fundamental linguistic features in the Illinois Test of Psycholinguistic Abilities (ITPA). This test was designed for clinical use to pinpoint specific areas of linguistic difficulty in individual assessment and remedial prescription.

Wiig and Semel (1975) have provided extensive research on the linguistic functions of learning disabled children and have reported broad and varied deficiencies in this group. Compared with normal children, the learning disabled children exhibited problems in naming, and used sentences of shorter phrase length and worse grammatical form (Wiig & Semel, 1975). They have also demonstrated deficient comprehension of linguistic concepts requiring logical operations (Wiig & Semel, 1973), and poor comprehension of verb tense and complex syntactic relations (Wiig & Roach, 1975). The inadequate comprehension of dual meaning words in the learning disabled group has led Wiig and Semel (1976) to suggest these problems may be attributable to retention of narrow word meanings, indicative of the tendency to remain concrete and limited in imagery, symbolization, and conceptualization.

Multiple Subgroups of Learning Disabilities

As deficiencies in many areas of cognitive functioning were demonstrated, learning disabilities were viewed as a multi-type disorder with varying etiologies. Investigators became concerned with delineating subgroups of learning problems and etiological classes. De Hirsch's (1974) interest in psychodynamics and language influenced her development of

four etiological categories of learning problems: 1. psychogenic, 2. neurogenic, 3. linguistic, and 4. environmental. Boder (1973), in analyzing reading and spelling errors of dyslexics, used three classifications: 1. dysphonetic dyslexia, a deficit in symbol-sound integration; 2. dyseidetic dyslexia, a deficit in perception of whole words without phonetic difficulty; and 3. mixed dysphonetic-dyseidetic dyslexia, deficits include both of the above making this the most severe type.

Many researchers have been interested in defining subgroups of Verbal IQ and Performance IQ patterns (Belmont & Birch, 1966) and patterns of subtest scores (Bannatyne, 1968, 1971; Miller, Stoneburner, & Brecht, 1978) displayed by learning disabled children on the Wechsler Intelligence Scale for Children (1949). Huelsman (1970) reviewed the literature in this area and concluded that the pattern of low performance on information, arithmetic, and coding subtests was characteristic of groups of disabled learners, but this pattern was rarely observable in individual subjects. Superior Performance IQ compared to Verbal IQ was found by Huelsman to represent approximately 20 percent of reading disabled subjects. One difficulty in the interpretation of these results is that lowered performance on the verbal subtests could be a consequence of general reading difficulties rather than a characteristic of the disorder per se.

Mattis, French, and Rapin (1975) administered a large battery of tests including cognitive, perceptual, language, and motor tasks to children with developmental dyslexia, to brain damaged nonreading children, and to brain damaged readers, in an attempt to reveal clusters of disabilities. The pattern of performance displayed by the dyslexics was

quite different from the nondyslexics. The poor readers' performance could be classified in one of three specific syndromes, while the nondyslexics' performance could not. The three dyslexic syndromes were: 1. language disorders, including anomia and difficulties in language comprehension, sentence repetition, or speech sound discrimination; 2. articulatory and graphomotor dyscoordination, including difficulties in sound blending, sequencing of articulatory segments, and graphomotor control; and 3. visual-spatial perceptual disorder, including deficient visual retention, a relatively low Performance IQ, and a relatively low score on the Ravens Colored Progressive Matrices.

Other researchers have attempted to delineate cognitive clusters in subgroups of learning disabled children. Learning disabled subjects were assigned to one of three subgroups on the basis of their relative strengths and weaknesses in reading, spelling, and arithmetic, and were assessed on a wide range of cognitive, perceptual, and linguistic tasks (Rourke & Finlayson, 1978). The first group was composed of subjects uniformly deficient in reading, spelling, and arithmetic. The second group was composed of subjects whose arithmetic ability, although clearly below age expectation, was significantly better than their reading and spelling abilities. The third group had normal reading and spelling levels, but was markedly impaired on arithmetic. Subjects in groups 1 and 2 were significantly better than subjects in group 3 on measures of visual-perceptual and visual-spatial abilities. Group 3 subjects performed significantly better than subjects in groups 1 and 2 on measures of verbal and auditory-perceptual functions. Since different cognitive dysfunctions were associated with different subgroups of learning disa-

bled children, the findings from this study suggest it is important to adequately characterize the type of learning disabled subjects being studied.

Further investigation of these same groups on bilateral psychomotor and tactile-perceptual tasks revealed relatively greater indications of right hemispheric dysfunction in subjects with marked arithmetic disability (Group 3) and relatively greater indications of left hemispheric dysfunction in subjects with marked reading and spelling disorders (Group 2) (Rourke & Strang, 1978). The results of these studies point out the etiological significance of differing patterns of cerebral dysfunction for several subgroups of learning disabilities. This also demonstrates that different findings may result from similar studies depending on the type of learning disabled group examined. It seems necessary therefore, in order to improve reliability of findings, to more accurately define the groups of learning disabled subjects under study.

Memory Functions of Learning Disabled Children

The study of memory functions per se in learning disabled groups has been a relatively recent phenomenon, although in the past it has been tied in with the study of other areas of cognitive functioning. For example, Wiig and Roach (1975) found this group's short-term memory to be better for structurally simple sentences, such as active declaratives, than for structurally complex semantic sentences. In studies of selective attention, defined as central recall minus incidental learning, incidental learning was essentially equivalent for learning disabled and

nondisabled groups, but learning disabled groups were significantly inferior on central learning tasks (Hallahan & Cruickshank, 1973; Hallahan, Gajar, Cohen, & Tarver, 1978; Tarver, Hallahan, Kauffman, & Ball, 1976). In these instances, questions about linguistic and attentional competencies have precluded interpretation of the findings in terms of memory functions.

Visual Short Term Memory

In order to control for possible perceptual or attentional factors in visual memory, visual-motor (drawing) reproductions were compared with visual-oral (naming) reproductions of the same stimuli for disabled and normal readers (Vellutino, Steger, & Kandel, 1972; Vellutino, Smith, Steger, & Kaman, 1975). Nonverbal stimuli (geometric designs) and verbal stimuli (3, 4, or 5 letter words; 3, 4, or 5 letter scrambled words; and 3, 4, or 5 digits) were presented tachistoscopically for 600 msec. The normal readers performed equivalently on the visual-motor and visual-oral tasks. The reading disabled group performed significantly worse on the visual-oral task than the visual-motor task. Compared with normal readers, the reading disabled group was significantly impaired on the visual-oral task for all stimuli, and on the visual-motor task for 5 letter words, and 4 and 5 letter scrambled words. The authors suggested that a deficit in visual-oral encoding, rather than perceptual functioning or attentional factors, produced impairment on memory tasks in which learning disabled subjects were required to repeat from memory what they have seen.

In order to determine the effects of differential rates of linguistic familiarity between normal and disabled readers on visual memory tasks that use words and letters as stimuli, Vellutino, Pruzek, Steger, and Meshoulam (1973) and Vellutino, Steger, DeSotto and Phillips (1975) required poor and average readers to copy Hebrew words, an orthography equally unfamiliar to both groups. Since the groups performed equally well, the poor readers were thought to have exhibited adequate attention and perceptual-motor capacities. Following a second presentation of the Hebrew words, subjects reproduced them again. No differences between groups were found on the second trial. These findings have led Vellutino and his colleagues to explain their previous findings (Vellutino, Smith, Steger, & Kaman, 1975; Vellutino, Steger, & Kandel, 1972) of poor reproductive memory for letter sequences as the result of linguistic familiarity and not as a manifestation of inadequate visual memory.

However, other investigations have revealed visual memory deficits in learning disabled groups. Dyslexics were found to need twice as much time (700 msec) as nondyslexics (350 msec) to recognize 5 or 6 digits presented tachistoscopically (Ellis & Miles, 1977). These findings have been essentially replicated using recognition paradigms following tachistoscopic presentation with varying exposure times for rectangular shapes (Lyle & Goyen, 1975), geometric designs (Goyen & Lyle, 1971; Lyle, 1968), and for letters, lines, and simple two-dimensional shapes with immediate and delayed recall (Lyle & Goyen, 1968). These findings provide indications of incomplete analysis by learning disabled groups for visual stimuli presented in short durations but not for longer tachistoscopic exposures. It is possible that they do not adequately ana-

lyze distinctive features as quickly as normal children, and that learning disabled subjects need more time for processing visual information, which leaves less time for mnemonic processing.

Tests of recall following bisensory simultaneous presentation have been used in order to approximate social learning environments to determine the additive effect of dual modality stimulation on recall and to demonstrate possible visual or auditory channel preferences. In bisensory paradigms, a pair of stimuli is presented simultaneously; one item is presented auditorily while another is presented visually. The stimuli generally used are digits, with three pairings the typical procedure. Subjects are asked either to repeat the stimuli in their original paired presentation or to repeat all the stimuli presented in each sensory modality separately, i.e., all visually presented stimuli followed by all auditorily presented stimuli or vice versa (Senf, 1969). Compared to normal subjects, learning disabled subjects made significantly more errors in both types of recall conditions (Davis & Bray, 1975; Senf, 1969; Senf & Feshbach, 1970; Senf & Freundl, 1971), but the more severe decrement was found generally in the modality recall condition (Senf, 1969; Senf & Feshbach, 1970; Senf & Freundl, 1971). While control groups showed no modality preference, learning disabled groups were more likely to respond to the auditory channel first (Senf & Feshbach, 1970; Senf & Freundl, 1971) and to make significantly more errors in the visual modality (Senf & Freundl, 1971). This preference may suggest that learning disabled groups have difficulty in decentralizing attention, (i.e., focusing on more than one sense modality at a time), with auditory stimuli predominating, or that they may have a defect in visual processing.

Senf and Freundl proposed that auditory stimulation may interfere with visual information processing and cause a "masking effect," i.e., the processing of stimuli in one sense modality may mask or partially interfere with the processing of stimuli presented simultaneously to another modality.

Such interpretations may be limited to symbolic-representational stimuli. Inter- and intra-modality paired associate learning tasks, where the stimuli had a less symbolic/representational character, such as tones and dots, were performed equivalently by learning disabled and normal children (Vellutino, Steger, & Pruzek, 1973). However, significant differences were noted on paired associate learning tasks where stimuli had a greater representational quality, such as nonsense syllables (Vellutino, Steger, & Pruzek, 1973), and words and letters (Samuels & Anderson, 1973; Vellutino, Smith, Steger, & Kaman, 1975; Vellutino, Steger, & Kandel, 1972).

Memory for stimulus orientation and sequence have also been studied with learning disabled groups using visual presentation formats. Studies of visual recognition and reproductive memory show no significant differences in the amount of orientation errors made by good and poor readers. These groups produce similar rates of rotation and reversal errors (Lyle & Goyan, 1968; Samuels & Anderson, 1973; Shankweiler & Liberman, 1978; Vellutino, Pruzek, Steger, & Meshoulam, 1973). However, analyses of sequence errors have brought forth contradictory findings. Vellutino, Pruzek, Steger, and Meshoulam's (1973) study of the reproduction of Hebrew letters show no greater degree of sequence errors in the disabled group. Davis and Bray (1975) found no difference in errors of

sequential order on their test of bisensory memory, while Senf and Feshbach (1970) and Senf and Freundl (1971) did find more sequential order errors in learning disabled subjects' recall. Significantly inferior ability was also demonstrated by learning disabled children on a test specifically designed for memory of sequence, form, and position (Noelker & Schumsky, 1973), and on a test of sequential ordering of pictured objects (Torgesen & Goldman, 1977). Guthrie and Goldberg (1972) correlated three tests of visual sequential reproduction (Benton's Visual Retention Test, the visual sequential memory subtest of the ITPA, and the Knox Cube Test) with three reading tests (the Gray Oral Reading Test, the Metropolitan Reading Test, and the reading subtest of the Wide Range Achievement Test). There were significant positive associations between visual sequential memory and paragraph comprehension, oral reading, word recognition. However, only moderate intercorrelations were found for the sequential memory tests, suggesting these tests do not measure identical abilities. Although successful performance on all of these tests require sufficient sequencing ability, the Benton Test of Visual Retention is also sensitive to other decrements in performance, such as memory for form. In addition, learning disabled and nondisabled groups produced equivalent rates of reversal and rotation errors, and sequential errors on an unfamiliar orthography, but learning disabled groups produced more sequential errors than nondisabled groups on pictures of objects and geometric forms.

In summary, visual short-term memory deficits have been demonstrated for learning disabled groups for reproductive memory and recognition with both meaningful and non-meaningful stimuli. Explanations of these

impairments include such factors as diminished linguistic familiarity, slower visual processing, insufficient analysis of visual features, and inadequate decentralization or failure to attend selectively. Since orientation (reversal and rotation) errors made by learning disabled children were within the range of nondisabled children, consideration of reversal errors as a pathognomic feature of dyslexia (Orton, 1925) is questionable. Errors of sequence or order have been frequently demonstrated in learning disabled groups. Although tests of visual sequential memory did not have high intercorrelations, they were highly related to reading ability.

Auditory Short Term Memory

The auditory short-term memory abilities of learning disabled children has also been investigated extensively, with an emphasis predominantly on verbal stimuli. There have been considerable attempts to explore processes underlying deficient auditory memory ability such as rehearsal, organization and stimulus encoding.

Investigation of immediate and delayed free recall of a series of concrete words presented auditorily, revealed significant differences between learning disabled and normal subjects in the number of items recalled and differences in the pattern of recalled responses (Bauer, 1977a). In immediate recall conditions, normal subjects exhibited primacy and recency effects, which are typical patterns of serial recall. However, learning disabled subjects showed similar recency, but very little primacy effects. Bauer indicated that recency recall is thought to represent immediate recall from an auditory or short-term memory

store, while primacy recall is thought to be facilitated by rehearsal and may represent retrieval from long-term storage. Thus, it is possible that the lack of primacy recall may be caused by deficient rehearsal strategies. With delayed recall there was a primacy effect for normal subjects but neither a primacy nor a recency effect for learning disabled subjects. These findings are consistent with the notion of deficient rehearsal strategies in the learning disabled group. Similar results were found using consonant trigrams (Bauer, 1977b), digits, and color sequences (Bauer, 1979). Bauer (1977a, 1977b, 1979) also showed that recall of subspan lists (3 items) by learning disabled subjects was similar to normal subjects' recall in immediate recall conditions but not under delayed (unfilled) conditions. Bauer (1977a) concludes "immediate recall of subspan lists probably requires little rehearsal, whereas delayed recall of subspan lists and both immediate and delayed recall of supraspan lists probably requires active rehearsal. Therefore, recall of the learning disabled is apparently inferior to that of the nondisabled in those tasks requiring substantial rehearsal."

Cermak, Goldberg, Cermak, and Drake (1980) studied verbal recall using the Peterson and Peterson (1959) short-term memory distractor task to control for the effect of rehearsal in an attempt to determine the rate of forgetting for learning disabled and nondisabled children. Three groups of learning disabled children were created based on Verbal IQ and Performance IQ score patterns: low verbal/high performance; high verbal/low performance; and equivalent verbal and performance IQ. The authors hypothesized that learning disabled children with evidence of linguistic impairment (the low verbal/high performance IQ group) would

have higher rates of forgetting. Mono-syllabic word triads were presented at the rate of one per second, followed by a distractor task of color naming for durations of 0, 3, 9, or 18 seconds prior to recall. Contrary to expectations, none of the learning disabled groups showed a higher rate of forgetting than the nondisabled group at any of the delay conditions. These findings support Bauer's conclusions that when rehearsal is restrained no differences exist in the short-term memory performance of subspan material for learning disabled and nondisabled groups.

By equating verbal rehearsal activity, other researchers have found equivalent memory performance in learning disabled and nondisabled groups. Tarver, Hallahan, Kauffman, and Ball (1976) and Torgesen and Goldman (1977) have also found diminished rehearsal, reduced recall and a lack of primacy effect in the serial order recall of learning disabled groups. However, these researchers reported dramatic improvements after learning disabled children were instructed or trained to label and rehearse. Under these conditions, learning disabled subjects' recall and rehearsal was essentially equivalent to that of normal subjects (Torgesen & Goldman, 1977) and the primacy effect was established to the same degree (Tarver, et al., 1976).

Torgesen and Goldman suggested that diminished spontaneous rehearsal by disabled readers may be a symptom of a more general failure to approach tasks in a planned, organized, and active manner. Since non-rehearsers were induced to rehearse successfully, the problem may be one of initiation of appropriate strategies rather than competency. They suggest this may be caused by a delay in executive, meta-memory func-

tions (the ability to be aware of one's own cognitive processes and the conscious adaptation of strategies to meet task demands, Kreutzer, Leonard, & Flavell, 1975) or by assuming the role of a passive learner (Torgesen, 1977a; Torgesen & Goldman, 1977). They point out that a habit of dependency is incompatible with the development of a sense of oneself as an active agent in learning. This notion was supported by the results of questionnaires measuring perceived locus of control (Hallahan, Gajar, Cohen, & Tarver, 1978). Success in school and in general situations was perceived by normal subjects to be internally controlled, but perceived as externally controlled by learning disabled subjects. The authors suggest that the learning disabled child's external view of control may hinder him from actively seeking appropriate learning strategies such as verbal rehearsal. However, it is also possible that inactive learning strategies and the perception of external locus of control may have arisen from years of frustrated learning attempts.

Another perspective on understanding verbal memory problems in learning disabled subjects focuses on the organization of the material. The process of chunking (Miller, 1956) is seen as an efficient strategy for retention of information which exceeds the immediate memory span. Some similarity must be observed, or an association must be made between items such that recall of one elicits recall of the other. Category membership has been one of the dimensions found to be useful in clustering or chunking (Bousfield, 1953; Cohen, 1963). In studies examining the effect of category similarity (Freston & Drew, 1974; Drew & Altman, 1970; Parker, Freston, & Drew, 1975), normal subjects exhibited better recall on a list of words from the same semantic category compared to

recall from a list of unrelated words. However, learning disabled subjects did not benefit from the external cue inherent in the related list. Suiter and Potter (1978) did not replicate these findings using visual presentation of stimuli and challenged the notion of a deficit in the ability to make use of external organization. In the latter study, however, learning disabled subjects were screened for visual memory deficits and were included only if normal performance was established. These researchers may have obtained very different results if they had also included the subjects who were disqualified, since deficiencies in organization are more likely to play a role in subjects with memory impairments.

Organization of stimulus material into conceptual categories during study periods was not characteristic of learning disabled children's attempts to memorize (Torgesen, 1977b), although it was characteristic of normal children's memorization attempts (Moely, Olsen, Holmes, & Flavell, 1969; Torgesen, 1977b). Recall scores improved significantly when learning disabled subjects were instructed to cluster stimuli during study periods (Torgesen, 1977b). After establishing recall and clustering differences between groups on a free recall test, Torgesen, Murphy and Ivey (1979) had learning disabled and normal subjects sort different items into taxonomic categories before an unexpected memory test for these materials. Differences in recall between good and poor readers were eliminated when both groups engaged in the same sorting activity. Compared to the previous free recall condition, clustering scores at retrieval were significantly higher for both groups and were essentially equivalent. Also, the groups did not differ in their ability to sort

according to semantic category. Therefore, it seems category conceptualization is possible for learning disabled subjects although they do not spontaneously do so during attempts to memorize information. Again Torgesen suggested that the active, efficient, and organized management of cognitive resources is the crucial factor underlying individual differences on experimental memory tasks as well as reading skills.

Another factor that has been found to be related to memory performance is phonetic coding. Phonetic similarity (rhyme) normally produces a detrimental effect on recall (Baddeley, 1968; Conrad, 1964). Shankweiler and Liberman (1976; 1978) presented rhyming and nonrhyming consonant letter strings to good and poor readers. Rhyme had a detrimental effect on the recall of these letter strings for the good readers, as expected, but rhyme did not significantly reduce the recall of the poor readers' performance. These findings indicate that poor readers may utilize phonetic codes to a lesser degree, or may rehearse less, thereby affording these items less potential for interference.

To determine whether the interaction between reading groups and the recall for lists differing on degree of phonetic similarity could be a function of different amounts of rehearsal between groups, Mark, Shankweiler, Liberman, and Fowler (1977) presented subjects with words followed by a surprise recognition task. The items on the recognition task were either identical or sound-alikes of the original words. Good readers selected more sound-alikes than the poor readers and again were more confused by phonetic similarity. Since this technique was used to minimize the opportunity for rehearsal, these findings lend support to the idea that learning disabled children are less sensitive to the phonetic characteristics of verbal material.

Additional support for this view was also provided by an analysis of errors made by subjects on a paired associate learning task where the responses were nonsense syllables (Vellutino, Steger, Harding & Phillips, 1975). The errors made by normal readers most commonly involved phonetic substitutions of letters in the nonsense syllables, while the errors of poor readers typically involved substituting whole new nonsense syllables, unrelated phonetically to the target items. Additional support comes from examination of the reading and spelling errors of dyslexics, where 67 percent could be classified as dysphonetic (Boder, 1973). Wiig & Semel (1976) also report that phonemes differing in one phonetic characteristic are the ones most commonly confused. Furthermore, Goetzinger, Dirks, and Baer's (1960) study comparing learning disabled to normal subjects on the Wepman Auditory Discrimination Test, which requires perceptual sensitivity to single phonetic differences between words, resulted in significantly poorer performance by the learning disabled group, although auditory acuity and pure tone thresholds were well within the normal range.

One group of researchers has developed a very useful technique for the study of underlying processes of visual and auditory memory impairments of learning disabled children (Ceci, Lea, & Ringstrom, 1980; Ceci, Ringstrom & Lea, 1981). Assuming that not all learning disabled children have visual or auditory memory impairments, these researchers decided to prescreen and select subjects for visual and/or auditory impairments before examining related factors. This procedure takes into account the heterogeneity of individuals broadly defined as learning disabled and adds a dimension of control necessary for making valid gener-

alizations, since inferences for some subgroups of learning disabilities may not hold true for other subgroups.

After screening subjects for memory ability on the visual and auditory memory subtests of the Detroit Test of Learning Aptitude, four groups were formed: 1. learning disabled subjects with visual memory impairment, 2. learning disabled subjects with auditory memory impairment, 3. learning disabled subjects with both auditory and visual memory impairments, and 4. nondisabled subjects with normal visual and auditory memories. All subjects participated in two experimental memory tasks. In the visual task, objects representing exemplars of several semantic categories were presented on a card and were drawn in one of several colors. In the auditory task, exemplars of semantic categories were selected based upon phonetic similarity (rhyme) to one of four words and were presented in male or female voices. Free recall and cued recall were assessed for each task. In concordance with the screening, subjects with visual memory impairment recalled less on the visual task than auditory memory impaired or normal subjects, and less than they did on the auditory task. Complementary findings were demonstrated for the auditory memory impaired subjects on the auditory memory task. Interestingly, learning disabled subjects' recall in the nonimpaired modality was somewhat greater than the normal subjects' recall, suggesting a compensation effect for the nonimpaired modality. Subjects with both visual and auditory memory deficits recalled less on both tasks than all other groups. Thus, the findings of the initial screening were confirmed (Ceci, Lea & Ringstrom, 1980; Ceci, Ringstrom, & Lea, 1981).

Of greater interest were the findings from semantic and nonsemantic cued recall which followed free recall. Cues, randomly presented, included category name (semantic cue), color or location (nonsemantic cues on the visual task), and rhyme or voice gender (nonsemantic cues on the auditory task) such as, "tell me all the words you heard that rhymed with air. . . , were given in a female voice." Semantic cues tended to produce better recall than the perceptual (nonsemantic) cues only on tasks in the subjects' nonimpaired modality. Semantic cues provided significantly less assistance than perceptual cues on the visual task only for the visual memory impaired group, and on the auditory task only for the auditory memory impaired group. Semantic cues were better utilized than perceptual cues on both tasks for the normal control group. But semantic and perceptual cues were equally ineffective in prompting recall on both tasks for the learning disabled group with bisensory memory impairment. Learning disabled subjects showed abnormal patterns of semantic cue effectiveness suggesting diminished semantic processing only on memory tasks in their impaired modality. Specific modality impairments were not, however, associated with decrements in nonsemantic processing (Ceci, Lea, & Ringstrom, 1980; Ceci, Ringstrom & Lea, 1981).

When subjects were provided with a semantic orienting task in which they sorted items according to semantic category, Ceci, Lea, and Ringstrom (1980) found semantic cueing now provided greater recall than perceptual cueing for normals and subjects with deficits in only one modality. Moreover, semantic orienting tasks significantly improved recall in the impaired modality to a greater extent than in the nonimpaired modality. The normal control group performed similarly in the semantic

orienting and no orienting conditions; apparently they automatically encoded semantic information at the time of storage without external prompting. Learning disabled subjects with bisensory memory impairments, however, did not improve their free recall or cued recall following the orienting task, suggesting a semantic processing deficit is not sufficient to explain their inferior mnemonic performance.

It appears that semantic encoding is an underlying factor in successful memory performance. Specific memory impairments for material presented in one modality (auditory or visual) is associated with diminished semantic processing of items presented in that modality. Subjects with a memory impairment in only one modality appear to encode along primarily nonsemantic dimensions in that modality and find nonsemantic cues more helpful. Deficient recall by children with only one impaired modality seems to have its origin at the level of stimulus encoding since a semantic orienting task substantially improves their recall. For learning disabled children with memory impairments in both modalities, semantic encoding deficiency alone does not explain their inferior performance. Since all perceptual cues as well as semantic cues provided significantly less help for this group compared to all others, a severe multi-dimensional encoding deficiency may underly their memory impairment.

Summarizing the findings concerning auditory/verbal memory defects in learning disabled children, deficiencies have been found for recall, recognition, and paired-associate learning. Active and efficient mnemonic strategies for learning, such as rehearsal and organization of material, has been found to be diminished compared to nondisabled chil-

dren. A general inability in executive function has been implicated in memory impaired learning disabled children which calls into question the integrity of meta-memory processes, especially since substantial improvements in memory abilities have been documented following training, instruction, or orientation tasks in strategic cognitive processes. Encoding deficiencies have been implicated by these studies for semantic and phonetic dimensions. Use of active, executive mnemonic functions, such as organization and clustering strategies, are dependent on initial perception of essential dimensions, such as superordinate category at the time of presentation. Encoding of semantic and nonsemantic features must occur at the time of storage if internal or external cues are to provide benefit at the time of retrieval. Thus, it appears efficient verbal encoding processes are essential for successful verbal memory ability.

Verbal encoding deficiency may account for deficits outside the realm of verbal memory as well. On a test of auditory-visual integration, judgments of auditory-visual equivalence were impaired in a reading disabled group, and were attributed to perceptual dysfunction (Birch & Belmont, 1964). Other investigations of auditory-visual integration have found evidence to support an alternative view that verbal labelling of spatial and temporal sequences underly the judgement difficulty (Blank & Bridge, 1966; Zurif & Carson, 1970). These researchers suggested that an inability to adequately verbally encode visually presented nonverbal stimuli leads to a relative inefficiency in the intermodal transfer of information.

Accounting for findings of visual memory impairment in learning disabled groups, Spring (1976) hypothesized that an unusually slow visual-verbal encoding process would result in a pre-emption of time available for item rehearsal. To test this view, dyslexic and nondyslexic subjects were required to name, as rapidly as possible, visually presented digits, color patches, and pictures of common objects. Results show a significant discrepancy between groups in the expected directions for all stimulus conditions. Comparable findings on similar naming tasks were found by Denckla and Rudel (1976) who also suggested their results may be due to a visual-verbal encoding deficiency such that rapid automatic verbal associations to visually presented stimuli are diminished for dyslexic groups of children. Thus rapid verbal encoding is also necessary for proper processing of visually presented material for future recall.

Implications from the research yielding results of visual processing difficulty for rapidly presented stimuli, decrements in intermodal transfer of information, diminished use of rehearsal and organization strategies, inferior sensitivity to phonetic qualities of verbal material, and the relative ineffectiveness of semantic cues in visual and/or auditory memory impaired learning disabled children point to verbal encoding deficiency as a possible contributing factor to these difficulties. Appropriate techniques for examining verbal encoding processes in learning disabled children can be adopted from studies examining encoding processes of normal children.

Encoding Processes in Children

There have been many techniques used to study the salient dimensions along which children encode verbal stimuli. In the false recognition paradigm, the experimenter presents the subject with an initial list of words for study. Afterwards, another list of words is presented with words that are identical to the previous list, unrelated to the words on the previous list, and related to the words on the previous list along different dimensions such as meaning or perceptual features. The subject's task is to decide whether the words in the second list were in the initial list.

Using this technique, in an auditory presentation format, researchers have found more false positive recognition errors with phonetically similar items than semantically related items for normal children in first, second, and third grades, and equal or greater rates of false positive recognition errors with semantically related items for normal fourth and sixth graders (Cramer, 1976; Felzen & Anisfeld, 1970; Hasher & Clifton, 1974). With visual presentation of lists, first and second graders incorrectly chose similar looking words more often than they chose conceptually related or unrelated items (Cramer, 1976; Freund & Johnson, 1972), while fourth graders' error rates were equal for orthographic and semantically similar items, and fifth and sixth graders tended to err more with conceptually related material (Cramer, 1972, 1973). Such error patterns are thought to reflect attribute salience in the organization of words in memory. Words that are processed and organized similarly are the ones more likely to cause confusion and recognition errors. Thus, the pattern of results from these studies indicate

a perceptual/conceptual shift with age in the saliency of encoding dimensions. It appears that younger children are predisposed to encode stimuli along perceptual dimensions, while older children are more likely to encode stimuli semantically.

Support for the encoding shift hypothesis has been provided by research using other techniques. Reiss (1946) conditioned the galvanic skin response of subjects to verbal stimuli and then replaced target words with homonyms, antonyms, and synonyms. Transfer of the conditioned response was significantly greater for homonyms in the 7 year old group, for antonyms in the 10 year old group, and for synonyms in the 14 and 18 year old groups. On a sorting task, the color of objects was the dominant dimension used to form groups by nursery school children but conceptual dimensions were most commonly used to group items by second and fifth graders (Melkman & Deutsch, 1977). Color cues also provided greater assistance for recall in nursery school children, while for children in grades 2, 4, and 5, conceptual cue was as useful (Ceci, Lea & Howe, 1980) or better (Melkman & Deutsch, 1977) in prompting recall. Fourth, sixth, and eighth graders showed greater clustering in free recall along categorical, potency and evaluative dimensions than along the sense impression dimension (Kroes & Libby, 1973).

The Wickens Technique for Release from Proactive Interference

Proactive interference (PI) is the interfering effect of previous learning upon the recall of newly learned material. Wickens' (1970) task for release from PI has been used to determine encoding dimensions in adults and children. This task is a variant of the Peterson and Peterson

(1959) short-term memory distractor technique. The rationale of this paradigm is based on the fact that PI develops quickly after a few trials on this task (Keppel & Underwood, 1962). The rate of interference build-up is based on the relatedness of the material across trials (McGeoch & McDonald, 1931). The greater the similarity of items, the faster PI develops, greatly increasing recall difficulty on latter trials. However, when a final trial is presented with material differing from the dimension used previously, PI is disrupted and recall improves substantially. Graphic representation most dramatically illustrates a "release" from the negative slope of PI on such a trial. This task demonstrates changes in encoded dimensions since similar items must be perceived similarly by the subject if there is to be a rapid build-up of PI, and the unique dimension of the unrelated trial must be perceived for there to be a new retrieval cue and a release from PI. Specifically, if different words from one conceptual category are presented for three trials and on the fourth trial words from a different conceptual category are used, and if the subject encodes along these conceptual dimensions, the slope of recall will be negative across the first three trials and then positive on the third to the fourth trial, since recall improves on the fourth trial with this new retrieval cue. However, if a subject does not encode along these conceptual dimensions, the slope of recall would be essentially negative along all four trials. There would be no release from PI on the fourth trial since the words were encoded similarly.

Many dimensions of encoding have been studied in adults using this technique. Wickens (1970) reports that shifts in stimuli that have been

found to produce the largest release from PI include shifts between nouns and numbers, semantic classes, presentation modality of stimuli, words differing on the evaluative, potency, and activity scales of the semantic differential (Osgood, Suci, & Tannenbaum, 1957), and words differing in the sense impression they convey such as "round" or "white." Release patterns have also been found for shifts in word frequency, syllabic length, and imagery.

Normal children as young as 7 years of age have demonstrated release from PI when recalling words differing in terms of semantic categories (Kail, 1976; Kail & Schroll, 1974; Kroes, 1974; Libby & Kroes, 1971; Zinobar, Cermak, Cermak & Dickerson, 1975). Consistently high test-retest reliability scores have been demonstrated using semantic dimensions (Kroes, 1974). Children in this age range have also demonstrated evidence of encoding words along masculine and feminine dimensions. Such results were found in the work of Kail and Levine (1976) who used lists of items which differed only in terms of their gender associations. In these studies, three exemplars from conceptual categories were presented auditorily to the subject who then engaged in a distractor task for 15 seconds (usually counting or color naming) followed by recall. This procedure is repeated for several trials. In the release or shift condition, stimuli on the last trial are used from a different conceptual class. In the no-shift condition, stimuli used on all trials are from the same conceptual category. The last trial of the shift and no-shift conditions are compared for recall differences. Typically in these studies recall is about 90 to 95 percent correct on the first trial, followed by significant declines in recall. On release trials, however,

recall approximates levels on trial 1 with 85 to 100 percent recall recovery or higher (Kail, 1976; Libby & Kroes, 1971). No differences are exhibited for recall on trials 1-3 between shift and no-shift conditions on the final trial for stimuli differing in semantic class. These findings indicate that young children use semantic dimensions to encode information.

Similar findings have been reported for stimuli of different values on the evaluative scale of the semantic differential, but only with children 11 years of age or older. Children younger than this do not appear to use the dimension of evaluation as an encoding feature (Cermak, Sagotsky, & Moshier, 1972; Kail & Schroll, 1974). Young children's recall also does not benefit from stimulus shifts in sense impression (Kail, Jongeward, Daoust & Aaron, 1976; Zinobar, et al., 1975), although shifts in these attributes do significantly reduce interference effects for older children and young adults. Findings of overall age related differences in recall suggest that the ability to encode along multiple dimensions is related to superior mnemonic skill (Cermak, et al., 1972). This view is supported by the results of the study by Kail, et al. (1976) who reported improved recall and a significant interference release for young children when sensory dimensions of words were made salient by experimenter intervention. It appears that the more sophisticated the levels of encoding needed to discriminate between two opposing classes of information, the older the child must be before he can accomplish the task. It may be that with increasing age, there is a corresponding increase in the number of dimensions along which words are encoded (Zinobar, et al., 1975).

According to the results of these studies, semantic dimensions are a salient aspect of young children's verbal encoding, whereas semantic and perceptual attributes, including sense impression and phonetic factors, are typical of encoding processes of older children and children demonstrating improved recall performance. The use of Wickens' technique for release of PI apparently leads to dissimilar conclusions from that of other measures used to evaluate children's encoding abilities who found indications of perceptual encoding in earlier years and semantic encoding in older children. However, these findings are not as discrepant as they appear. Compared to other measures, the Wickens technique may be a more sensitive indicator of semantic encoding. In previous studies using other techniques, color features were found to be encoded when stimuli were presented visually. Encoding along sensory dimensions may be considered more sophisticated when stimuli were presented auditorily such as in the studies using Wickens' technique. The sense impression feature detected by this task seems to be a very faint or illusive aspect of the verbal encoding process since very rarely are subjects even aware of this similarity in the stimuli (Wickens, 1970). This type of fine perceptual encoding is certainly not equivalent to gross perceptual encoding of visual stimuli for color or location attributes. Rather than providing inconsistent results, the Wickens task provides greater refinement and differentiation of verbal encoding abilities.

In one attempt to determine whether differences exist between reading disabled and nondisabled children in the attributes of words stored in memory, Lehman and Brady (1982) employed the Wickens technique using words differing along the semantic dimension. Similar demonstrations of

release from PI were found for both groups leading the authors to conclude that good and poor readers were alike in their ability to store information about a word's taxonomic category membership. Based on research demonstrating a relationship between verbal encoding and verbal memory ability in normal (Geis & Hall, 1976; Waters & Waters, 1976) and learning disabled groups (Ceci, Lea, & Ringstrom, 1980; Ceci, Ringstrom & Lea, 1981), different results may have been obtained if these researchers had identified and included in their study subjects with specific memory impairments. Semantic encoding ability would not be expected to be deficient in learning disabled children with normal verbal memory ability. Of greater relevancy is the determination of underlying cognitive functions of learning disabled subjects identified as memory impaired. It is expected that such a group would not demonstrate similar verbal encoding ability as children with normal verbal memory functions. The finding of differences between learning disabled and normal subjects' encoding ability would also have important implications regarding memory structure, processes, and development.

The Encoding Process and Memory Function

The encoding process is accepted as an important feature of memory process by the major theorists of memory function. The two store model of memory proposed by Atkinson and Shiffrin (1968, 1971) incorporates the notion of a control mechanism which is responsible for the transfer of information from the transient, limited, and primarily acoustic short-term store to the permanent, unlimited, semantically organized long-term store. This control mechanism is thought to extend the length of time

an item may be kept in short-term store via a rehearsal buffer. It also allows for an interaction between short-term and long-term stores. Automatic or selected associations from long-term store, based on experience, instructional set, or mnemonic strategy, may be rehearsed along with the to-be-remembered item to ensure its transfer to long-term store and its accessibility. The encoding process is that which creates automatic and optional associations and is therefore an essential element of the control mechanism.

Craik and Lockhart's (1972) model of memory is based on the notion that retention is positively related to the depth to which information is encoded. According to this model, a memory trace results from different levels of processing. Primary processing is superficial with an emphasis on physical, sensory features of stimuli, leading to the process of pattern recognition. Later stages of processing include the encoding of various semantic associations. The persistence of the trace is seen to be a function of the depth of analysis with stronger traces resulting from more elaborate encoding. Encoding processes are thought to occur in parallel, with deeper levels of stimulus enrichment dependent on greater breadth of the encoding process.

According to these theories, there is an automatic/optional dimension to the encoding process. Some associations may occur spontaneously, probably based on past experiences, while other associations may be consciously controlled such as when mnemonic strategies are employed to improve recall. Bower (1972) describes a method for memory improvement which involves creating bizarre or unusual associations among the items. Lorayne and Lucas (1974) describe another technique which involves

creating associations between easily retrieved stimuli such as numbers and the information that is to be recalled.

The development of memory skills is hallmarked by the use of more complex memorization strategies and the awareness of one's own memory abilities (Flavell, Friedrichs, & Hoyt, 1970). Studies examining the development of spontaneous mnemonic strategies during study periods before recall have found utilization of deliberate rehearsal by age 6 or 7, and categorization techniques to be characteristic of somewhat older children's memorization attempts and improved recall (Flavell, et al., 1970; Moely, Olson, Halwes, & Flavell, 1969; Neimark, Slotnick, & Ulrich, 1971; Salatas & Flavell, 1976). The knowledge of one's own memory capacity and mnemonic skills is referred to as meta-memory (Kreutzer, Leonard, & Flavell, 1975). Aspects of meta-memory functions appear to be age related. Older children are more likely than younger ones to accurately predict their memory capacity and readiness for recall, and are more aware of the effectiveness of employing active strategies to improve recall (Flavell, et al., 1970; Neimark, et al., 1971). According to Salatas and Flavell (1976) first graders' accuracy in answering "meta-memory" questions about the facilitative effect of category grouping during study did not relate to their use of categorization techniques during memorization attempts or semantic clustering during retrieval.

Although young children are aware of the efficacy of categorization, they may not spontaneously use this option in the encoding process. Lange and Hultsch (1970) studied this issue with subjects in grades 1, 3, 5, 7, and 9. Half the subjects were instructed to sort the items by

category and half the subjects were instructed simply to study the items before a recall test. The sorting activity had a significant facilitative effect on the recall of the subjects in grades 1, 3, and 5, but not for the subjects in grades 7 and 9. Apparently, the older subjects are spontaneously engaging in mental activities equivalent to the action of overt categorization. Waters and Waters (1976) required subjects in kindergarten and grade 2 to judge words as either nice or not nice during presentation of the stimuli in order to assure encoding along the evaluative dimension. These subjects, compared to subjects who were not required to participate in the evaluative orienting task, had significantly higher free recall and clustering scores.

Geis and Hall (1976) had children in grades 1, 3, and 5 engage in semantic, acoustic and orthographic orienting tasks, using different words for each task, and then unexpectedly, asked for recall of those words. In the semantic task, subjects had to respond to questions concerning category classification such as, "is it part of your body?" or "is it a flower?" For the acoustic task, subjects were asked, "does it rhyme with 'larm'?" or "does it rhyme with 'eel'?" And in the orthographic task, subjects were asked if words were presented in big or small letters. At all ages, semantic orienting tasks provided significantly better recall than the acoustic or orthographic tasks. Recall of words in the acoustic and orthographic tasks was similar. No developmental differences were found. The authors conclude that the absence of developmental differences in recall in this paradigm suggests that mnemonic activity at encoding is more important for subsequent retention than mnemonic activity at the time of retrieval. Furthermore, it seems

that it may be the optional encoding processes that are responsible for age differences in intentional and incidental learning.

These studies indicate that younger children, although capable of categorizing stimuli and aware of its facilitative effect upon recall, may not spontaneously engage in such "optional" processes to improve their recall. Perhaps older children, having more experience with memory, realize the extent of activities necessary for better recall. On the other hand, younger children may have inferior capacity for parallel encoding along diverse dimensions. It may be that as children grow older, there is an increase in the number of encoding dimensions they can simultaneously employ, which may be related to a change in the organization of their mental filing system. The same possibilities may be true for the encoding process of learning disabled children, since their memory deficiencies seem to resemble the normal memory performance of younger nondisabled children (Lyle, 1968; Senf & Feshbach, 1970; Tarver, et al., 1976).

The structure of long term memory in adults is thought to be organized semantically in a hierarchical network of related concepts (Collins & Quillian, 1969, 1970), or in sets of defining and/or characterizing elements (Meyer, 1970). Miller (1969, 1976) hypothesized that grammatical/relational information is organized along with semantic features of items in an individual's lexicon. Relationships commonly used in sentences such as inclusion (a dog is an animal), part-whole (a dog has a tail), and function (a dog barks), are considered as important as the semantic features. Relational and semantic information, according to Miller, are coded with an item to determine categorical set and hier-

archical structure in an associative network. Therefore, responses on word association tasks or sorting tasks would be governed by both syntactic/relational factors as well as semantic factors.

There are typical age related changes in responses on these types of tasks that are thought to reflect changes in conceptual organization of information. On sorting tasks, salient dimensions change from perceptual to semantic (Malkman & Deutsch, 1977), and the formation of semantic categories are found to change from limited, highly stereotyped sets to larger, more general conceptualizations (Lange & Hultsch, 1970). Nelson (1974) studied the variations in children's category conceptualization by requiring subjects to name as many exemplars as possible to different semantic categories. Age differences were found in the number of responses given per category. Nelson suggested that the developmental change of increased number of responses to superordinate category is related to hierarchical expansion of these categories.

The largest amount of evidence indicting a reorganization of hierarchical relations comes from studies demonstrating changes in response pattern on word association tasks (Nelson, 1977). Word association responses of the same grammatical form as the stimulus are referred to as paradigmatic, while responses from a different grammatical form class are considered syntagmatic (Ervin, 1961). Syntagmatic responses are said to continue syntactic order while paradigmatic responses function as replacement words. Brown and Berko (1960) previously used the terms homogeneous and heterogeneous to classify responses based simply on grammatical form. A shift in response type has been found to occur developmentally. Although both types of responses are given by subjects

of all ages, adults and older children tend to give more paradigmatic responses, and young children tend to give more syntagmatic responses (Brown & Berko, 1960; DiVesta, 1964; Entwisle, 1966; Ervin, 1961; Ingersoll, 1974; Palermo, 1971). Since nouns are the most common response forms for young children, the syntagmatic/paradigmatic shift is observed much more dramatically for stimulus words that are adjectives, verbs, and adverbs (Deese, 1962). The percentage of noun responses to adjectives, verbs and adverbs drops as the child ages and is replaced by paradigmatic responses that approximate adult levels by 8 to 10 years of age (Entwisle, Forsyth, & Muuss, 1964). This shift is considered to represent a general cognitive reorganization (Nelson, 1977), and reflect developmental changes in cognitive and linguistic processes (Francis, 1972).

The findings of developmental changes for sorting dimensions, category conceptualization, and paradigmatic/syntagmatic responses on word association tasks indicate a restructuring of saliency of features in conceptual organization. In Miller's terms, such developmental changes would signify a restructuring of the associative network from predominantly relational (syntagmatic or functional) to predominantly conceptual (paradigmatic or semantic) groupings. Such cognitive reorganization is likely to be related to developmental changes in encoding processes, particularly with respect to the perceptual-conceptual encoding shift previously reported. Furthermore, verbal encoding deficiency, if it exists in specific learning disabled groups, may be related to diffuse idiosyncratic organization, or delayed reorganization of lexical structures.

To determine if cognitive restructuring was developmentally delayed in learning disabled children, Bartel, Grill, and Bartel (1973) analyzed word association responses of 8 and 11 year old learning disabled and nondisabled children. No differences were found between groups at either age for frequency of paradigmatic or syntagmatic responses to all grammatical form classes of stimuli. For both groups similar developmental differences were found in the expected direction for paradigmatic/syntagmatic shifts in response type. Further research is needed to determine if semantic hierarchical networks are similar in learning disabled and nondisabled groups and whether this structure is related to verbal encoding processes.

In summary, the encoding process is seen to be an essential component of prominent theories of memory function. In the distinction between automatic and optional encoding processes, it seems to be the latter that accounts for developmental differences in memorization abilities and in the use of mnemonic strategies such as categorical organization. Young children, when instructed, can use evaluative and categorical information to improve their recall. A reorganization of the semantic filing system and the utilization of more sophisticated mnemonic techniques are seen to occur at similar developmental levels. Also, this reorganization of semantic information seems to be related to the greater use of optional, more elaborate encoding processes. Deficiencies in learning disabled children's verbal encoding processes may be related to the (dis)organization of semantic associative networks. Preliminary research has thus far yielded evidence of similar conceptual associations for learning disabled and nondisabled groups, however, this

work did not use subgroups of learning disabled subjects, and therefore, the results can not be generalized to a specific type of learning disabilities. If verbal encoding deficiency is demonstrated for a specific learning disabled group, additional information concerning the network of hierarchical organization of semantic associations of this group will be valuable for a fuller understanding of this deficiency and will provide a stronger basis from which to make recommendations for remediation.

The Research Hypothesis

Based on the foregoing theory and research, it appears that there is a subgroup of learning disabled children who have memory impairments. It is hypothesized that learning disabled children with a verbal memory impairment as a group will include a higher proportion of children with deficiencies in the verbal encoding process compared to groups of learning disabled and nondisabled children without a verbal memory impairment. To test this hypothesis, Wickens' technique for release from PI will be used to assess verbal encoding. This task will be used to examine encoding along semantic and phonetic dimensions. It is predicted that the release patterns demonstrated by the learning disabled group with a memory impairment will be inferior to the release patterns demonstrated by the learning disabled and nondisabled groups without a memory impairment. Based on the work of Cermak, et al. (1980), who found equal rates of item decay at zero to eighteen seconds of delay on the Peterson - Peterson short term memory distractor task, it is assumed that no differences will exist between groups for the initial rate of

forgetting or build-up of PI on this type of task. It is reasoned, therefore, that group differences on release trials represent differential encoding abilities rather than differential rates of decay. Since the Peterson-Peterson distractor task is designed to prohibit rehearsal, it is further assumed that group differences on release trials are not due to differential rates of rehearsal.

Since the reorganization of semantic information has been associated with more elaborative encoding processes (Hasher & Clifton, 1974) and improved memory ability (Lange & Hultsch, 1970; Melkman & Deutsch, 1977), tasks that examine associative semantic and phonetic structure will be administered in order to more fully understand the nature of the verbal encoding deficiency. The measures that will be used for this purpose are verbal associative fluency tasks for categories and letters, a word association task, and a word clustering task. These tasks were selected because they provide information about speed of association and types of association made (i.e., in determining whether the subject's response priorities are governed by conceptual or other dimensions). It is expected that the memory impaired learning disabled groups' associations will differ in kind and/or number from the comparison groups' associations. A slower association process would result in fewer responses on the timed verbal associative fluency tasks and in longer latencies on the word association test. A structurally immature associative network may result in more idiosyncratic or functional responses on the word association test and on the word clustering task. It is assumed that quantitative or qualitative differences on these tasks will be related to verbal encoding deficiency in the memory impaired learning disabled group.

METHOD

Subjects

Three groups of subjects were compared in this study: 1. learning disabled children with memory impairment (LDMI), 2. learning disabled children without memory impairment (LDO), and 3. normally achieving children without memory impairment (NC). The LDMI group consisted of 22 subjects, 18 males and 4 females, ranging in age between 8.0 and 10.8 years, with a mean of 9.7 years (116 months). The mean Full Scale IQ for this group was 98.3, as measured by the Wechsler Intelligence Scale for Children, Revised Edition (WISC-R) (Wechsler, 1955). The LDO group consisted of 17 subjects, 13 males and 4 females, ranging in age between 8.0 and 9.8 years, with a mean age of 8.9 years (107 months). The mean Full Scale IQ for this group was 98.5. The NC group consisted of 17 subjects, 12 males and 5 females, ranging in age between 8.2 and 10.6 years, with a mean age of 9.5 years (114 months). This group's mean Full Scale IQ was 101.9.

Assignment to each group was based upon performance on a battery of screening and assignment tests. These tests are described in the next section. The subjects in the LDMI group were selected after demonstrating a specific verbal memory impairment independent from any problem in speech sound discrimination. The subjects in the LDO group were selected based upon demonstration of normal verbal memory ability. Subjects in this group presumably have other cognitive deficiencies which impede

reading ability but lie outside the realm of verbal memory. The subjects in the NC group had grade appropriate academic skills and normal memory performance.

All subjects in the learning disabled (LD) groups had been certified as learning disabled by the Committee of the Handicapped of the Board of Education of the City of New York. Criteria for the classification of the learning disabled students were within the guidelines set by the National Advisory Committee on Handicapped Children (1968) presented previously. All learning disabled students were mainstreamed in regular classes, but participated in special Resource Rooms for the learning disabled one hour per day. No subject had a history of bilingualism or moderate to severe emotional disturbance. NC subjects were chosen from the same classes as the LD subjects in an attempt to equate educational exposure. In order to ensure adequate cognitive abilities, all subjects had a score equal to or greater than 85 on either the Verbal Intelligence Quotient (VIQ) or the Performance Intelligence Quotient (PIQ) of the WISC-R.

The Screening and Assignment Battery

Academic Abilities

Prior to group assignment, current academic achievement was assessed for all potential subjects. Reading level was determined by the Gray Oral Reading Test (1967). In order to be assigned to either LD group, reading performance had to be at least 1.5 years below appropriate grade level. NC subjects had to obtain reading scores within 6 months of normal grade level. The Gray Oral Reading Test is a timed test of oral pa-

paragraph reading. Reading achievement is measured as a function of both speed and accuracy on paragraphs of increasing difficulty. Four comprehension questions measuring recall of the literal meaning of each paragraph were given immediately following the reading of each paragraph. Performance on these questions were not used in the determination of grade equivalent scores, but were used as a separate measure. The Gray Oral Reading Test was selected as a criterion measure of reading ability because of its sensitivity to a wide range of abilities necessary for successful reading.

Word recognition and arithmetic subtests of the Wide Range Achievement Test (WRAT) (Jastak & Jastak, 1965) were also administered. The WRAT reading subtest measures sight reading ability of isolated words of increasing difficulty with no time limits for administration. This test is a good indicator of a subject's sight vocabulary and decoding abilities. The arithmetic subtest of the WRAT has two parts, an orally administered section requiring mental computations of simple concepts, and a written test requiring mastery of increasingly difficult concepts. Both arithmetic sections together have a total time limit of ten minutes. The reading and arithmetic subtests of the WRAT were included in the screening and assignment battery for descriptive purposes. Mean scores for all groups are presented in the Results section.

Intellectual Ability

All subtests of the WISC-R were administered individually to each subject. Although a score of 90 is generally considered to be the lower limit of the normal range, a score of 85 was used in this study because

a learning disability may produce less than normal acquisition of information. Thus scores on such subtests as Information, Vocabulary, and Arithmetic might be lower than expected. In fact, a learning disability may negatively predispose a child to any test taking situation. A VIQ or PIQ score of less than 85 may indicate a deficiency in sensory, perceptual, linguistic, attentional, and/or motor functions. Therefore, subjects were disqualified from the study if they obtained verbal or performance scores of less than 85, even if their FSIQ score was above this cut-off. There were no restrictions set for the upper limits of intellectual achievement for the LD groups. However, the intellectual achievement for the subjects in the NC group was selected for comparability with the LD groups, such that no subject in the NC group achieved scores above the range achieved by the LD subjects.

Auditory Discrimination Ability

Prior to administration of the memory test, subjects were tested for speech sound discrimination ability. Successful performance on an auditory verbal memory test requires the ability to adequately perceive the spoken word and distinguish words from each other. Rather than presume that all subjects were capable of making this discrimination, all potential subjects were tested for this ability with the Wepman Auditory Speech Sound Discrimination Test (Wepman, 1958). Subjects determine if two words which are presented orally are the same or different. Forty pairs of single syllable words are presented, 30 differ by one phoneme either at the beginning or the end of the word, while 10 pairs are identical. The subject must rely only on auditory cues in this task because

he is unable to see the experimenter produce the words. According to the norms, three or more errors by children eight years of age or older represent deficient auditory discrimination ability. For this reason, all subjects making 3 or more errors were disqualified from the study.

Memory Abilities

The Rey Auditory-Verbal Learning Test (Lezak, 1976; Taylor, 1959) was used to measure verbal memory ability. A list of 15 words was presented for five trials, with all the words repeated in the same order for each trial. The subject had 60 seconds to recall as many words as possible in any order. Standardized norms are provided for trials 1, 3, and 5, and for total recall for all 5 trials (Taylor, 1959). Normal memory performance was considered to be the achievement of scores equivalent to the 20th percentile or above. For this reason, NC subjects who obtained scores below the 20th percentile were disqualified. All subjects in the LDO group were above the 20th percentile, while all subjects in the LDMI group were below the 20th percentile on this test.

Although not used as part of the screening criteria, the Rey Auditory-Verbal Learning Test has measures of proactive interference (PI) and retroactive interference (RI). RI is the interfering effect of newly learned material on the recall of previously learned material. Immediately following the fifth trial, a new list of 15 words was presented for recall. After this, the subjects recalled the initial list without repeated presentation. The measure of PI was established by subtracting recall scores on the new list from recall scores on trial 1 of the old list. RI was calculated by subtracting the recall scores on trial 5 from the final recall score.

Procedure

All subjects participated individually in each of the six experimental tasks. Two of these are separate modifications of the Wickens technique for release from PI, which were used to measure verbal encoding along semantic and phonetic dimensions. The remaining four experimental tasks, two verbal associative fluency tasks, a word association task, and a word clustering task, addressed limited aspects of linguistic associations and conceptual structure in long-term semantic memory.

The Phonetic Encoding Task

To assess phonetic encoding Wickens' technique for release from PI was used with stimuli of the same initial consonant blends. In the release condition, condition 1, words with a different initial sound were presented on the final trial. In the nonrelease condition, condition 2, all the words presented were of the same initial consonant blend. The final trial of each condition were compared to determine the extent of phonetic release. The stimulus words used in each condition are listed in order of presentation in Table 1. All items used in this task were mono-syllabic, with A and AA word frequency counts (Thorndike & Lorge, 1944). The average word frequency was equal for all trials.

Stimulus words were tape recorded and presented to the subject via headphones at a 1 per second rate. Immediately following the presentation of the words on trial 1, the subject began the distractor task. The distractor task entailed naming colors as quickly as possible from a sheet placed directly in front of the subject. Red, blue, yellow, green, black and brown colored circles were randomly presented in rows

TABLE 1

Phonetic Encoding Task Stimuli

Release Condition:

Street	Strange	Strength	Face
Strong	Strike	Stream	Fell
String	Stretch	Strain	Fame

Nonrelease Condition:

Stood	Stone	Star	Stand
Store	Start	Storm	Stock
Stair	Stove	Staff	Stamp

on an 8 x 11 white cardboard sheet. To ensure prompt attention to the distractor task and to avoid rehearsal attempts, immediately following the last word on each trial the experimenter pointed to the first circle from which the subject would begin color naming. The subject's participation in the distractor task continued for 15 seconds at which time the tape prompted stimulus retrieval with the command signal "recall." The subjects then had 12 seconds to recall the three words in any order until the tape returned with the orienting command "ready," followed immediately by the words on the next trial. This procedure was repeated for each trial. The instructions used to introduce this task were as follows:

Can you name these colors out loud for me? (Subject demonstrates familiarity with color names.) Now on this tape-recorder you will hear three words. Listen carefully to those words. After you hear the three words I want you to name these colors again, but as quickly as you can, and continue naming them until you hear the recorder say "recall." Then stop naming the colors and tell me the three words that you heard. You will have a short period of time to recall the words and then the tape will say "ready" and then another three words. Again, immediately start naming the colors until you hear the tape say "recall." Then tell me the second three letters you heard. We will continue like this until the tape says "stop." Now let's try a practice one.

In the practice trial, the numbers 1, 2, and 3 were presented followed by 5 seconds of color naming before recall was requested. This practice trial was repeated if any subject had difficulty with the procedure. The experimental task immediately followed successful recall of the numbers.

The Semantic Encoding Task

The Wickens technique was also used to measure semantic encoding. The procedure used for this task was identical to that used in the phonetic encoding task, with the exception of the stimuli. In the release condition, condition 3, the stimulus words were names of common animals for the first three trials, and names of articles of clothing on the last trial. In the nonrelease condition, condition 4, names of articles of clothing were presented on all four trials. The words used in this task are listed in order of presentation in Table 2. All words were monosyllabic, high frequency words, presented with headphones at the rate of one per second. Average word frequency was equated for all trials. The same instructions, practice trial, and distractor task were used.

Each condition of the phonetic and semantic encoding tasks was given on a separate day, with a minimum of one week intervening between administrations. Order of administration was randomized. The instructions and practice trial were used before administration of each condition. All responses given during the recall period were recorded by hand.

TABLE 2

Semantic Encoding Task Stimuli

Release Condition:

Goat	Lion	Bear	Skirt
Dog	Horse	Sheep	Belt
Pig	Deer	Fox	Dress

Nonrelease Condition:

Hat	Scarf	Vest	Coat
Shirt	Tie	Cap	Slip
Cape	Glove	Shoe	Boot

The Verbal Associative Fluency Task--FAS

On the verbal associative fluency task (Benton, 1968; Borkowski, Benton, & Spreen, 1967) subjects were required to give as many words as possible in one minute that begin with a specified letter of the alphabet (F, A, S), excluding proper names, numbers, or the same word with different endings. These letters have been found to elicit a relatively greater amount of responses compared to other letters and higher word frequency counts for both normal and brain damaged adults (Borkowski, et al., 1967). Subjects were prompted to give more items if they stopped responding before one minute. Repetitions were not included in score tabulations. Instructions for this task were:

I am going to say a letter of the alphabet, then I want you to tell me as many words as you can think of that begin with that letter. Tell me them as quickly as you can. Do not use names of people or places, numbers, or the same word with different endings like 'break, breaking, broke,' because they are all really the same word.

The Verbal Associative Fluency Task--Category Naming

Category naming was used as a second measure of associative productivity (Nelson, 1974; Spreen & Benton, 1969). In this task, subjects were required to give as many category exemplars as possible in one minute. The four categories in order of presentation were animals, articles of clothing, fruits, and jobs. This order represents ascending levels of difficulty in eliciting responses (Nelson, 1974). No restrictions were placed on responses as long as they were exemplars of the category. Slang words were also accepted. However, exemplars of the job category

had to be true titles such as salesman or pilot. Descriptive exemplars such as "a person who works in a store" or "a person who flies a plane," were not accepted. Instructions to subjects were simply "Tell me as many different kinds of animals (items of clothing, fruits, jobs) as you can think of, as quickly as you can."

The Word Association Task

A word association test was used as a measure of linguistic development and semantic organization. The stimulus words were selected from a larger list of words found by Halperin (1965) to represent the type of words least likely to produce long latencies and perseverative/idiosyncratic responses by dysphasic adults. The words chosen were characterized by medium to low abstraction level, short word length, and high frequency of occurrence. Nouns have been found to yield significantly more paradigmatic (homogeneous) responses than verbs and adjectives (Bartel, et al., 1973; Brown & Berko, 1960; Deese, 1962), and less deviant responses and shorter response latencies than verbs and adjectives (Halperin, 1965). Therefore, the stimulus words were chosen to represent each of these form classes. The stimulus words were: Jump, Mile, Tall, Join, Cat and Sick. The instructions to each subject were as follows: "Now let's play a word game. I am going to say a word and I want you to tell me the first word it makes you think of. Tell me only the first word that comes to mind, and tell me it as quickly as you can." Response latencies were recorded along with each response. If a subject gave a response that was ambiguous with respect to grammatical class, the subject was asked to use that word in a sentence after completing

the word association task. The grammatical form of the response word used in the sentence was noted as the grammatical form of the response.

The Hierarchical Clustering Task

This task is a modification of the word clustering task used by Zurif, Caramazza, Myerson, and Galvin (1974) with aphasic adults. This technique allows subjects to demonstrate their organization of conceptual categories. Each subject was presented with a word triad and was required to select the two which were the most similar. A set of eight words were arranged in every possible combination of three, yielding 56 trials presented one at a time in a fixed random order. All words in this set were related to each other, either closely or remotely, along semantic or functional dimensions. The eight item set was comprised of the following high frequency words: Husband, Wife, Lady, King, Crown, Hat, Tie, Dress. Each word was printed separately in large black bold face letters on a 3" x 5" white card. The subject read each word aloud. If an error was made, it was corrected and the subject read the entire set again correctly. Subjects then demonstrated familiarity with the stimulus words by defining them in their own words. If the subjects were hesitant to respond, they were prompted to express their ideas with questions such as "What is a" and "What else does the word mean?" After demonstrating adequate familiarity, the word triads were presented. The instructions were "Read these three words out loud and then pick the two words that you think are the most similar." The experimenter pointed to each of the three possible pairs that the subject could consider as most similar. These instructions were given for the

first several trials and were repeated on later trials if the subjects did not read each word aloud.

All subjects were tested individually over four sessions in a quiet room in the school building. In session I, subjects were administered the release condition of the phonetic encoding task followed by the category naming task. In session II, subjects were administered the non-release condition of the phonetic encoding task followed by the word clustering task. In session III, the release condition of the semantic encoding task was administered followed by the word association task. In session IV, the nonrelease condition of the semantic encoding task was administered followed by the FAS task. This order of presentation of tasks was designed to prevent the use of stimuli heard on the encoding tasks as responses on the verbal fluency task. Therefore, the phonetic encoding tasks were not followed by the FAS task and the semantic encoding tasks were not followed by the category naming or word clustering tasks. Order of presentation of these sessions was randomized. Each session lasted for a maximum of twenty minutes in order to optimize attention and motivation and reduce fatigue.

RESULTS

This section presents the results of the analyses of group differences on the screening and assignment battery tests followed by the data analyses of the experimental tasks. The experimental task results are presented in two parts: those pertaining to data obtained on the encoding tasks and those pertaining to the data obtained on the verbal fluency, word association, and clustering tasks. Each part is followed by a brief summary and discussion of the findings.

The Screening and Assignment Battery

Table 3 presents the average group performance on the screening and assignment battery tests. Subjects not meeting the screening criteria were disqualified from the study and were not included in this section. Of the 53 students referred by teachers as achieving normally, 36 were disqualified for the following reasons: Four had VIQ or PIQ scores less than 85; one had a FSIQ of 130 which was above the highest FSIQ of any learning disabled subject; nine had memory scores less than the 20th percentile; eleven had insufficient reading levels; nine had reading levels too high above appropriate grade level; and two had insufficient auditory discrimination abilities. Of the 71 students referred by teachers as learning disabled, 17 were disqualified by school records indicating insufficient intellectual levels, emotional problems or too high reading levels. Another 15 learning disabled students were disqua-

lified following the screening and assignment battery. In all, a total of 32 learning disabled subjects were disqualified for the following reasons: Fifteen had VIQ or PIQ scores below 85; ten were reading too close to grade appropriate levels; four had moderate to severe emotional problems; and five had insufficient auditory discrimination ability.

Age, Sex, and Race

The mean age in months of the NC, LDO, and LDMI groups was 114, 107, and 116, respectively. An analysis of variance for group differences in age resulted in a significant group effect, $F(2,52) = 6.130, p < .01$. Examination of the group differences with Duncan's new multiple range test (Kirk, 1968) revealed that the LDO group was significantly younger than both the NC and LDMI groups ($p < .05$). Since there was a significant age difference between groups, analyses of covariance were performed along with analyses of variance in order to rule out the possibility that age differences were responsible for any differences between the groups on any other measure. In all instances, significant differences found with the analysis of variance were also found with the analysis of covariance, with only slight changes in the magnitude of the probability levels. All nonsignificant findings were duplicated using both tests. For all reported results, significance levels are based on analyses of covariance, unless otherwise specified. In all cases pairwise a posteriori comparisons using Duncan's new multiple range test were applied to significant differences in order to provide a better understanding of the treatment effects.

Male to female ratios were essentially constant between groups. No group differences were found for sex of the subjects in each group, $F(2,52) = 0.312$, $p > .10$. Racial and ethnic composition was mixed in each group. White to nonwhite ratios were essentially equivalent in each group (NC = 14/3, LDO = 11/6, LDMI = 16/6). No group differences were found for racial composition between groups, $F(2,52) = 0.699$, $p > .10$.

Academic Abilities

Performance on the reading and arithmetic tests for all groups is shown in Table 3. A repeated measures analysis of covariance for performance on reading tests revealed significant group differences, $F(2,52) = 91.447$, $p < .001$. The LD groups were significantly inferior to the NC group on both tests of reading ($p < .001$). Analysis of the significant main effect for reading scales indicated that the Gray Oral Reading Test was substantially more difficult across groups than the reading subtest of the WRAT, $F(1,53) = 68.746$, $p < .001$. Analysis of the significant group X reading test interaction, $F(2,53) = 4.935$, $p < .01$, revealed that the NC group scored higher on the WRAT than on the Gray Oral Reading Test, and their scores on both tests were higher than both LD groups' scores. Both LD groups performed similarly on the reading subtest of the WRAT and their scores on this test were significantly higher than their scores on the Gray Oral Reading Test. Although on both tests the NC group achieved higher scores than both LD groups, on the Gray Oral Reading Test, the LDO group performed significantly higher than the LDMI group, while no significant differences were found for the LD groups on the WRAT.

Analysis of paragraph comprehension scores on the Gray Oral Reading Test yielded significant differences between groups, $F(2,52) = 16.914$, $p < .001$. The LDO and LDMI groups retained less information than the NC group ($p < .001$). Similar significant group differences were found on the arithmetic subtest of the WRAT, $F(2,52) = 14.465$, $p < .001$. A posteriori comparisons demonstrated significantly greater arithmetic achievement for the NC group compared to both LD groups ($p < .001$). No differences between the LD groups' arithmetic scores were found. Both LD groups could be considered primarily reading impaired, since for all LD subjects, arithmetic scores were higher than the average of the two reading scores. This relationship was not found in the academic scores of the NC group.

TABLE 3

Mean Performance on the Screening and Assignment Battery

	<u>NC</u>	<u>LDO</u>	<u>LDMI</u>
Full Scale IQ	101.93	98.47	98.25
Gray Oral Reading (*)	0.02	-1.99 a	-2.65 a,b'
Gray Oral Comprehension	2.18	1.69 a	1.42 a
WRAT Reading (*)	0.47	-1.18 a	-1.44 a
WRAT Arithmetic (*)	0.21	-0.55 a	-0.98 a
Errors on Auditory Discrimination	0.83	0.64	0.73
Memory Per- formance (**)	50.12	45.82	35.05 a,b
PI	-1.71	-0.94	-0.23
RI	-1.77	-2.12	-1.96
Primacy Effects	1.29	0.65 a''	0.59 a'
Recency Effects	2.18	1.35 a''	1.00 a'

 (*) Scores represent deviations in years from appropriate grade level.

(**) Total number recalled over the five presentations.
 (a, a', a'') Significantly inferior to NC ($p < .001$,
 $p < .01$, $p < .05$).

(b, b') Significantly inferior to LDO ($p < .001$,
 $p < .01$).

Intellectual Abilities

A repeated measures analysis of covariance was carried out on verbal and performance IQ scales. The main effect for group was not significant, $F(2,52) = 0.046$, $p > .10$, nor was the main effect for IQ scale, $F(1,53) = 2.854$, $p > .10$. The group X IQ scale interaction was nonsignificant, $F(2,53) = 1.949$, $p > .10$. Also, the one-way analysis of covariance for Full Scale IQ produced no significant group effects, $F(2,52) = 1.027$, $p > .10$.

Auditory Discrimination Abilities

On the Wepman Test of Auditory Discrimination errors ranged from zero to two. No significant differences among groups were found, $F(2,52) = 0.699$, $p > .10$.

Memory Abilities

The mean total memory score for each group on the Rey Auditory-Verbal Learning Test was compared. The main effect for group was significant, $F(2,52) = 62.771$, $p < .001$. The LDMI group recalled significantly fewer total words than the NC and LDO groups ($p < .001$), but the NC and LDO groups did not differ significantly from each other ($p > .10$).

A comparison of group differences on the interference scales of the Rey Auditory-Verbal Learning Test was performed. The main effect for group was not significant, $F(2,52) = 2.136$, $p > .10$. The significant difference between interference scales, $F(1,53) = 11.699$, $p < .01$ indicated that for all groups combined, RI was greater than PI. Although

the interaction between group and interference scale was not significant, $F(2,53) = 2.890$, $p < .065$, post hoc analysis at the .05 significance level suggests a trend in the data. Although PI and RI were essentially equivalent for the NC group, RI was greater than PI for both LD groups. In fact, the PI score for the LDMI group was substantially lower than the NC group's PI score. The LDMI group's low PI score may be a function of their low recall scores on the first trial of the initial list; therefore, a floor effect may have been responsible for the fact that their performance on the second list of words was not much lower, resulting in smaller PI scores. This trend may explain, in part, the finding of a greater RI score compared to PI score across groups.

Since PI and RI are commonly thought to contribute to primacy and recency serial order effects (Klatzky, 1975), the first trial of the Rey Auditory-Verbal Learning Test was examined for serial order differences in an attempt to obtain a clearer picture of cognitive differences between the groups. In determining a subject's primacy score, only consecutive words recalled from the beginning of the list were considered. The primacy score was the total number of words recalled from the beginning of the list before a word was skipped. If a subject recalled words 1, 2, 3, and 5, the primacy score would be three, since that was the total number recalled from the beginning of the list before a word was skipped. The recency score was determined in the same fashion except the words were totaled from the end of the list. Post hoc analysis of the significant main effect for group, $F(2,52) = 7.639$, $p < .01$, revealed greater serial order effects for the NC group compared to the LDO group ($p < .05$) and the LDMI group ($p < .01$). Overall, the recency ef-

fect was significantly larger than the primacy effect, $F(1,53) = 7.688$, $p < .01$. The two-way interaction between group and serial order was not significant, $F(2,53) = 0.331$, $p > .10$, indicating that the NC group remained superior to the other groups for both primacy and recency recall.

Summary and Brief Discussion

The results of the screening and assignment battery are consistent with the criteria for group selection. Since the LDO group was younger than the other two groups, age adjustments were applied to all data obtained in order to correct for this difference by means of analyses of covariance. The results demonstrate that the groups were matched with respect to sex, race, intellectual functioning and auditory discrimination ability. Both LD groups were inferior to the NC group on word recognition, paragraph reading, passage comprehension, and arithmetic. The LDO group was superior to the LDMI group on paragraph reading, but equivalent to this group on all other indices of academic abilities. Both LD groups were primarily reading impaired, exhibiting relatively smaller deficits in arithmetic abilities.

Results from the Rey Auditory-Verbal Learning Test indicated that the NC and LDO groups had significantly superior verbal recall compared with the LDMI group, confirming the selection criteria. Although group differences were not found for interference scales, a trend was indicated for the interaction of group and type of interference. It was suggested that a floor effect may have limited the LDMI group's PI effect. Since this group had poor recall, their low scores on the initial trial may have precluded strong PI effects. The floor in PI effects for this

group may have also contributed to the finding of a significant difference in strength of interference scales; on this task, RI was greater than PI, averaged across groups. Serial order effects were analyzed on the first trial of the memory test. The NC group had greater serial order effects than both LD groups. Overall, recency effects were greater than primacy effects. This finding suggests that differences may exist between NC and LD groups in some underlying cognitive processes for the acquisition of supraspan lists of verbal information.

The Encoding Tasks

In order to compare learning disabled and control groups for encoding ability, recall scores on the Wickens task were analyzed with a repeated measures analysis of covariance. A significant main effect was found for group, $F(2,52) = 5.555, p < .01$. A posteriori pairwise comparisons indicate that the LDMI group was inferior to the NC group ($p < .01$), with the scores of the LDO group falling in between the two and not significantly different from either. Significant main effects were also found for condition, $F(3,158) = 41.087, p < .001$. Post hoc tests established that condition 1, the phonetic release condition, and condition 4, the semantic nonrelease condition, were not discriminable but both were higher than condition 2, the phonetic nonrelease condition, ($p < .001$) and lower than condition 3, the semantic release condition, ($p < .001$). Significant main effects were also found for trial, $F(3,158) = 95.390, p < .001$. Post hoc tests found trials 2 and 4 were indistinguishable but greater than trial 3 ($p < .001$) and lower than trial 1 ($p < .001$). No significant results were found for the group X condition in-

teraction, $F(6,158) = 1.047$, $p > .10$, or the group X trial interaction, $F(6,158) = 1.047$, $p > .10$. The condition X trial interaction was significant, $F(9,476) = 12.616$, $p < .001$. Recall on the shift trial in the release condition was greater than recall on the corresponding trial of the nonrelease condition for both phonetic and semantic encoding tasks ($p < .001$). Also, the release trial was essentially equivalent to the first trial in both release conditions, substantiating in general, the potency of the release effect ($p < .001$).

The three way interaction, group X condition X trial was also significant, $F(18,476) = 2.4114$, $p < .01$. Descriptions of this interaction is facilitated by examination of Figures 1 and 2 which show the percentage of words correctly recalled by each group on all trials in release and nonrelease conditions for the phonetic and semantic encoding tasks, respectively. All group scores on trial 4 of both nonrelease conditions were not significantly different, ($p > .10$). The last trial in the release and nonrelease condition were compared for both encoding tasks. For the NC group, significant differences between these trials were demonstrated for both phonetic and semantic encoding tasks, with increased recall for the release conditions ($p < .001$). Similar significant differences were also demonstrated between these trials for the LDO group for both encoding tasks ($p < .001$). The LDMI group, however, demonstrated significantly greater recall on the last trial of the release compared to the nonrelease condition only for the semantic encoding task ($p < .001$). On the phonetic encoding task, there was no difference between trials for this group ($p < .001$).

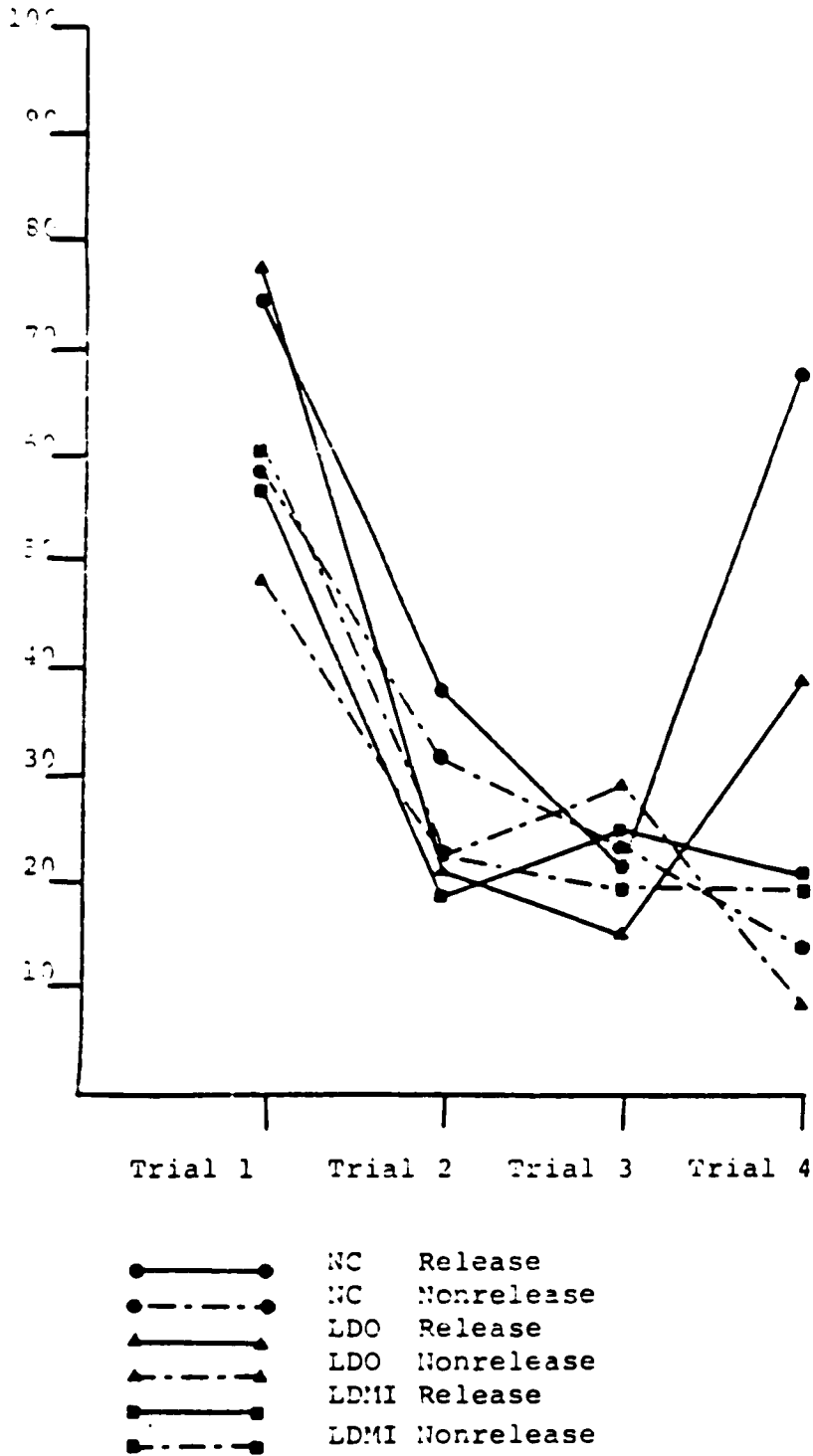


Figure 1: Percent Correct on the Phonetic Encoding Task

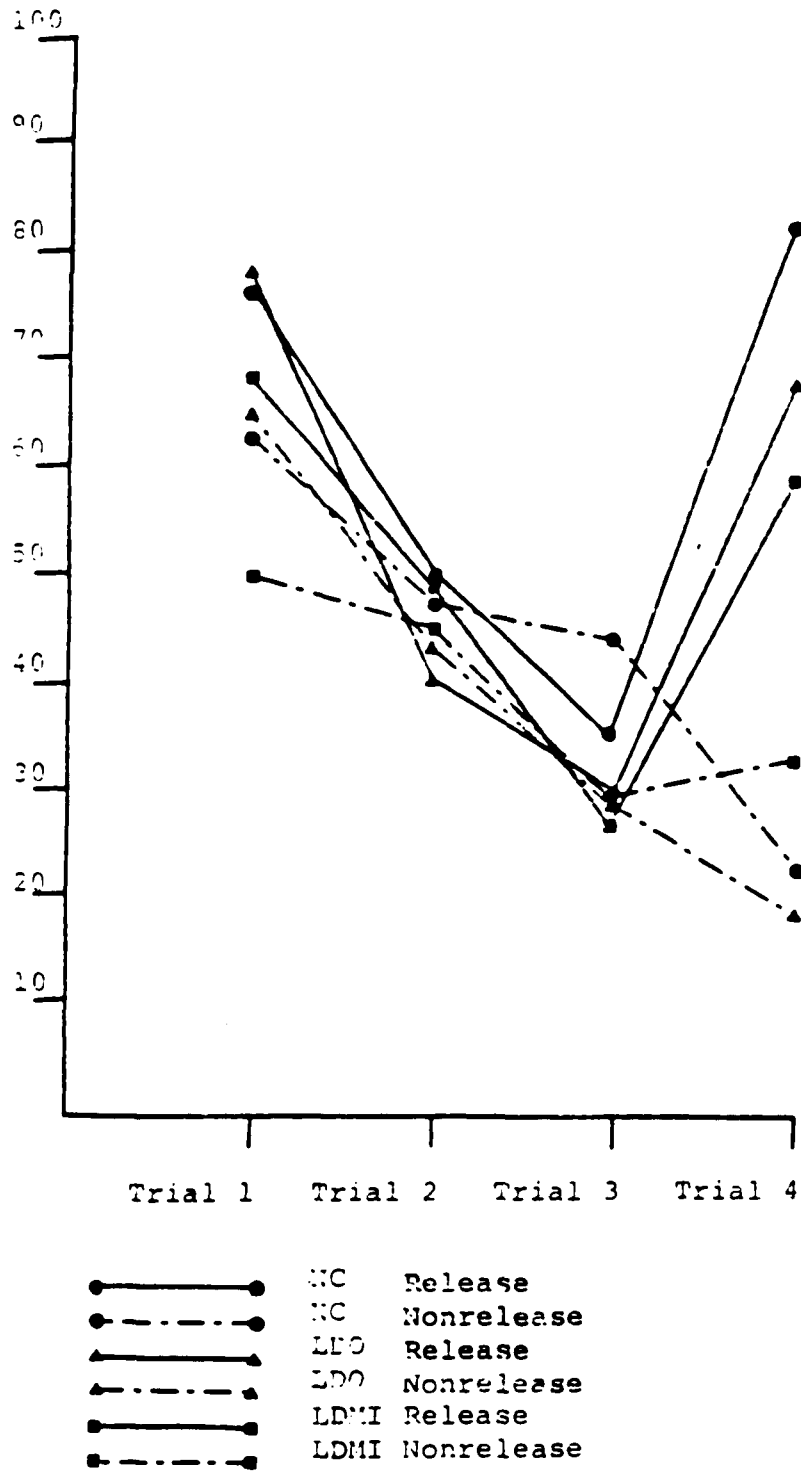


Figure 2: Percent Correct on the Semantic Encoding Task

Significant findings of release from PI were also demonstrated by increases in recall from trial 3 to trial 4 of the release condition. Trial 3 scores were equivalent for all groups in all conditions ($p > .10$). Significant improvements in recall following a shift in the stimulus dimension occurred for both NC and LDO groups in the release conditions for both phonetic and semantic stimuli ($p < .001$). The LDMI group demonstrated significant improvements with the semantic category stimulus shift ($p < .001$), but not with the phonetic stimulus shift ($p > .10$). The recall scores of the NC group were significantly higher than the recall scores of both LD groups on trial 4 of the phonetic release condition ($p < .001$) and were significantly higher than the recall scores of the LDMI group on trial 4 of the semantic encoding task ($p < .001$). Although the LDMI group did show a disruption of PI on the semantic encoding task, it was not to the same extent as the NC group. The LDO group demonstrated a smaller release pattern than the NC group on the phonetic encoding task, although they did show a significant release from PI, which the LDMI group did not.

The continued effect of PI was demonstrated in the nonrelease conditions. In the nonrelease conditions of both tasks for NC and LDO groups trial 4 was significantly inferior to trial 1 ($p < .001$). Similar results were found for the LDMI group on the phonetic encoding task only ($p < .01$). Trials 1 and 4 were essentially equivalent on the nonrelease condition of the semantic encoding task ($p > .10$), suggesting a less potent PI effect in this dimension for this group, especially since recall on the first trial of the nonrelease condition was similar across groups ($p > .10$). Furthermore, trials 3 and 4 on the nonrelease condition of

both tasks were essentially equivalent for all groups, except for the NC group's performance on the semantic encoding task. In the nonrelease condition of the semantic encoding task this group's performance on trial 4 was significantly lower than their performance on trial 3 ($p < .05$), suggesting a more potent PI effect for the NC group compared to the other groups, especially since trial 3 of this condition was essentially equivalent across groups ($p > .10$).

The magnitude of the release phenomenon was substantiated for the NC group, since the recall scores on the shift trial were not significantly different from the recall scores on the first trial of the release condition for both encoding tasks ($p > .10$). The magnitude of recall scores on the first and last trials of the semantic release condition were comparable for the LDO group also ($p > .10$). However, the LDO group's phonetic release did not reach equivalent levels to the initial trial of the phonetic release condition ($p < .001$). The LDMI group's recall on the shift trial was significantly poorer than their recall on the first trial of the release condition for phonetic release ($p < .001$). In the semantic release condition, trial 1 and trial 4 were not significantly different for this group ($p > .10$).

The percent of recall recovery was calculated for the release conditions of the phonetic and semantic encoding tasks by comparing trial 4's approximation to trial 1. Trial 4 was divided by trial 1 and multiplied by 100, resulting in the percent of recall recovery. As can be seen from Table 4 the percent of recall recovery was much higher in the semantic condition compared to the phonetic condition. Also, the NC group's percent of recall recovery was much higher than the LDO and LDMI

group's percent of recall recovery. On the semantic release condition, trial 4 scores for the NC group was actually slightly higher than their scores on trial 1, resulting in a percent of recall recovery score of 108.

Consistent findings regarding the magnitude of release from PI were found using another measure of phonetic and semantic release. The recall score on the last trial of the nonrelease condition was subtracted from the score on the last trial of the release condition for each subject for both encoding tasks. The results of these computations were referred to as phonrel and taxrel, respectively, denoting the magnitude of the release from PI in the phonetic and semantic encoding tasks. Significant main effects for group were found for these measures, $F(2,52) = 13.582$, $p < .001$. Post hoc analysis established that the NC and LDO groups were not distinguishable on these measures and that both were higher than the LDMI group on these measures ($p < .001$). A significant main effect was also demonstrated for release type, $F(1,53) = 6.792$, $p < .05$, such that the magnitude of the taxrel scores was greater than the magnitude of the phonrel scores, measured across groups. The interaction of group and release type was not significant, $F(2,53) = 1.04$, $p > .10$, which indicates the degree of superiority of the control groups over the LDMI group remained constant for both release types. Table 5 presents the scores obtained by all groups for phonrel and taxrel measures.

An analysis of error type can be as useful as analysis of recall pattern in revealing underlying processes. For this reason, intrusion errors on the encoding tasks were examined and compared across groups.

TABLE 4

Mean Percent of Recall Recovery

	<u>NC</u>	<u>LDO</u>	<u>LDMI</u>
Phonetic Release	92	52	36
Semantic Release	108	87	87

TABLE 5

Mean Phonrel and Taxrel Scores for all Groups

	<u>NC</u>	<u>LDO</u>	<u>LDMI</u>
Phonrel	1.65	0.94	0.05 a,b
Taxrel	1.77	1.47	0.77 a,b

-
- (a) Significantly inferior to NC ($p < .001$).
(b) Significantly inferior to LDO ($p < .001$).

Errors were classified as 1. Proactive Intrusions (PI) when erroneous responses were used as stimuli on previous trials in that condition, 2. Previous Proactive Intrusions (PPI) when erroneous responses were used as stimuli in previous conditions, 3. Consistent Intrusions (CI) when erroneous responses were consistent with the stimulus dimension used on that trial but not used previously as a stimulus word, 4. Non-Consistent Intrusions (NCI) when erroneous responses were not consistent with the stimulus dimension used on that trial, and not used previously, and 5. Retroactive Intrusions (RI) when erroneous responses were used on the distractor task, i.e., they were color names. The number of omissions were also calculated for each subject, but analyzed separately from the error types. Table 6 presents the mean number of responses for each error type across all encoding conditions, for each group. A significant main effect for group was demonstrated for error type, $F(2,52) = 3.70$, $p < .05$. Post hoc test results show no differences between LD groups in total number of errors made, but both LD groups made more errors than the NC group ($p < .05$). The main effect for error type was also significant, $F(4,211) = 54.326$, $p < .001$. A posteriori analysis established PI as the most common error type, followed by CI, NCI, PPI, and RI. In each instance all error types differed significantly from all others ($p < .001$) except for PPI and RI errors which never differed in the post hoc analysis ($p > .10$). A significant interaction for group and error type was found, $F(8,211) = 2.342$, $p < .05$. The post hoc analysis showed similar rates of error type differences as those found in the main effect for error type, except that the rate of NCI errors for both LD groups was essentially equivalent and significantly higher than the

rate of NCI errors produced by the NC group ($p < .05$). Although a significant difference occurred between groups in the number of erroneous responses made, there was no significant differences in the number of omissions, $F(2,52) = 0.807, p > .10$.

TABLE 6

Mean Incidence of Error Types across all Encoding Conditions

<u>Error Type</u>	<u>NC</u>	<u>LDO</u>	<u>LDMI</u>
PI	5.92	6.90	7.17
PPI	1.03	1.20	0.86
CI	4.86	5.96	4.13
NCI	0.68	3.90 a.	4.31 a.
RI	-0.03 *	0.20	0.95
Omissions	12.28	11.33	14.24

 (*) The negative value for the incidence of RI errors listed for the NC group is a result of the adjustments made to the scores in the analysis of covariance.

(a.) Significantly higher than NC ($p < .05$).

Summary and Brief Discussion

The results from these analyses indicate that a higher proportion of learning disabled children with memory impairment have inferior phonetic and semantic encoding ability compared to normally achieving and learning disabled children without memory impairment. These findings confirm the major hypothesis of this study. The LDMI group had significantly less disruption of PI than the NC group for phonetic and semantic encoding as demonstrated by significant recall differences on the shift or final trials of both release conditions. Although the LDO group demonstrated a significant release pattern on both dimensions, their release pattern on the phonetic task was not as large as that of the NC group since significant recall differences also occurred between these groups on the final trial of the phonetic release condition. However, the most significant differences for both the demonstration of release from PI and for the magnitude of the release from PI were found between the LDMI and the control groups for both dimensions.

Demonstration of the release pattern was established in two ways. In one, the final trials of the release and nonrelease conditions of each encoding task were compared. In the other, trials 3 and 4 of the release condition were compared for each encoding task. In each observation the same results occurred. The NC and LDO groups both demonstrated the expected pattern of release from PI for both the phonetic and semantic encoding conditions. The LDMI group, however, demonstrated this pattern only on the semantic encoding task and not on the phonetic encoding task.

The magnitude of the release from PI for each group was determined by comparing the first and last trials of each release condition. The NC group's scores on the release trials were essentially equivalent to their scores on the initial trial of both encoding tasks. This was true also for the two LD groups' scores on the semantic release condition. However, on the phonetic encoding release condition, both the LDO and the LDMI groups' scores on the release trial did not reach equivalent levels to their initial scores on this task. Since the LDMI group did not demonstrate a significant release effect on the phonetic encoding task, it was not surprising that these trials were not significantly different. The LDO group, however, did demonstrate a significant release effect with phonetic stimuli. Based on this finding, it appears their pattern of release is not of the same magnitude as the NC group's, especially since both groups initial scores on this task were very close.

The results of this analysis are supported by the percent of recall recovery figures achieved for each group. All groups' percent of recall recovery scores on the semantic encoding task are consistent with those found by other researchers (Kail, 1976; Kail & Schroll, 1974; Libby & Kroes, 1971) studying patterns of release from PI using stimuli shifting along semantic lines with children. On the other hand, on the phonetic encoding task, the LD groups' percent of recall recovery is not close to those of the NC group, although the NC group's percent of recall recovery is consistent with the magnitude of the release effect found using semantic category stimuli both in this study and in the previous works cited.

Further analysis of the magnitude of release from PI was performed by subtracting trial 4 of the nonrelease condition from trial 4 of the release condition. This resulted in measures referred to as phonrel and taxrel for the phonetic and semantic encoding tasks, respectively. On this measure, the NC and LDO groups performed similarly, achieving a greater magnitude in their release patterns compared to the LDMI group on both tasks. Although the LDO group's initial and final scores on the phonetic release condition did not reach equivalence as the NC group's did, this measure of the magnitude of release pattern places them more solidly in line with the NC group. The LDMI group's release pattern for both semantic and phonetic stimuli were inferior in magnitude to the NC and LDO groups' release pattern when scores were compared in this fashion. This measure also established that shifts in semantic stimuli produce greater release patterns than shifts in phonetic stimuli, when scores for all groups are combined.

The results from this analysis in conjunction with the previous analyses provide a more complete understanding of encoding ability in these groups. When LDO and LDMI groups demonstrate the release pattern, it is not always of the same magnitude as the release pattern of the NC group. The LDO and NC groups' release patterns were similar on all measures of magnitude for semantic stimuli. They were also similar on the measure of release pattern magnitude for phonetic stimuli, phonrel. However, their scores on their final trial were not equivalent to their scores on the initial trial on the phonetic release condition, although this did occur with the NC group's scores. The LDMI group did not demonstrate the release pattern for shifts in phonetic stimuli and their release

patterns on the semantic encoding task were not of the same magnitude as those of the NC and LDO groups on all measures. Additionally, significant recall differences were found between the NC group and both LD groups on the final trial of the phonetic release condition, while the NC group was superior only to the LDMI group for recall on the final trial of the semantic release condition.

In line with the results of Cermak, et al., (1980), rates of PI build-up on this short-term memory distractor task were found to be similar for all groups. Therefore, differential rates of forgetting could not account for the differences found between groups on the last trial of the release condition. Furthermore, it is not possible to attribute the release pattern to a spontaneous release from PI on trial 4 since recall scores on this trial in the nonrelease conditions continued to decline or remained constant for all groups. It appears, therefore, that the distinguishing factor between groups is not the rate of build-up of PI, but rather the amount of release from PI following shifts in the encoding dimension.

The analysis of error pattern also revealed similar rates of PI for each group, as well as PPI, CI, and RI errors. Only NCI error rates were unequal across groups, having a higher rate of production by both LD groups. Although there was a difference in the type of NCI errors made, rates of omission were constant between groups.

Verbal Association Fluency -- FAS

The mean number of responses generated on this task for each group is shown in Table 7. There were significant group differences in verbal associative fluency as measured by the total number of responses, $F(2,52) = 3.975, p < .05$. Post hoc comparisons demonstrated significant differences between NC and both LD groups ($p < .05$). Repeated measures analysis of covariance for responses to the individual letters F, A, and S, produced significant group differences, $F(2,52) = 4.26, p < .05$. Post hoc analysis demonstrated no differences between LD groups, but found the number of responses given by the NC group to be greater than those given by either of the LD groups ($p < .05$). The main effect for letter was significant, $F(2,105) = 53.844, p < .001$. The letter "S" elicited more responses than the letter "F" which elicited more responses than the letter "A" ($p < .001$). The interaction between group and letter was not significant, $F(4,105) = 0.780, > .10$.

Phonetic similarity was examined between consecutive responses on this task. Phonetic similarity was defined as equivalent initial phoneme blends in at least two consecutive responses. Equivalent phoneme blends were established when at least the first two phoneme representations listed in Webster's New World Dictionary (1968) were identical. Each occurrence of two phonetically similar responses in succession was scored as an instance of phonetic similarity such that 5 consecutive phonetically similar responses would be scored a 4. This number was then divided by the total number of responses given to this letter and multiplied by 100 in order not to confound this measure by differences in the number of responses given by subjects in each group. The final

TABLE 7

Mean Number of Responses on the FAS Task

<u>Stimulus Type</u>	<u>NC</u>	<u>LDO</u>	<u>LDMI</u>
F	8.14	6.46 a"	7.24 a"
A	6.61	4.34 a"	4.61 a"
S	9.48	8.05 a"	7.88 a"

Total Score	23.93	19.90 a"	19.28 a"

 (a") Significantly inferior to NC ($p < .05$).

measure of phonetic similarity was a percentage of the total number of responses given to allow for more accurate comparisons between groups. Table 8 presents the percentages of phonetically similar responses given to the individual letters. A repeated measures analysis of covariance for phonetically similar responses to the letters F, A, and S revealed significant group differences, $\underline{F}(2,52) = 6.068, p < .01$. Pairwise post hoc comparisons yielded differences between the NC and LD groups; the NC group produced more phonetically similar responses than the LDMI group ($p < .01$) and the LDO group ($p < .05$). The main effect for letter was significant, $\underline{F}(2,105) = 8.518, p < .001$. Phonetically similar responses for "S" were significantly greater than for "F" and "A" ($p < .001$). The interaction between group and letter was not significant, $\underline{F}(4,105) = 0.591, p > .10$. Phonetic similarity was also analyzed using the total score for this measure. The total phonetic similarity score is a composite of the phonetic similarity scores for the three letters. Group differences were found for this measure, $\underline{F}(2,52) = 6.053, p < .01$, such that all groups were significantly different from each other. The NC group scored significantly higher than the LDO group, and both control groups scored higher than the LDMI group ($p < .05$).

Another measure of phonetic similarity was analyzed by comparing the incidence of consecutive rhyming responses. This was calculated in the same way as phonetic similarity, resulting in a percent of rhyme response on the FAS task. Table 9 presents the average percent of rhyming responses on this task. As can be seen in this table, consecutive rhyming responses were infrequent. Group differences on this measure were not significant, $\underline{F}(2,52) = .447, p > .10$. The main effect for stimulus

TABLE 8

Mean Percent of Phonetically Similar Responses, the FAS Task

	<u>NC</u>	<u>LDO</u>	<u>LDMI</u>
F	26.86	12.44 a''	11.16 a'
A	15.97	13.38 a''	7.07 a'
S	31.62	25.62 a''	19.20 a'

Total Phonetic Similarity	75.60	48.04 (a')	39.80 (a',b'')

(a', a'') Significantly inferior to NC ($p < .01$,
 $p < .05$).

(b'') Significantly inferior to NC ($p < .05$).

type was significant, $F(2,105) = 6.237, p < .01$, such that rhyming responses were more common to the letter S than to the letters F and A ($p < .01$). A group X rhyme interaction was not significant, $F(4,105) = 0.396, us. p > .10$.

Responses on this task were also analyzed for frequency of occurrence based on the Thorndike - Lorge (1944) word frequency count. The mean word frequencies for words given on this task are presented in Table 10. A repeated measures analysis of covariance resulted in significant group differences, $F(2,52) = 3.779, p < .05$. Post hoc analysis established that the LDO group gave words with higher word frequency counts than the NC group ($p < .05$) and the LDMI group scored between the two and was not significantly different from either. The main effect for stimulus type was significant, $F(2,105) = 5.762, p < .01$. Higher word frequency of response was observed for the letter F as compared to the letters A and S ($p < .05$). The interaction between group and stimulus type was not significant, $F(4,105) = 1.19, p > .10$.

TABLE 9

Mean Percent of Rhyming Responses on the FAS Task

	<u>NC</u>	<u>LDO</u>	<u>LDMI</u>
F	0.98	1.23	0.73
A	-0.02	0.06	-0.04
S	2.39	-0.30	1.00

TABLE 10

Mean Word Frequency Counts for Responses on the FAS Task

	<u>NC</u>	<u>LDO</u>	<u>LDMI</u>
F	59.57	80.28 a.	74.50 a.
A	58.16	64.31 a.	59.14 a.
S	58.32	64.48 a.	63.94 a.

(a.) Significantly higher than NC ($p < .05$).

Verbal Association Fluency -- Category Naming

The mean number of responses on the category naming task for each group are shown in Table 11. There were significant group differences for total number of responses, $F(2,52) = 9.341, p < .001$. The NC group produced a significantly greater number of responses than both LD groups ($p < .05$). A repeated measures analysis of covariance for responses to the categories of animals, clothing, fruits, and jobs also resulted in significant group differences, $F(2,52) = 9.341, p < .001$. The post hoc analysis demonstrated significantly less responses for the LDMI group compared to the NC group at the .001 significance level, and significantly less for both LD groups compared to the NC group at the .05 significance level. The main effect for category was significant, $F(3,158) = 76.963, p < .001$. All categories differed from the others in terms of the total number of responses generated; the category of animals had the most responses followed by clothing, fruit, and jobs ($p < .001$). The group X stimulus type interaction was not significant, $F(6,158) = 1.439, p > .10$.

Word frequency counts for each word were determined based on the Thorndike - Lorge (1944) norms. Average word frequency counts for each group are presented in Table 12. Group differences were not significant, $F(2,52) = 0.228, p > .10$. The main effect for category was significant, $F(3,152) = 18.420, p < .001$. Word frequencies for responses given to the categories animals, clothes, and jobs were significantly greater than the word frequencies of the fruit responses across groups ($p < .001$). The two way interaction was not significant, $F(6,152) = 0.701, p > .10$.

TABLE 11

Mean Number of Responses Generated on Category Naming Task

<u>Stimulus Type</u>	<u>NC</u>	<u>LDO</u>	<u>LDMI</u>
Animals	12.78	13.03 a"	11.24 a
Clothing	10.54	9.26 a"	9.28 a
Fruit	9.01	8.15 a"	6.42 a
Jobs	7.42	4.97 a"	4.56 a

Total Category Naming	39.84	35.14 a"	31.67 a

(a,a") Significantly greater than NC ($p < .001$,
 $p < .05$).

The five most common responses given to each category were very similar for each group. These responses are presented in Appendix A. Four out of five of the most popular responses given by each group were identical for each category except for the category of animals for which a three out of five correspondence was demonstrated. This is consistent with the finding of nonsignificant differences in word frequency of response across groups. Although the breadth of category responses are significantly different, the core representations of the category sets are common across groups.

TABLE 12

Mean Word Frequencies on the Category Naming Task

	<u>NC</u>	<u>LDO</u>	<u>LDMI</u>
Animals	38.61	38.66	42.45
Clothing	39.49	38.80	39.08
Fruit	24.78	28.92	27.16
Jobs	40.69	36.80	37.57

The Word Association Task

Responses on the word association task were classified as paradigmatic, syntagmatic, or other. Responses were judged to be paradigmatic if (a) they could be used as substitutions for the stimulus word, (b) they were of the same grammatical class as the stimulus word, and (c) they were conceptually related to the stimulus word. Responses were classified as syntagmatic if (a) they were of a different grammatical class than the stimulus word, and (b) they were judged to be commonly used in close syntactic proximity to the stimulus word. Responses were classified as other if (a) they were either of the same or different grammatical class but judged to be conceptually or syntactically unrelated to the stimulus word, (b) they were perseverations of previous responses or stimulus words, regardless of conceptual or syntactical relatedness, or (c) they were clang or nonsense words. Overall response types to the six stimulus words were calculated for each group, and are presented in Table 13.

The LDO group gave significantly less paradigmatic responses than the NC group, $F(2,52) = 3.029, p = .057$, and significantly more other responses than the NC and LDMI groups, $F(2,52) = 6.217, p < .01$. Significant group effects were not found for syntagmatic responses, $F(2,52) = 1.688, p > .10$. Since the syntagmatic/paradigmatic shift has been found to occur at different stages of development for nouns, verbs, and adjectives (Deese, 1962), response type differences between groups were calculated for each grammatical class of stimulus words. The main effect for group was not significant, $F(2,52) = 0.00, p > .10$. A main effect for grammatical form of stimulus type was not significant, F

TABLE 13

Word Association Response Types

<u>Response Type</u>	<u>NC</u>	<u>LDO</u>	<u>LDMI</u>
Paradigmatic	3.525	2.191 a''	3.172
Syntagmatic	1.464	0.781	1.472
Other	1.011	3.028 a.	1.356

(a'') Significantly inferior to NC ($p < .06$).

(a.) Significantly higher than NC ($p < .01$).

(2,105) = 0.00 $p < .05$. The group X grammatical form of stimulus type was not significant, $F = 1.235$, $p < .05$. A significant main effect for response type was found, $F (2,105) = 13.497$ $p < .001$. Post hoc analysis established that paradigmatic responses were given more commonly than "other" responses. The interaction between group and response type was significant, $F (4,105) = 4.761$ $p < .01$. Post hoc analysis revealed that the NC group made significantly more paradigmatic responses than syntagmatic ($p < .05$) and other responses ($p < .01$). Also, this group gave more syntagmatic responses than other responses ($p < .05$). The LDMI group's response pattern was similar. This group gave more paradigmatic than syntagmatic and other responses ($p < .01$), although their rates of syntagmatic and other responses did not differ. The LDO group's responses contrasted with these groups' responses. The LDO group gave significantly more other responses than syntagmatic responses ($p < .05$), while their rate of paradigmatic responses fell between the rates of other and syntagmatic responses and did not differ significantly from either. The LDO group's frequency of other responses on this task was significantly greater than the NC group's ($p < .01$) or the LDMI group's ($p < .05$) frequency of other responses.

The interaction of response type X grammatical form of the stimulus was also significant, $F (4,211) = 9.004$ $p < .001$. For all subjects, adjectives generated more paradigmatic and less syntagmatic responses than nouns generated ($p < .001$). Verbs also generated more paradigmatic and less syntagmatic responses than nouns generated ($p < .05$). Adjectives generated significantly more paradigmatic responses than syntagmatic or other responses ($p < .001$). Paradigmatic responses to verbs were signi-

ificantly greater than syntagmatic and other responses to verbs ($p < .001$). Nouns, however, generated equivalent paradigmatic, syntagmatic and other response types. The three way interaction was not significant, $F(8,211) = 0.541, p > .10$.

Response type was also analyzed based simply on whether responses were of the same or different grammatical class as the stimulus word. This criterion parallels the one used by Brown and Berko (1960) in their determination of homogeneous and heterogeneous responses. Homogeneous responses were considered to be responses of the same grammatical class as the stimulus word and heterogeneous responses were those of a different grammatical class than the stimulus word. No significant group differences were found on this measure, $F(2,52) = 0.00, p > .10$. For all groups, homogeneous responses were given significantly more often than heterogeneous responses, $F(1,53) = 8.532, p < .01$. The group X response type interaction was not significant, $F(2,53) = 0.749, p > .10$.

The finding of a nonsignificant group by response type interaction using this criterion differs from the findings using the response type classification criteria of paradigmatic, syntagmatic, and other, in which a significant group X response type interaction was found. It appears that the latter criterion is more sensitive to response differences between groups, since it provides for the classification of idiosyncratic, perseverative, and nonsense responses.

Word frequencies were determined for the responses on the word association task and are presented in Table 14. Significant group differences were found, $F(2,52) = 4.445, p < .05$. The average word associa-

tion response given by the NC group had a higher frequency of occurrence than the average word association response given by both LD groups ($p < .05$).

Latency of response was noted and averaged across stimuli for each group. Latency was defined as the length of time between stimulus presentation and the subject's response. A significant main effect for group was found, $F(2,52) = 5.254$, $p < .01$. A posteriori pairwise comparisons resulted in significant differences between NC and LDMI groups at the .01 level of significance and between all three groups at the .05 significance level with the NC group requiring the least amount of time to respond, the LDMI group requiring the greatest amount of time to respond, and the LDO group requiring an intermediate amount of time to respond. The average latency of response for each group is presented in Table 15.

TABLE 14

Mean Word Frequencies on the Word Association Task

	<u>NC</u>	<u>LDO</u>	<u>LDMI</u>
Mean Word Frequency Counts	88.1	77.3 a"	74.1 a"

(a") Significantly inferior to NC ($p < .05$).
 p
< .05).

TABLE 15

Mean Response Latency for Word Associations, in Seconds

	<u>NC</u>	<u>LDO</u>	<u>LDMI</u>
Mean Latency	12.0	19.1 a..	22.1 a.,b.

(a., a..) Significantly greater than NC ($p < .01$,
 $p < .05$).

(b.) Significantly greater than LDO ($p < .05$).

Hierarchical Clustering Task

Subjects' selections on the hierarchical clustering task were summed for each group and analyzed in two ways. In the first analysis, choices were classified as categorical if the pair of words chosen were from the same conceptual category, or functional if each member of the pair was from a different category since the stimulus categories themselves were related functionally (humans and articles of clothing). Significant group effects were found for category consistent choices, $F(2,52) = 5.248$, $p < .01$. The NC group made significantly more category consistent selections than both LD groups ($p < .01$).

In the second analysis, a hierarchical clustering scheme (HCS) was applied to the subject's selections. This technique was described by Zurif, Caramazza, Myerson, and Galvin (1974) in their study of brain damaged aphasics:

HCS operates on a similarity matrix which takes the form of an incidence matrix, each cell representing the frequency with which a particular word is grouped with another. At each stage the two words that are most closely related are merged and treated as a single entry in a new and smaller matrix. A visual account of this sequence of mergings takes the familiar form of a tree graph. What must be considered is how well the data fit a hierarchical structure. In an ideal hierarchical ordering, the two items merged at each stage should be equally related to the other words of the matrix. But in practice when two words are clustered together they are often not equidistant to a third, and the problem arises of determining whether in fact we are dealing with a hierarchical structure. Following Miller (1969), our solution has been to carry out two parallel cluster analyses: one always based on the stronger relations between the cluster and the other words of the matrix (minimum method), the other always based on the weaker relations (maximum method). To the extent that subjects have been sorting on the basis of an implicit hierarchical structure, there should be no difference between the solutions. In practice, if the minimum and maximum solutions produce only numerical

differences of the form of different strengths of the same clusters, the data are accepted as being at least minimally compatible with a hierarchical organization. If the solutions yield striking qualitative (topological) differences, such an assumption is usually not supported. The data are accepted as being compatible with a conceptual hierarchy only when most of the clusters are common to both methods of analysis.

Tree graphs were constructed for each group based on the total sum of each subject's incidence matrix divided by the total number of subjects in each group to permit comparisons among groups. Figures 3 - 8 show the maximum and minimum tree graphs for NC, LDO, and LDMI groups, respectively. Comparisons of maximum and minimum tree graphs for each group reveals adequate correspondences for the NC and LDO groups, but insufficient correspondence for the LDMI group, according to the above outline. Thus, NC and LDO groups demonstrated evidence of sorting based on an implicit hierarchical organization. However, a similar inference for the LDMI group could not be supported. Comparison of this group's maximum and minimum graphs does not indicate a stability of hierarchical structure.

As can be seen in Figures 3 - 6, the human items are clearly differentiated from the clothing items for NC and LDO groups. In fact, the stepwise hierarchical structure depicted in the graphs was very consistent between groups. Human and clothing items were not clearly differentiated in the LDMI group (Figures 7 and 8). The functional relationship between King and Crown was more prominent than category membership in the LDMI group's similarity choices. The topological structure of the hierarchies depicted in the maximum and minimum tree graphs were discrepant from each other as well as from those depicted in the tree graphs of the NC and LDO groups, especially with respect to clothing items.

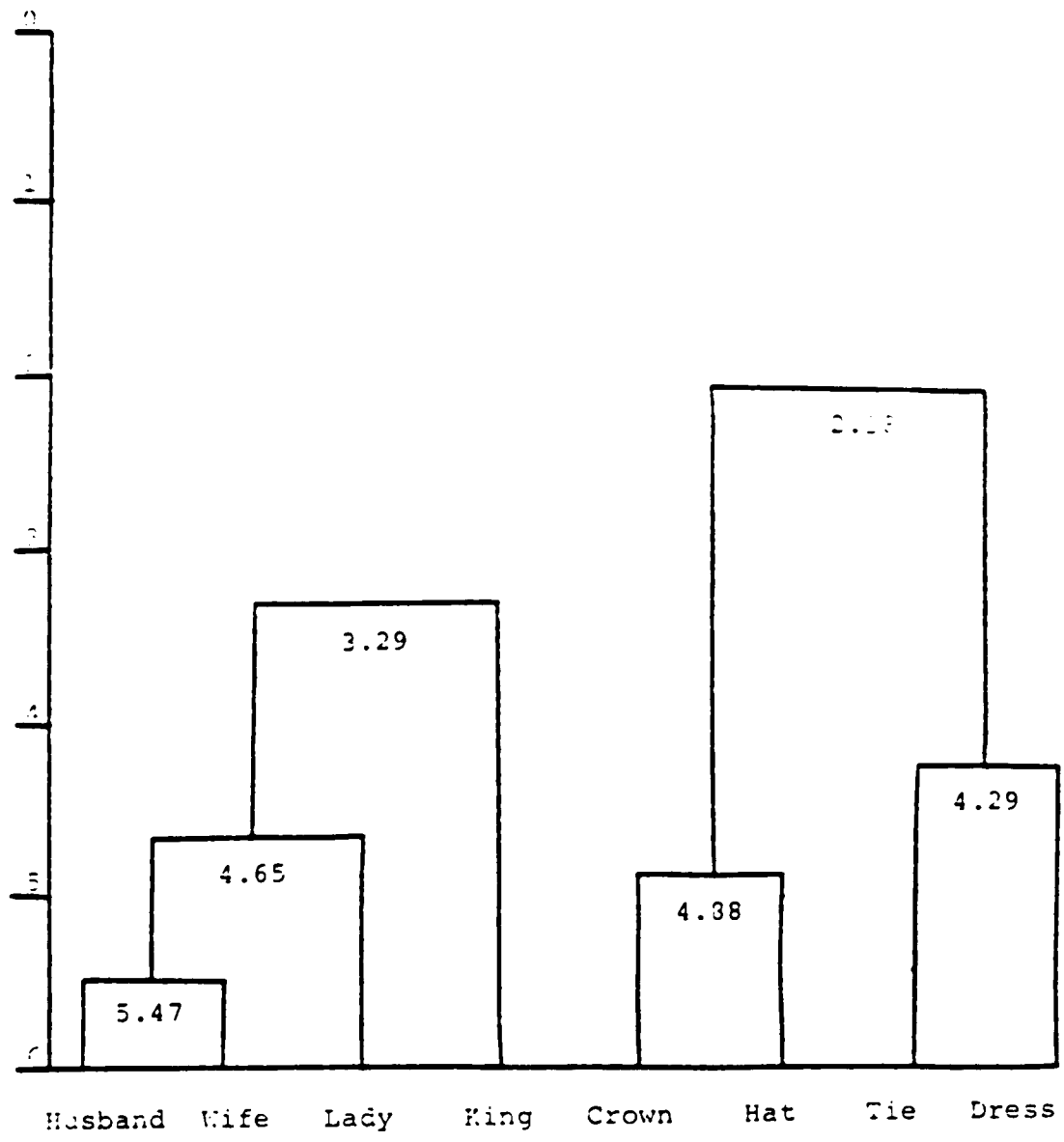


Figure 3: HCS -- Maximum Method -- NC Group

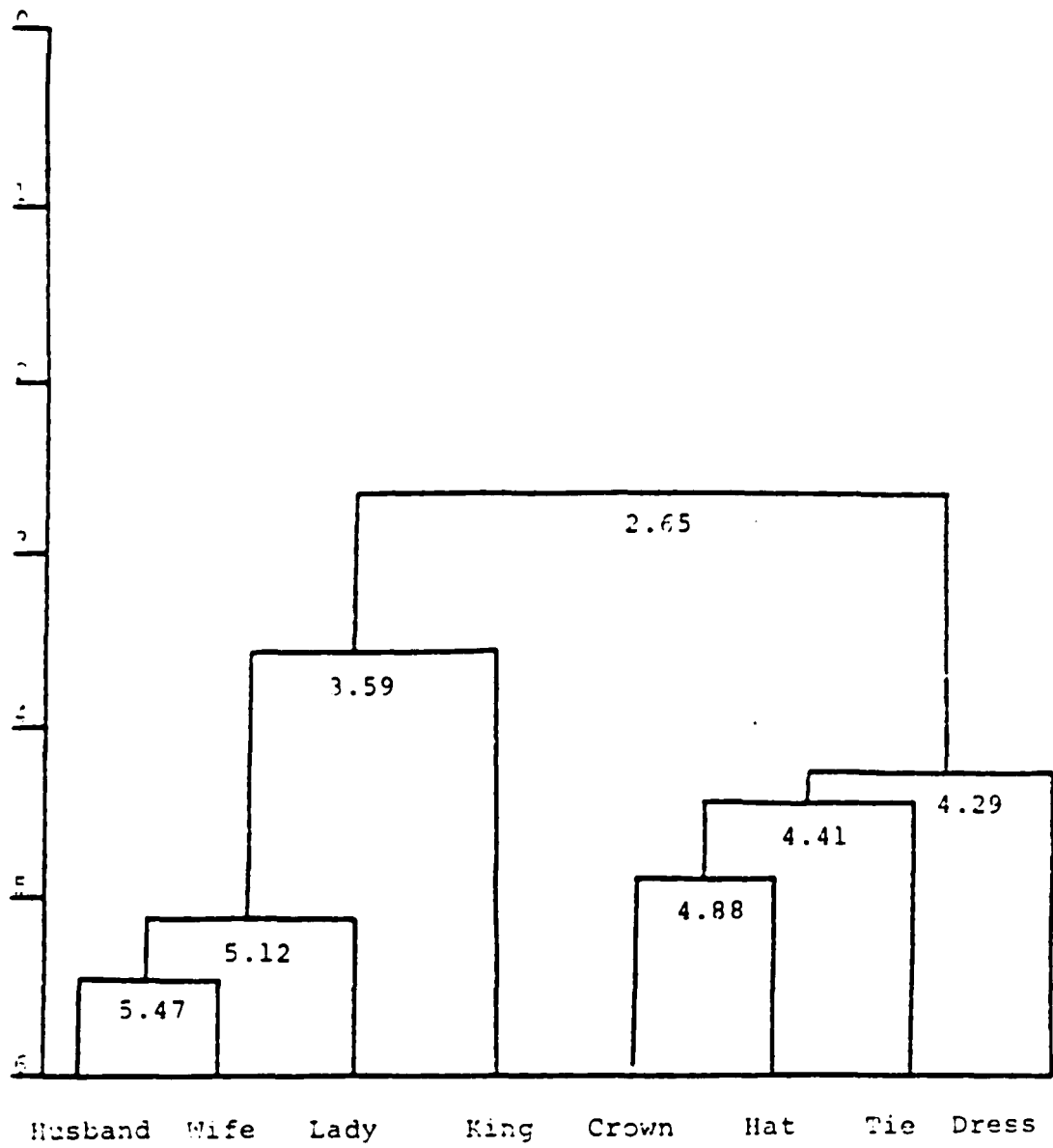


Figure 4: HCS -- Minimum Method -- NC Group

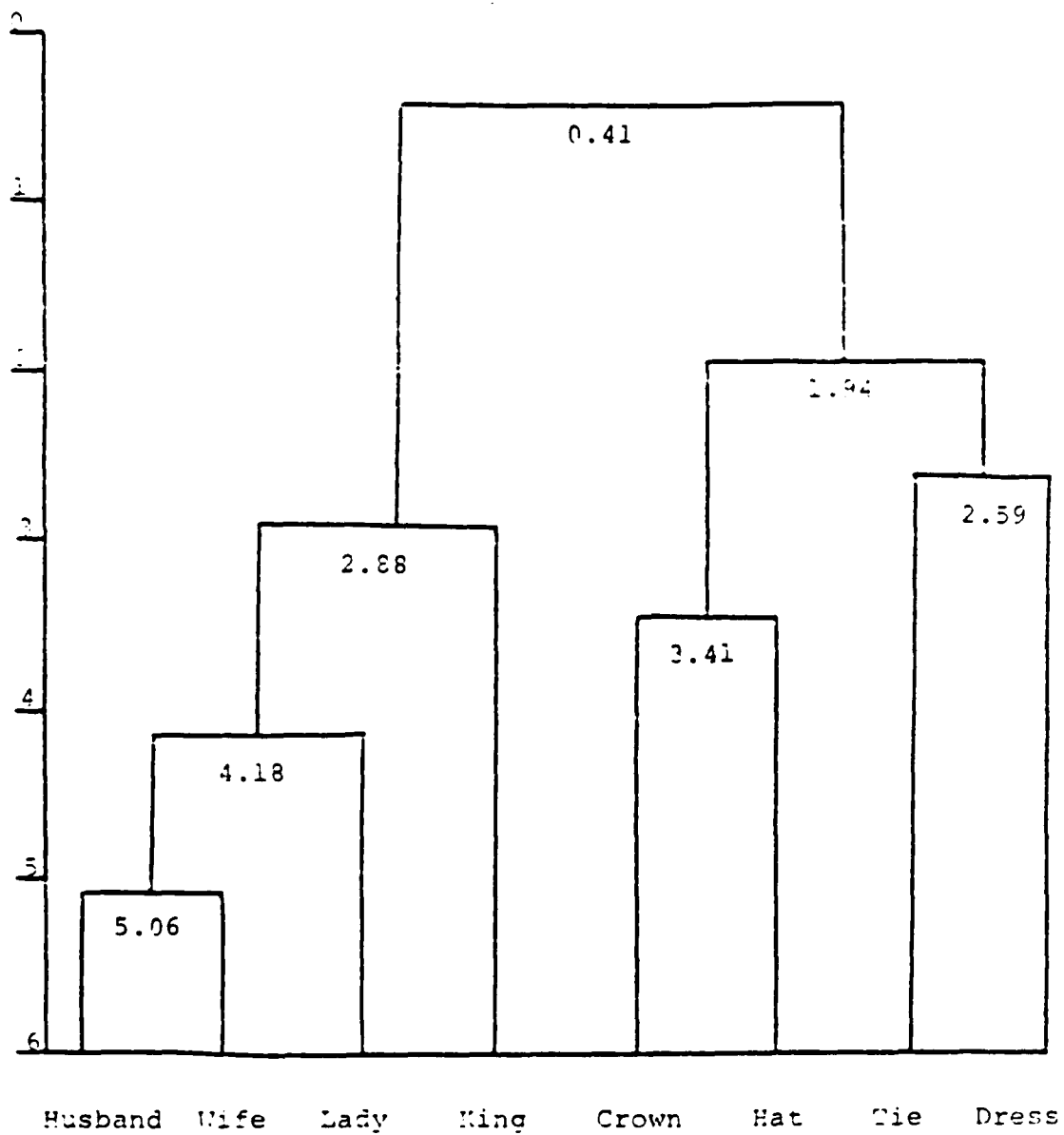


Figure 5: HCS -- Maximum Method -- LDO Group

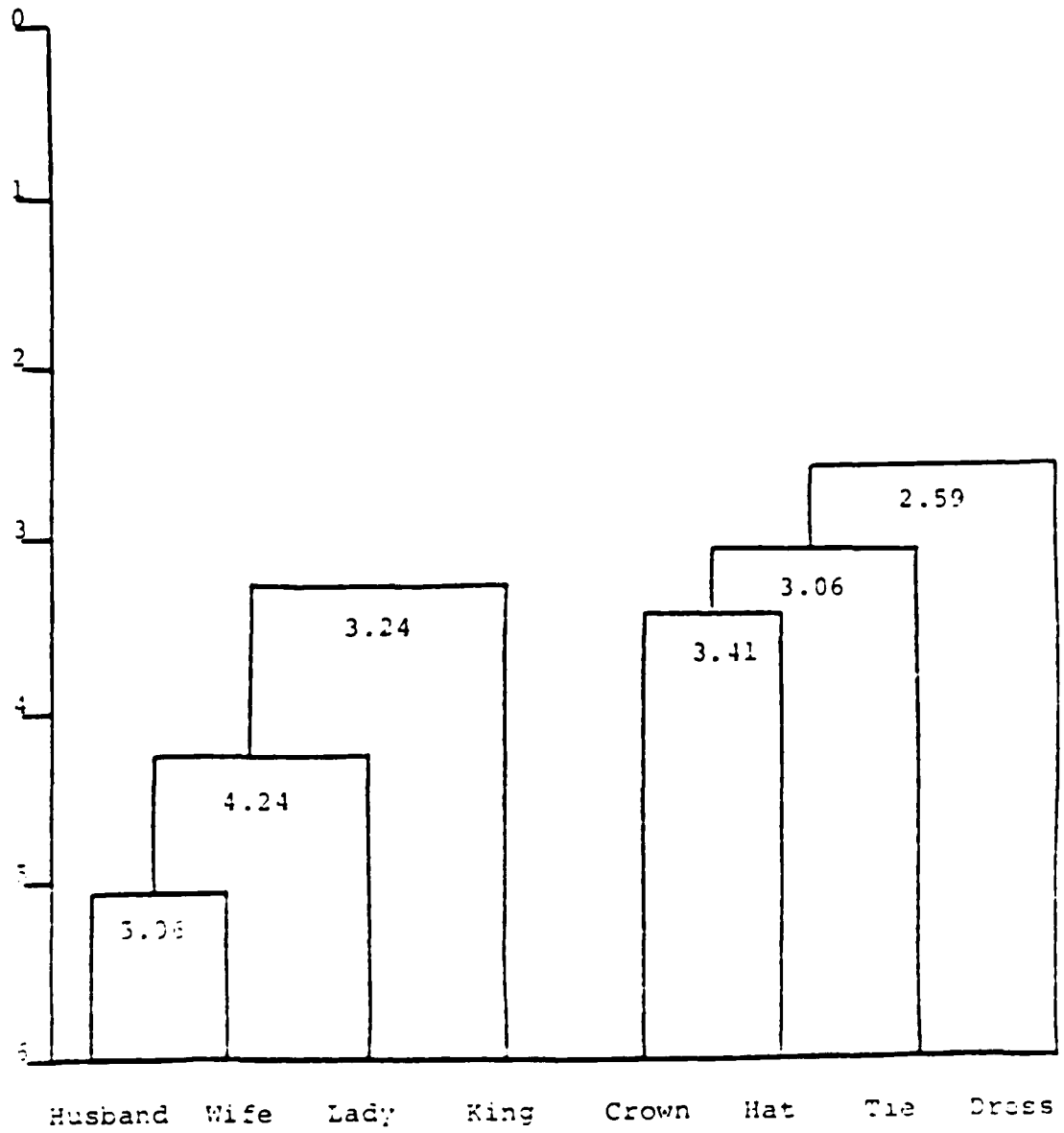


Figure 6: HCS -- Minimum Method -- LDO group

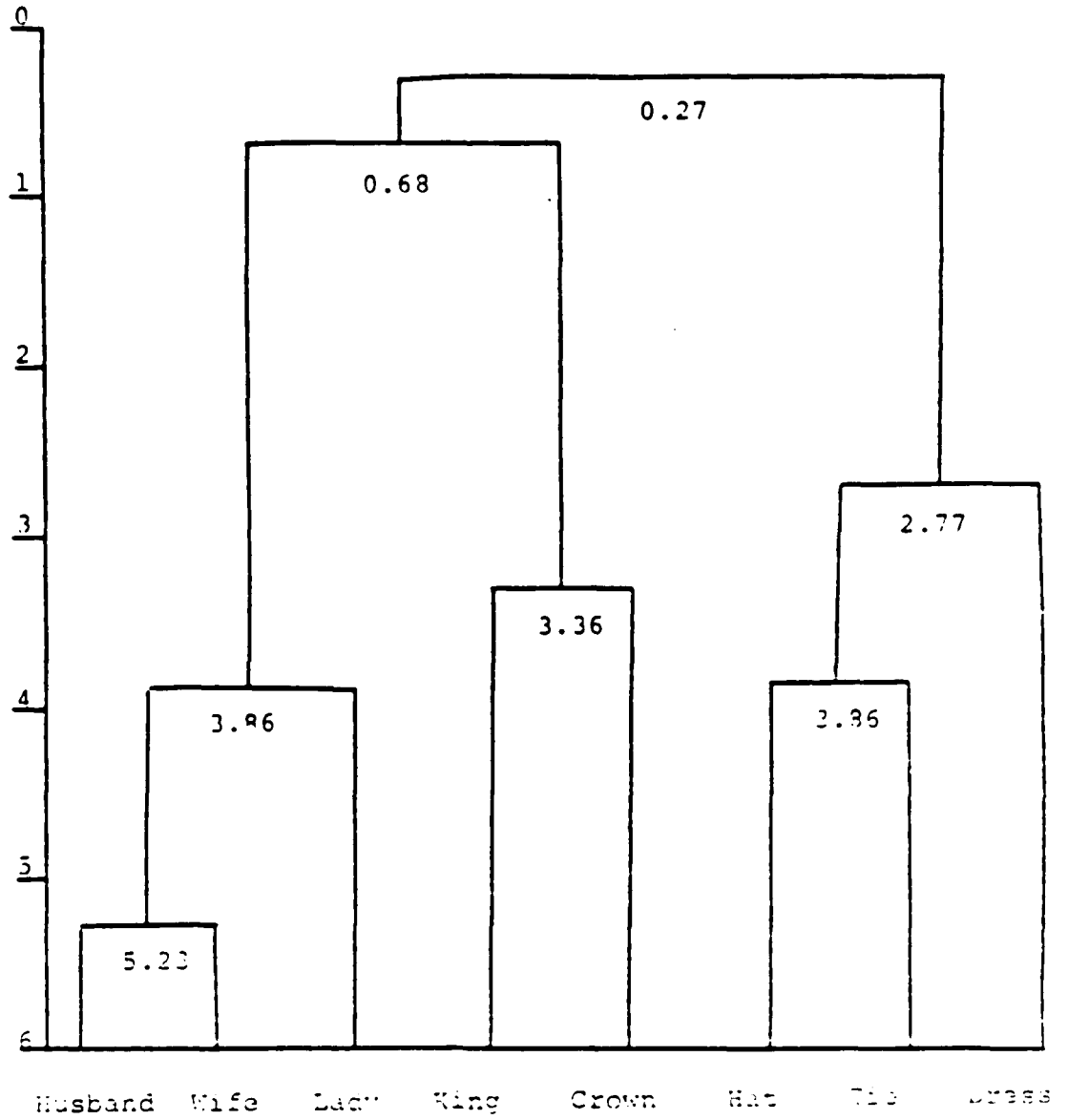


Figure 7: HCS -- Maximum Method -- LDMI Group

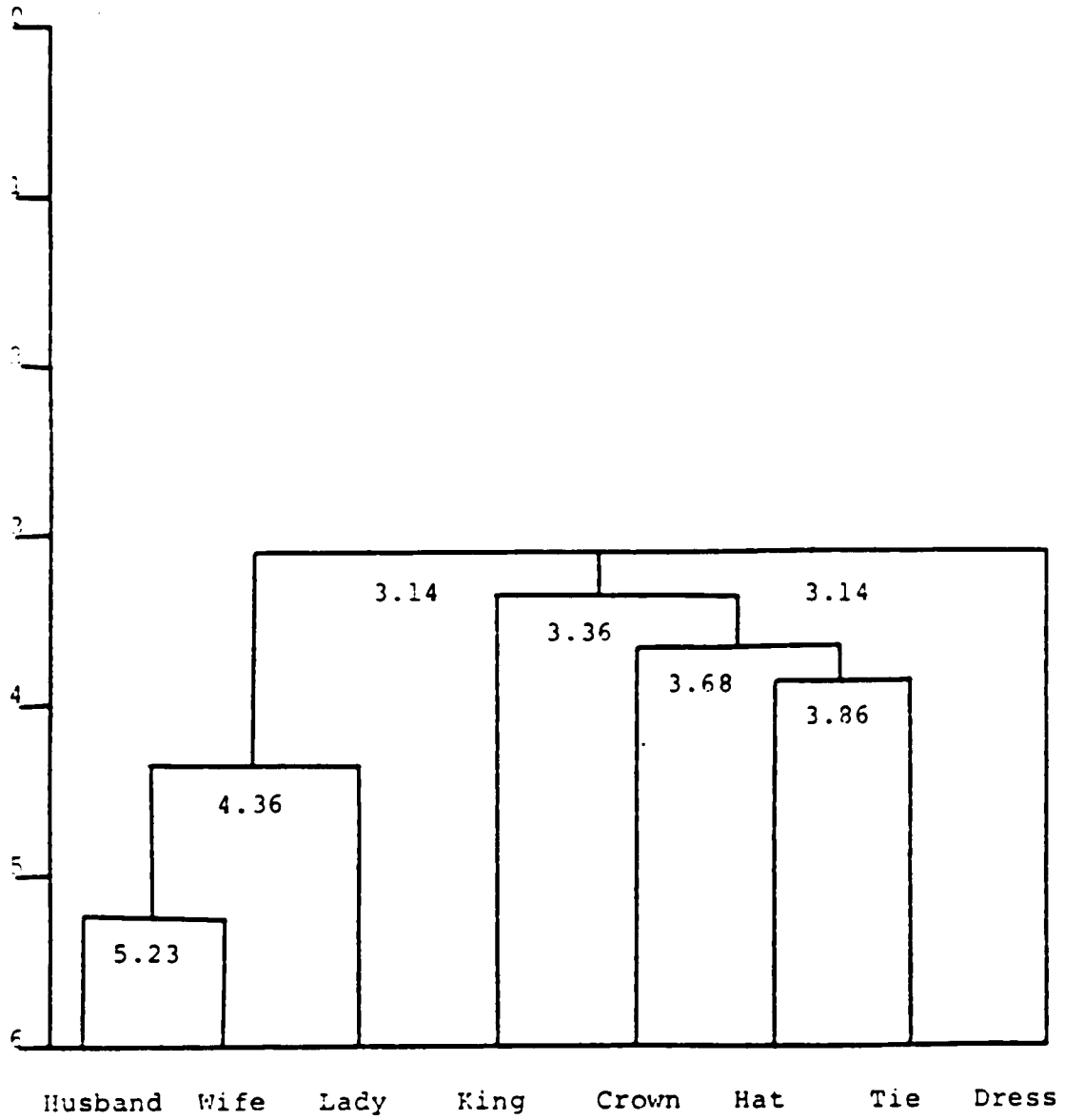


Figure 8: HCS -- Minimum Method -- LDMI Group

Variability within depicted constructs is represented by the height of the node connecting two items. Internal variability or noise inherent in the similarity judgments was greater in the graphs of both LD groups compared to the NC group's graph. The LDO and LDMI groups' choices were more inconsistent than the NC group's choices. In all cases, the most consistent choices were for human items, but to a lesser degree for both LD groups.

Summary and Brief Discussion

On the verbal fluency tasks the LDO and LDMI groups performed similarly, particularly in terms of the number of responses generated in sixty seconds to letters and categories. Both groups were inferior to the NC group on these measures. The same pattern of results were established for the average phonetic similarity score to the letters F, A, and S; the NC group's scores were higher than the LD groups' scores. Group differences on phonetic similarity scores summed across letters yielded slightly different results. In this case, the NC group had higher scores than the LDO group, and both had higher scores than the LDMI group. Analysis of rhyming responses on this task, on the other hand, produced no significant group differences.

Analyses of word frequency counts for responses generated on these tasks and on the word association task produced inconsistent results. The NC group had higher word frequency counts than LDO and LDMI groups for responses on the word association task. The group that took the least time to respond generated words with higher word frequency counts. A different pattern was observed on the FAS task. Word frequency counts

for the LDO group were higher than for the NC group, while the LDMI group did not differ significantly from either group. Yet, on the category naming task no group differences were established. There appears to be no relationship between word frequency and the number of responses generated on the verbal fluency tasks.

On the word association task, the LDMI group performed more similarly to the NC group than to the LDO group. For the NC group, paradigmatic responses were more common than syntagmatic responses, and these were more common than other responses. For the LDMI group, paradigmatic responses were more common than syntagmatic and other responses. For the LDO group, other responses were more common than syntagmatic responses with paradigmatic responses midway between. Furthermore, the LDO group's number of other responses was greater than the number of other responses given by the NC and LDMI groups. All groups were significantly different from each other in terms of latency of response. The LDMI group required the most time to respond with a word associate, followed by the LDO group. The NC group required the least amount of time to respond.

The Brown and Berko (1960) criteria of homogeneous and heterogeneous response categories provided less information about group response differences than the trifurcated classification of paradigmatic, syntagmatic and other. Homogeneous responses were more common than heterogeneous responses, in line with the pattern found to be typical of 8 year olds by Entwisle (1966). However, no group effects or group interactions were demonstrated, in contrast to the group X response type interaction found when using the trifurcated criteria. The homogeneous/heterogene-

ous distinction did not allow for the classification of perseverative, idiosyncratic, clang or nonsense responses. A word of the same grammatical form class as the stimulus word is not necessarily a substitute, contrast, or synonymous word. In the same vein, words of a different grammatical form class are not always found in close syntactic proximity to the stimulus word. The addition of the "other" response type category allows for more accurate classification of responses and is, therefore, more sensitive to group differences.

The results from the word association task contrast with the results of Bartel, et al. (1973) concerning the pattern of response of normal and learning disabled children. In their study, similar response patterns were found for learning disabled and normal children. However, they used only paradigmatic and syntagmatic response classifications and did not differentiate learning disabled subjects based upon memory ability. Their conclusions are not supported by the present findings. For at least one subgroup of learning disabled children, there appears to be a delay in the development of linguistic categorization strategies characteristic of the syntagmatic/paradigmatic shift.

In contrast to the patterns of word association responses found by others (Deese, 1962; Palermo, 1971), paradigmatic responses were not the most common to nouns. Paradigmatic responses were more common for adjectives and verbs. Again, differences between response classification systems may be responsible. Since nouns are generally the most common form class generated to all stimulus words (Entwisle, Forsyth, & Muuss, 1964), classifications disregarding the semantic relations between stimulus and response words may overrate the number of appropriate paradigmatic responses generated to nouns.

On the word clustering task, both LDO and LDMI groups chose categorical groupings significantly less frequently than the NC group. In terms of hierarchical structure, both LD groups appeared to have more variability than the NC group in their similarity groupings. The LDO group's choices, however, were more similar to the NC group's in that both demonstrated clear differences between categories, while the LDMI group combined members from different categories. Finally, the NC and LDO group's maximum and minimum tree graphs revealed adequate correspondence, while the graphs for the LDMI group had different topological forms. These results suggest that both NC and LDO groups have a stable hierarchy of semantic structure, whereas the LDMI group has a less consistent structure.

The results from the analyses made in this section do not consistently differentiate the LDMI group from the comparison groups. More often than not, the LDMI group's performance was similar to the LDO group's performance. In fact, in only three instances did the LDMI group perform distinctly from the other groups.

Speed of Associations. On the verbal fluency tasks, the two LD groups were virtually indistinguishable in terms of the number of responses generated within the time limits. Over a relatively extended period of time, compared to the time intervals of the other timed tasks, the LD groups were comparable in the number of relevant associations made, both producing less than the NC group. The LD groups would have required more time to respond with the same number of appropriate associations. One interpretation of these results is that compared to the performance of normal children, the speed of association of related ver-

bal material was slower for LD groups. These results would be expected to occur also if accessibility of semantically or phonetically related items was diminished. This interpretation is considered more fully below.

On the word association task, the LDMI group had longer latencies than the LDO group, and both required more time to respond than the NC group. This finding is consistent with the idea that learning disabled children, particularly those with memory impairment, have slow rates of verbal associations. An alternative explanation can also be maintained. It is possible that learning disabled children, having more failure experiences in testing situations, may be more hesitant than normal children to venture a response. However, since learning disabled and normal subjects ventured the same number of responses on the encoding task, which was also timed, the subjects in the LD groups were probably as motivated to respond as the NC group.

Associative Structure. Both learning disabled groups appeared to exhibit an immature associative structure. On the word association test the LDO group's pattern of responses was very different from the NC and LDMI groups' responses. The NC and LDMI groups were similar in their more frequent production of paradigmatic responses. The LDO group gave more idiosyncratic, perseverative, and nonsense words as associations than the NC and LDMI groups. Since responses on the word association task are widely thought to reflect changes in the hierarchy of conceptual relationships (Nelson, 1977), these findings suggest the children in the LDO group have not developed, or tend not to spontaneously utilize, the same semantic hierarchies as the children in the other groups or that the development of their semantic organization has been delayed.

On the word clustering task, both LD groups relied more prominently on functional properties of words in making similarity judgments and had more variability in their choices compared to the NC group. Yet, the LDO group demonstrated an implicit hierarchical organization similar to the NC group, which the LDMI group did not demonstrate. Based on these differences, it may be inferred that the LD groups do not organize information in the same way as the NC group. The data indicate that the NC group's hierarchies of organization are based upon semantic categories more often than functional categories and that their organization priorities are more stable than those of either LD group.

Group differences on the verbal fluency tasks are also consistent with the idea that the LD groups' semantic organization is different from that of the NC group. If semantic and/or phonetic stimuli are closely related in memory structure, then responses on a timed verbal fluency task, using categories or letters as elicitation prompts, should result in more responses compared to the situation where semantic and/or phonetic stimuli are not as closely organized. This reasoning assumes a well organized semantic structure provides better accessibility to related items, lessening search time and resulting in more responses in the time allowed. Nelson (1974), in her study of developmental variations in children's naming responses to categories, found primarily quantitative differences occurring with age. She relates a greater number of responses on this task to increased articulation and hierarchical expansion of categories in long-term semantic memory by older children. Following this reasoning, the differences between NC and LD groups suggest that the LD groups are developmentally delayed in their hierarchical expansion of category constructs.

The totaled scores of phonetic similarity on the FAS task appear to be a more sensitive measure than the average phonetic similarity score since total phonetic similarity scores differentiated all three groups, while the average score only differentiated the NC group from the LD groups. Group differences on phonetic similarity scores may also reflect organization differences in memory. Learning disabled subjects, particularly those with memory impairment, appear to rely on phonetic organization to a lesser degree than normal subjects.

In general, large differences were found between NC and LD groups, on verbal fluency, word association, and word clustering measures. The expectation that differences would result between the LDMI and both control groups was seldomly substantiated. The LDMI group differed from both control groups on measures of word association latency of response, total phonetic similarity, and in terms of correspondence of hierarchical organization of word clusters. In terms of both the overall number and kind of associations produced, clearer differences emerged, however, between NC and both LD groups.

GENERAL DISCUSSION

Interpretation of Results from the Encoding Tasks

On Wickens' modification of the Peterson-Peterson short-term memory distractor task, all groups experienced a build-up of PI across trials when the stimuli were from the same semantic category or had similar initial consonant blends. Although all groups showed release from PI on the semantic encoding task following a category shift, the magnitude of the release pattern differed among groups. The LDMI group showed less release from PI than the NC and LDO groups. Although information about semantic features of words were encoded by all three groups, the significantly smaller release from PI found for the LDMI group most likely indicates that this group is less competent in semantic encoding. The LDMI group did not demonstrate a release from PI following shifts in the phonetic dimension; whereas both comparison groups demonstrated a release from PI on the shift trial. These results indicate that children without verbal memory impairments encode information about the initial phonemes of words, but subjects with verbal memory disorders are impaired for this type of encoding. These findings support the hypothesis that children in the memory impaired learning disabled group have deficient verbal encoding abilities compared to nondisabled and learning disabled children without a verbal memory impairment.

The Relationship between Phonetic and Semantic Encoding

For all subjects combined, the release pattern produced by shifts in semantic stimuli was greater than the pattern produced by shifts in phonetic stimuli, which suggests that semantic features may be more resistant to disruption than phonetic features. This notion is consistent with the normal developmental change in attribute salience found in false recognition paradigms (Cramer, 1976; Felzen & Anisfeld, 1970; Hasher & Clifton, 1974).

Additional analysis of the data indicates there was an overall significant positive correlation between phonrel and taxrel ($r = 0.330$, $p < .05$). Those subjects that showed release from PI along one dimension were likely to demonstrate release from PI along the other. Or, in other words, subjects storing the initial phonetic features were likely to also store the semantic category of the words they are trying to remember.

Comparisons to Previous Studies

The results from the NC group confirm previous studies of semantic encoding ability on the Wickens task (Kail, 1976; Kail & Schroll, 1974; Kroes, 1974; Libby & Kroes, 1971; Zinobar, et al, 1975). Normal children 8 to 10 years of age encode semantic category attributes of words when processing these items for memory. However, on release from PI on the phonetic task, the results from the NC group differ from a previous study (Zinobar, et al., 1975), which found that normal 8 to 10 years olds failed to encode along the phonetic dimension. However, the two studies are not comparable since in the Zinobar, et al. study words were

presented that were phonetically similar at the end of the words, i.e., the stimuli rhymed, while the stimuli used in the present study had phonetically similar initial consonant blends. It is possible that at this age, children are likely to encode the initial phonetic features of stimulus words more efficiently than the final phonetic features.

The relative strength of semantic to phonetic encoding in the present study is consistent with the findings that recall was aided more by semantic cueing than phonetic cueing in learning disabled and normal subjects without verbal memory impairment (Ceci, Lea, & Ringstrom, 1980; Ceci, Ringstrom, & Lea, 1981). However, Ceci and his colleagues found that learning disabled groups with a specific verbal memory impairment were aided more by perceptual (phonetic) cues than by semantic cues. It must be stressed that in these studies the phonetic cues were rhyming words, not words with similar initial consonant blends. The present finding of greater encoding along semantic dimensions than phonetic dimensions by the LDMI group would not be expected based on Ceci's research because this group should have been more accurate with perceptual cues. These somewhat inconsistent findings suggest that generalizations concerning the encoding capacities of learning disabled groups should be made with caution, since encoding along one aspect of a (phonetic or semantic) dimension does not ensure encoding along all aspects of that dimension. It is feasible that some types of phonetic or semantic features are more easily or routinely encoded than others.

The finding that the LDMI group's semantic encoding was not as efficient as the other groups' contrasts with the results of a study by Lehman and Brady (1982) who found no differences between good and poor

readers on the Wickens encoding task using shifts in semantic stimuli. Comparison of these findings with the present study is difficult for two reasons. First, their study compares performance on release trials of one group of subjects to the nonrelease trials of a second, matched group of subjects. This flaw in methodology makes calculations of differences in the magnitude of the release pattern between groups inappropriate. Second, the two reading groups may not have been matched on verbal memory ability. Based on the present work and the work of Ceci and associates, it appears imperative to determine specific memory abilities in learning disabled groups before an attempt is made to characterize their encoding abilities.

Performances on the encoding task and the Rey Auditory-Verbal Learning Test are consistent with Bauer's (1977a) findings involving supra- and subspan memory ability in children with learning disabilities. Bauer found differences in recall between learning disabled and normal children on supraspan word lists, but no differences in retention between groups on subspan word trials when rehearsal was restricted. Bauer concluded that differential rates of rehearsal were responsible for the differences between groups on supraspan lists. The LDMI group, which demonstrated poor memory performance on the Rey Auditory-Verbal Learning Test, achieved equal levels of recall with the groups without memory impairment on the first three trials of the encoding tasks. However, the recall differences exhibited between the groups on the final trial of the encoding tasks can not be explained by rehearsal differences alone, for two reasons. First, rehearsal activity was restrained by means of the distractor task, equating levels of rehearsal for all groups. Sec-

ond, the recall differences only occurred on the final trials of the release conditions, when the phonetic or semantic features of the words changed. On the final trial of the nonrelease conditions, when the dimensions remained constant, the recall scores for all groups remained equivalent. If rehearsal differences contributed to the recall differences on the final trial of the release conditions, they would have also affected recall on the final trial of the nonrelease conditions, which it did not. The unequal rate of recall on the release trials can best be interpreted as demonstration of differences in verbal encoding ability.

In the Bauer (1977a) study, normals showed the typical serial order primacy and recency effects, while the learning disabled showed similar recency but very little primacy effects. On the first trial of the Rey Auditory-Verbal Learning Test, both LD groups demonstrated smaller primacy and recency effects compared to the NC group. Although deficient rehearsal may account for the small primacy effects in the LD groups, it does not explain their low recency scores. A verbal encoding deficiency may account, in part, for this finding. A phonetic encoding deficiency, for example, could jeopardize immediate recall from primary acoustic stores. Both LD groups were significantly inferior to the NC group on the final trial of the phonetic release condition and both LD groups had lower recency recall compared to the NC group on the Rey Auditory-Verbal Learning Test. Furthering the contention that verbal encoding deficiency is a contributing factor to verbal memory impairment, a significant positive correlation was found between total recall on the Rey Auditory-Verbal Learning Test and phonetic release ($r = 0.574$, $p < .001$) and se-

semantic release ($\bar{r} = 0.283$, $p < .05$). Those subjects showing little or no disruption from PI, i.e., those not encoding the unique dimensions of the words on the release trials, were those with the poorest overall scores on the memory test.

Encoding and Memory

The theoretical formulations of the importance of encoding for efficient memory (Atkinson & Shiffrin, 1968, 1971; Craik & Lockhart, 1972) is supported by the results of the verbal memory and encoding tasks. The groups demonstrating the highest memory scores were those demonstrating efficient encoding patterns on both semantic and phonetic dimensions. Experimental evidence provided by Ceci (1980) demonstrated greater long-term retention of items by normal children following multiple dimension encoding training as compared to children instructed in single dimension encoding. Other studies involving induced semantic and evaluative recall of words for intentional or incidental recall have shown similar results (Geis & Hall, 1976; Lange & Hultsch, 1970; Till, Diehl, & Jenkins, 1975; Waters & Waters, 1976). Participation in orienting activities designed to increase semantic encoding has produced retention improvements in memory impaired learning disabled subjects as well (Ceci, Lea, & Ringstrom, 1980). It appears that the greater the number of attributes stored with a word, or the greater the number of dimensions encoded, the greater the chance of successfully recalling that word from memory. The problem with the memory impaired learning disabled group may be that they failed to, or were inconsistent in, the encoding of specific features into long term stores along with the stimulus material.

Interpretation of Results from the Associative Tasks

Performances on verbal associative fluency, word association, and word clustering tasks did not confirm the expected differences between memory impaired and non-impaired groups. It was expected that the LDMI group's scores would be inferior to the other groups' scores if verbal encoding deficiency was a result of a less well organized semantic network. Instead, these tests more aptly discriminated between LD and nondisabled groups. Both LD groups were inferior to the NC group in verbal associative fluency to letters and categories, and in the amount of phonetically similar responses produced on the FAS task. On the word association task, the responses of the NC and LDMI groups were comparable to the responses of normal children of equivalent ages, while the LDO group's responses were similar to responses characteristic of much younger children (Brown & Berko, 1966; Entwisle, 1966; Entwisle, et al., 1964; Nelson, 1977; Palermo, 1971). The LDMI group had a greater response latency than the LDO group; and both LD groups had longer response latencies than the NC group. On the word clustering task the NC and LDO groups established clear category differences between humans and animals, but the category dimension was less stable for the LDO group. Both LD groups based their selections on functional dimensions more frequently than the NC group. The overall pattern discerned from these tasks suggests that learning disabled groups do not use semantic or phonetic features of words to the same extent as nondisabled groups in their organization of information into long-term stores. It appears that the hierarchical structure exhibited by learning disabled children is based more frequently upon functional, descriptive, or other relations.

The Relationship between Associative Tasks

Correlational analysis revealed a significant positive relationship between the number of categorical selections made on the word clustering task and the number of paradigmatic responses given on the word association task ($\bar{r} = 0.345, p < .01$). Categorical selections were not significantly related to syntagmatic responses ($\bar{r} = 0.044, p > .10$), but a significant negative relation did exist between this and "other" responses on the word association task ($\bar{r} = -0.335, p < .05$). The correlations between functional choices on the word clustering task and paradigmatic, syntagmatic, and other responses on the word association task were of the same magnitude, but were in the reverse direction. These tasks were similar in that both allowed demonstration of the type of association or relation that had saliency to the subject. The subjects that made categorical selections tended to also produce paradigmatic associations, and subjects that made non-categorical selections often gave idiosyncratic associative responses.

A significant positive correlation also was found for the total number of responses made on both verbal fluency tasks ($\bar{r} = 0.292, p < .05$). Total percent of phonetically similar responses on the FAS task was directly related to the total number of responses on the FAS task ($\bar{r} = 0.440, p < .001$) and the total number of responses on the category naming task ($\bar{r} = 0.312, p < .05$). These tasks were not significantly related to the type of selections made on the clustering task or the type of responses made on the word association task. However, latency of response on the word association task was significantly related to these scores such that the shorter the latency, the greater the likelihood of

obtaining higher scores on the FAS task ($\bar{r} = -0.329$, $p < .05$), the category naming task ($\bar{r} = -0.384$, $p < .01$), and the percent of phonetically similar responses on the FAS task ($\bar{r} = -0.301$, $p < .05$). It appears that when the experimenter controls the task parameters for retrieval from long-term storage, speed of association and internal set structure are related to each other as well as to the ability to respond with more items.

The Relationship between Verbal Encoding and Semantic Structure

Concerning the relation between attribute encoding (e.g. semantic or phonetic characteristics of the stimuli) and hierarchical organization in long-term stores, it is suggested that an attribute may be encoded even if it does not have priority in lexical organization. It is reasonable to assume that in the development of organized associational structures, the individual first encodes and stores a specific attribute of a word before it can take on salience in the hierarchy of association structure. Based on the developmental research in the areas of semantic encoding (Cramer, 1976; Kail, 1976; Kroes, 1974; Zinobar, et al., 1975) and semantic reorganization in long-term stores (Brown & Berko, 1960; Di Vesta, 1964; Lippman, 1971; Nelson, 1977), it appears that these processes occur in close temporal proximity for normal children. This developmental sequence may be delayed for children with learning disabilities. A delay in either phonetic or semantic encoding may adversely affect the development of an organized associative network. However, since phonetic (perceptual) encoding occurs earlier than semantic encoding in the developmental sequence (Cramer, 1976; Felzen & Anisfeld,

1970; Hasher & Clifton, 1974; Melkman & Deutsch, 1977), deficiencies in phonetic encoding may have the greatest interfering effect. This contention is supported by correlations between the encoding tasks and the associative tasks. Phonetic release had a significant positive correlation with the total number of responses on the FAS task ($\bar{r} = 0.351$, $p < .01$), the category naming task ($\bar{r} = 0.394$, $p < .01$), and the total percent of phonetically similar responses on the FAS task ($\bar{r} = 0.466$, $p < .001$), and had a significant negative correlation with latency of response on the word association task ($\bar{r} = -0.316$, $p < .05$) and the total number of non-consistent intrusion errors on the encoding task ($\bar{r} = -0.265$, $p < .05$). The correlations between semantic release and these variables were in the same direction, but none reached significant levels. These additional data suggest that the subjects that had the greatest release from PI with shifts in the phonetic dimensions of words tended to be those that showed evidence of better organization in long term storage, had greater accessibility to phonetic and semantic category sets, and were quicker to respond with associations.

The LDO group, while demonstrating a disruption of PI, had significantly lower recall scores than the NC group on the final trial of the phonetic release condition, but had comparable recall scores on the final trial of the semantic release condition. It was expected that since they demonstrated a release pattern on both encoding tasks, they would tend to resemble the NC group on the associative tasks; instead they performed more similarly to the LDMI group. Perhaps even small deficiencies in phonetic encoding create delays in the organization of long-term memory structure.

Future Research

Another way of examining the relationship between verbal encoding, verbal memory and semantic structure, would be to create groups based on encoding ability and then examine the memory abilities and semantic structure of these groups. The Wickens task could be employed using shifts in several other phonetic/acoustic and semantic features of words. Groups of efficient and less efficient encoders could be formed based on their consistency of demonstrating encoding along these dimensions. Based on the speculations discussed above, subjects demonstrating the broadest encoding abilities would be expected to have better memory ability and to show evidence of a more organized associative network. This expectation would probably hold true for learning disabled as well as nondisabled subjects. Following developmental changes for these variables may help clear up the question of which occurs first: enriched encoding ability or reorganization of associative structures.

Another interesting research issue concerns the verbal encoding ability, memory ability, and the nature of associative structure for learning disabled subjects with poor auditory discrimination. These subjects were disqualified from the present study because their auditory discrimination problem would confound identification of a specific verbal memory impairment. However, this group would be useful to study since it is expected that encoding ability and the development of organized associative structure would also be related to this disorder. Research of this type could lead to improved remediation techniques for this subgroup of learning disabled children as well.

Research demonstrating improved mnemonic ability for learning disabled subjects following experimenter intervention (Tarver, Hallahan, Kauffman, & Bali, 1976; Torgesen, 1977b; Torgesen, Murphy, & Ivey, 1979), raises the issue of whether competency defects or performance variables are contributing to poor retention on recall tasks. Torgesen (1977b, 1978, 1980) suggests that learning disabled students do not undertake tasks in a planned, active, organized manner, but have taken the role of a passive, less involved learner. Responses to questionnaires given by Hallahan, Gajar, Cohen, and Tarver (1978) concerning locus of control in relation to academic success, showed that learning disabled children were much more likely than nondisabled children to perceive locus of control externally. Torgesen believes many performance deficiencies in learning disabled subjects may be attributed to a lack of executive functions in the selection and implementation of appropriate task strategies.

In this respect, memory impaired learning disabled children resemble younger, normal children. Both groups appear deficient in the use of adaptive, strategic memory processes, but can be encouraged to engage in such operations following instruction. Young children are aware of semantic category relationships, but are not aware that the strategic use of this information can improve recall (Tenney, 1975). Likewise, learning disabled subjects who did not use category organization as an aid in recall were able to sort these items into categories as rapidly and as accurately as normal children (Torgesen, Murphy, & Ivey, 1979). Although developmental changes occur in the understanding of the beneficial effect of strategic encoding processes upon memory, the knowledge of

this relationship, or metamnemonic insight, is not sufficient for the actual production of these useful operations by children (Salatas & Flavell, 1976; Yussen, Levin, Berman, & Palm, 1979). It is expected that future research will demonstrate a lack of metamnemonic insight in learning disabled children with memory impairment.

Practical Implications

Memory impaired learning disabled children, who lack strategic encoding behaviors and the awareness of the advantageous effects of such encoding processes on memory, should be instructed in such skills. Paris (1978) has outlined three levels involved in the purposeful acquisition of higher-order mnemonic processes that can be applied to programs with learning disabled children. The first level includes explicit teaching and active demonstrations of mnemonic skills provided by an external source (teacher/practitioner). The second step involves practice in the deliberate self-generation of these techniques, which in turn, leads eventually to spontaneous and automatic use.

Procedures used in the studies prompting verbal encoding can provide specific approaches for the teacher or learning disabilities specialist interested in improving verbal encoding abilities of memory impaired learning disabled children. One approach would be to enhance organization ability by engaging the child in category sorting activities (Ceci, Lea, & Ringstrom, 1980; Torgesen, Murphy, & Ivey, 1979). Participation in semantic, evaluative, and perceptual orienting tasks has also been profitable (Geis & Hall, 1976; Waters & Waters, 1976). In such activities children make judgments about the stimulus words, such as whether

it belongs in a specific category, whether the word is pleasant, or whether it rhymes with a previously presented word. Higgins and Chaires (1980) found that prior exposure to a specific linguistic relation increased the probability of a subject using it as an encoding dimension. They concluded that encoding constructs are influenced by experience and can be changed when a subject is exposed to a new functional set. Children could be encouraged also to make multiple associations to stimulus words or to recognize the multiple meanings of common words. Such exercises may enhance flexibility in thinking and promote insight into new dimensions of words. Cartelli (1978) has demonstrated that an increased awareness of relations between words has a favorable effect upon reading comprehension of learning disabled children. Considering the apparent slow speed of associations and deficiencies in many learning disabled students' verbal encoding processes, teachers would be wise to use unambiguous instructions when possible and to anticipate longer response latencies in these children.

Finally, one of the most important implications from this research concerns the identification of subgroups of learning disabled children. Researchers and practitioners who treat learning disabled groups as homogeneous entities lose important information about subpatterns and individual characteristics. In this study, subgroups of learning disabled subjects were selected based upon verbal memory ability. Definite verbal encoding differences, particularly with respect to phonetic features, were determined. These findings may have been obscured if learning disabilities were treated as a singular disorder. The results reported here can only be readily compared to other situations in which

subgroups are also distinguished based on verbal memory ability. This trend of defining and studying subgroups of learning disabled children has just recently gained momentum, fueled by reports of distinct cognitive deficiencies symptomatic of specific subgroups (Ceci, Lea, & Ringstrom, 1980; Ceci, Ringstrom, & Lea, 1981; Rourke, 1968). The direction of this trend will lead to more useful and individualized assessment and diagnostic procedures.

Appendix A

The Five Most Common Words Given on the Category Naming Task

	ANIMALS	CLOTHING	FRUITS	JOBS
NC	Cat	Socks	Apple	Teacher
	Dog	Shoes	Orange	Policeman
	Elephant	Pants	Banana	Doctor
	Tiger	Shirt	Pear	Principal
	Fish	Dress	Grape	Fireman
LDO	Tiger	Pants	Apple	Teacher
	Lion	Shirt	Orange	Fireman
	Cat	Socks	Banana	Doctor
	Dog	Shoes	Pear	Policeman
	Giraffe	Dress	Peach	Constructionworker
LDMI	Cat	Pants	Apple	Teacher
	Dog	Shirt	Orange	Policeman
	Tiger	Shoes	Banana	Fireman
	Bird	Socks	Pear	Doctor
	Lion	Hat	Peach	Principal

Appendix B

Since the groups were significantly different in reading abilities as measured by the Gray Oral Reading Test (Gray), the data were analyzed again with slight modifications in statistical procedures in order to control for the possibility that variables associated with this task may have contributed to the outcomes on the experimental tasks. In the first re-examination of the data, an analysis of covariance was applied to the data with reading scores on the Gray as the covariate. In the second procedure, an analysis of covariance was carried out as before, with age as a covariate, but with the five lowest performers on the Gray dropped from the LDMI group. For all post hoc comparisons, Duncan's new multiple range test was applied to the adjusted means.

Results of the First Analysis Modification

An analysis of covariance was used with the following dependent measures: the total score on the Rey Auditory-Verbal Learning Test, the total number of responses on the FAS task, the total number of responses on the category naming task, the phonetic release score (phonrel) and the semantic release score (taxrel). Controlling for reading performance on the Gray, all groups were now significantly different on the total number of words recalled on the Rey Auditory-Verbal Learning Test, $F(2,52) = 33.946, p < .001$. The NC group recalled more than both LD groups, and the LDO group recalled more words than the LDMI group. This

pattern of performance was paralleled by the groups' scores on phonetic release, $F(2,52) = 15.133$, $p < .001$, and semantic release, $F(2,52) = 3.040$, $p < .06$. Again, the NC group's scores were significantly higher than both LD groups' scores, and the LDO group's scores were significantly higher than the LDMI group's scores. The NC group gave significantly more responses than both LD groups, who performed similarly, on the FAS task, $F(2,52) = 2.603$, $p < .08$, and on the category naming task, $F(2,52) = 8.065$, $p < .001$.

These results provide additional support to the contention that deficient verbal encoding underlies verbal memory impairment. The pattern of verbal memory abilities was duplicated by the pattern of phonetic and semantic encoding abilities for these groups. Age differences between groups, however, were not controlled for in this analysis. The finding of lower recall and lower phonetic and semantic release scores for the LDO group is consistent with developmental research on these abilities. Although subjects in the LDO group were significantly younger than subjects in the LDMI group, subjects in the latter group demonstrated lower recall and lower phonetic and semantic release scores compared to both the LDO and NC groups. These results minimize the possibility that a factor integral to reading ability was also a significant contributing factor to the differences between groups on the encoding tasks.

Results from the Second Analysis Modification

Age was used as a covariate in the following analyses, but the LDMI group was modified. The data from the subjects achieving the five lowest scores on the Gray were eliminated from all computations, resulting in equal numbers of subjects in all groups ($n = 17$). Analyses of covariance were performed again for all the major variables.

Significance levels and group patterns discerned from these analysis duplicated the results from the original analyses presented in the Results chapter, except for the following. In the previous findings, all groups had significantly different scores on the Gray, latency of response on the word association task, and for the total percent of phonetically similar responses on the FAS task. The present findings yielded no differences between the LDO and LDMI groups on these measures, although both groups were still significantly different from the NC group. By equating the LD groups for reading level on the Gray, their major differences on the associative tasks were abolished. Now, even these tasks appear to be associated with academic ability. These results emphasize the common observation that there are many underlying processes (such as phonetic fluency and associative response speed) which are related to timed paragraph reading ability.

On the repeated measures analysis of covariance for the encoding tasks, all but two findings were replicated. Comparing trial 4 of the semantic release condition to trial 4 of the semantic nonrelease condition resulted in no significant differences for the LDMI group, although previously a significant difference was found. And, on the final trial of the phonetic release condition, all groups were significantly diffe-

rent; the NC group recalled more than the LDO group, who recalled more than the LDMI group. In the previous analysis, the NC group recalled more than both LD groups, but these groups did not differ. Thus, on both phonetic and semantic encoding tasks, more evidence was provided indicating deficient encoding ability by the LDMI group compared to the NC and LDO groups, when paragraph reading ability was equated for the LD groups.

Since group recall patterns on the Rey Auditory-Verbal Learning Test remained the same as those previously reported (NC and LDO groups were superior to the LDMI group) and the reading score differences on the Gray were now eliminated between the LD groups, the findings of additional group differences on the encoding tasks support the primary hypothesis even more strongly. Eliminating all the scores from the five lowest performers on the Gray increased the differences between the LDMI and the NC and LDO groups on the encoding tasks. These two statistical manipulations of the data convincingly indicate that group differences in the disruption of PI after shifts in phonetic and semantic dimensions were due to the selection of groups based upon memory ability, and not due to a variable associated with reading ability.

Appendix C

Individual Subject Scores on Screening Battery Tests

<u>Subj.</u>	<u>Age</u>	<u>VIQ</u>	<u>PIQ</u>	<u>FSIQ</u>	<u>GRAY</u> <u>ORAL</u>	<u>WRAT</u> <u>READ</u>	<u>WRAT</u> <u>MATH</u>	<u>TOTAL</u> <u>REY</u>
<u>NC Group</u>								
1	8-2	107	085	096	-0.5	0.3	1.1	45
2	8-5	114	085	092	-0.3	0.7	0.5	47
3	8-10	117	115	117	-0.6	0.3	0.3	47
4	8-11	106	098	102	0.2	0.1	0.3	41
5	9-2	107	098	102	-0.2	0.6	-0.2	55
6	9-4	101	093	097	0.6	0.7	0.7	50
7	9-5	100	090	094	0.6	1.0	0.3	56
8	9-5	097	121	109	0.6	0.7	-0.7	48
9	9-6	100	087	092	0.4	0.6	-0.7	46
10	9-7	097	120	108	0.0	1.3	-0.6	55
11	9-9	114	102	109	-0.3	-0.3	0.8	52
12	9-9	103	114	109	-0.5	0.1	-0.2	57
13	9-11	098	087	092	-0.4	0.2	-0.6	47
14	10-1	095	086	089	0.1	-0.4	-0.1	51
15	10-3	109	118	115	0.6	0.3	2.5	53
16	10-4	106	109	108	-0.3	1.5	-0.4	52
17	10-7	086	118	101	0.3	0.2	0.6	50

LDO Group

1	8-0	100	108	103	-1.5	-0.7	0.2	42
2	8-0	101	101	101	-1.5	-1.2	0.3	42
3	8-4	107	105	106	-1.9	-1.3	-0.9	44
4	8-6	094	124	108	-1.8	-1.0	-0.3	46
5	8-7	101	104	102	-1.5	-0.9	0.1	44
6	8-9	098	093	096	-1.8	-1.2	-0.5	50
7	8-10	096	086	090	-2.0	-1.4	-0.6	41
8	8-10	106	091	099	-1.7	1.3	-0.3	38
9	8-11	088	086	086	-2.6	-1.3	-1.1	40
10	9-0	085	098	090	-1.6	-1.5	-0.7	48
11	9-0	100	098	099	-1.7	-1.2	-0.2	45
12	9-1	091	105	097	-1.9	-0.5	0.2	47
13	9-3	090	104	096	-2.7	-1.8	-0.8	52
14	9-6	090	091	089	-1.6	-0.1	-0.5	48
15	9-7	098	096	097	-2.6	-3.7	-1.5	47
16	9-9	097	093	095	-2.2	-1.4	-1.2	51
17	9-10	119	121	123	-2.5	-0.8	-0.5	49

LDMI Group

1	8-0	107	093	101	-1.5	-0.3	0.0	21
2	8-7	117	105	112	-1.5	1.3	-0.2	38
3	8-8	096	101	098	-2.0	-1.5	-0.5	36
4	9-0	087	108	096	-1.8	-2.2	0.3	25
5	9-1	101	105	102	-2.4	-0.4	-1.3	38

6	9-2	109	114	112	-2.4	-1.8	-0.3	33
7	9-3	092	092	091	-2.7	-2.2	-0.9	26
8	9-3	097	091	093	-2.8	-0.9	-1.6	42
9	9-6	086	104	093	-2.6	-1.5	-0.8	34
10	9-6	092	108	100	-2.9	-2.3	-1.6	31
11	9-8	085	114	098	-1.8	-1.2	-0.8	34
12	9-9	094	090	091	-3.1	-2.2	0.3	37
13	9-10	100	124	112	-2.8	-2.5	-1.5	32
14	9-11	085	092	087	-2.8	-1.5	-1.1	40
15	10-0	085	104	092	-2.4	-0.5	-0.5	32
16	10-2	095	104	099	-4.0	-1.9	-1.6	42
17	10-3	101	096	099	-2.5	-0.9	-0.8	34
18	10-3	091	086	087	-3.7	-2.2	-1.4	39
19	10-4	086	109	096	-3.6	-1.7	-1.6	46
20	10-6	088	085	085	-2.6	-1.8	-1.3	32
21	10-8	100	101	100	-2.6	-1.6	-1.3	43
22	10-10	109	118	115	-3.8	-1.8	-2.1	36

Individual Subject Scores on Experimental Tasks

Number Correct on Encoding Tasks

<u>Sbj.</u>	<u>Condition 1</u>				<u>Condition 2</u>				<u>Condition 3</u>				<u>Condition 4</u>			
	<u>T1</u>	<u>T2</u>	<u>T3</u>	<u>T4</u>	<u>T1</u>	<u>T2</u>	<u>T3</u>	<u>T4</u>	<u>T1</u>	<u>T2</u>	<u>T3</u>	<u>T4</u>	<u>T1</u>	<u>T2</u>	<u>T3</u>	<u>T4</u>
<u>NC Group</u>																
1	1	2	0	3	1	1	1	0	3	2	1	2	2	1	1	2
2	2	0	1	3	2	1	0	0	2	0	1	3	3	1	1	0
3	3	2	0	3	1	1	0	1	2	2	0	3	2	2	1	1
4	2	1	0	2	3	0	1	0	3	1	0	3	2	0	0	1
5	3	1	1	2	2	1	1	1	3	2	2	3	1	2	1	1
6	1	1	1	0	0	0	0	0	1	3	0	2	1	2	1	0
7	3	1	1	2	3	2	0	0	3	1	2	2	2	1	2	0
8	1	2	1	2	2	0	0	0	2	2	1	3	2	1	2	1
9	2	1	1	3	1	1	1	1	1	2	1	2	2	2	1	1
10	1	1	0	2	0	2	2	1	3	1	2	2	2	1	2	1
11	3	0	0	3	3	2	1	0	3	3	3	3	2	2	1	1
12	3	1	1	2	2	1	1	0	2	3	1	3	3	2	1	1
13	2	1	2	0	1	1	0	1	2	1	1	2	1	2	1	1
14	3	0	0	2	2	0	1	1	2	1	1	2	2	2	2	0
15	2	1	1	3	3	2	2	1	2	0	0	2	2	1	2	0
16	3	2	1	2	2	0	0	0	3	2	1	3	1	0	2	0
17	3	2	0	1	2	1	1	0	2	0	1	2	2	2	2	1

LDO Group

1	2	0	0	1	1	0	0	0	1	1	2	0	1	0	0	1
2	2	0	0	1	1	0	0	0	2	1	0	3	2	1	1	0
3	1	1	1	1	2	0	0	0	0	2	2	0	1	1	2	0
4	2	0	0	2	2	2	2	0	1	1	0	2	2	2	2	1
5	3	0	0	1	1	1	0	1	3	2	2	2	2	1	1	0
6	2	1	0	1	1	0	2	0	2	2	1	2	2	1	1	1
7	2	1	0	1	1	0	1	1	3	0	0	2	2	0	0	2
8	2	0	2	0	2	0	1	0	2	0	1	2	1	0	0	0
9	3	0	1	1	2	1	0	0	3	1	1	2	2	2	1	0
10	3	2	0	0	1	1	1	0	3	1	2	2	3	2	1	2
11	2	0	0	1	2	2	1	1	2	1	0	2	2	1	1	0
12	2	2	0	2	1	0	1	1	3	0	0	3	2	2	0	0
13	3	1	0	2	2	1	0	0	3	1	0	2	2	2	0	0
14	2	1	0	1	1	1	1	0	3	2	2	3	1	2	2	2
15	3	0	1	2	2	1	1	0	2	3	0	2	2	2	2	0
16	2	0	1	2	1	0	1	0	3	2	0	2	3	0	0	1
17	3	1	1	1	1	1	2	0	3	2	2	3	3	3	0	1

LDMI Group

1	2	0	1	0	1	2	0	0	2	2	0	1	1	0	0	0
2	3	1	0	0	2	1	2	1	2	0	0	3	1	2	0	1
3	2	1	1	0	3	1	1	0	3	1	0	1	2	2	1	2

4	1	0	1	1	2	0	0	1	2	1	1	2	2	0	1	1
5	1	0	0	1	2	1	0	0	3	1	1	3	1	1	1	0
6	2	1	1	0	2	0	0	0	2	1	1	0	1	1	0	1
7	2	0	1	0	0	2	0	0	1	2	0	2	1	0	1	1
8	3	0	1	0	0	1	0	0	3	2	1	2	2	0	2	1
9	2	1	1	1	1	1	1	2	2	1	0	0	3	2	0	0
10	2	0	0	0	1	0	1	1	1	1	0	1	2	1	0	0
11	2	1	1	0	2	0	1	0	3	2	1	2	1	2	1	2
12	1	1	1	0	2	0	1	1	1	2	0	2	1	2	3	0
13	1	0	1	0	1	0	0	0	2	1	1	2	1	1	1	1
14	1	1	0	1	1	1	0	0	2	1	0	0	0	0	1	0
15	2	1	2	2	2	2	1	2	3	3	2	2	2	0	2	2
16	2	1	1	2	3	0	1	1	3	2	2	3	2	2	1	2
17	2	2	0	0	2	1	0	1	1	2	1	1	2	3	0	0
18	1	1	1	2	2	0	0	0	2	0	1	3	0	0	1	0
19	1	0	0	1	3	1	0	0	1	2	1	2	2	2	2	2
20	0	0	1	0	1	0	1	0	3	2	1	3	2	1	0	0
21	3	0	0	1	3	3	1	2	2	1	2	1	2	2	0	3
22	2	0	2	2	2	0	2	1	1	2	2	3	2	3	1	3

Responses on the Verbal Fluency Tasks

<u>Subj.</u>	<u>Word Fluency</u>			<u>Category Naming</u>			
	<u>F</u>	<u>A</u>	<u>S</u>	<u>Animals</u>	<u>Clothes</u>	<u>Fruit</u>	<u>Jobs</u>
<u>NC Group</u>							
1	4	5	10	13	8	9	5
2	3	7	8	11	12	8	6
3	9	6	10	16	11	6	10
4	7	7	8	13	9	9	5
5	9	4	7	16	13	15	11
6	8	4	5	9	8	6	6
7	6	4	8	12	9	7	5
8	10	7	13	13	12	12	7
9	10	7	13	13	13	7	5
10	5	4	10	12	9	10	6
11	12	9	13	9	9	10	15
12	11	9	11	16	13	10	9
13	9	9	10	13	16	6	6
14	9	9	9	9	10	8	8
15	6	10	9	13	12	14	9
16	11	4	9	19	9	8	8
17	9	8	9	12	8	10	7

LDO Group

1	9	7	10	14	6	7	4
2	6	6	3	11	12	7	4
3	4	3	4	12	13	9	4
4	9	4	10	12	6	7	4
5	5	2	7	17	12	7	7
6	5	2	5	13	7	6	7
7	7	5	9	9	9	11	0
8	7	5	9	20	7	7	6
9	6	3	6	10	6	10	5
10	4	4	7	12	9	8	3
11	3	2	6	7	4	6	3
12	5	3	9	13	9	8	3
13	6	6	12	12	12	7	3
14	10	7	12	9	9	6	3
15	7	7	8	12	11	10	10
16	10	6	12	20	10	10	5
17	7	2	6	13	10	7	8

LDMI Group

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

5	9	5	14	8	10	5	8
6	5	4	5	17	13	6	5
7	8	3	7	14	11	5	3
8	11	5	8	14	4	10	2
9	6	5	6	10	11	5	5
10	5	4	5	10	9	5	3
11	5	3	8	15	5	4	5
12	2	2	2	10	13	7	9
13	10	5	9	14	14	6	5
14	7	4	6	10	6	8	4
15	9	8	12	10	9	10	3
16	12	5	6	9	10	7	2
17	7	7	10	15	9	6	4
18	8	6	9	11	12	8	6
19	8	8	9	12	11	7	1
20	10	5	9	9	7	9	9
21	6	5	11	9	11	6	5
22	6	4	9	15	14	7	7

Responses on the Word Association and Word Clustering Tasks .

<u>Subj.</u>	<u>Word Association Task</u>				<u>Word Clustering Task</u>	
<u>Subj.</u>	<u>Latency</u>	<u>P</u>	<u>S</u>	<u>O</u>	<u>Categ.</u>	<u>Funct.</u>

NC Group

1	17	3	3	0	37	19
2	12.5	3	2	1	42	14
3	7.5	3	1	2	52	4
4	17	5	0	1	56	0
5	7.5	2	3	1	39	17
6	13	5	1	0	53	3
7	19	2	2	2	51	5
8	10.5	4	2	0	49	7
9	8	5	1	0	41	15
10	18	5	1	0	56	0
11	7	4	2	0	56	0
12	6	0	4	2	46	10
13	5.8	3	3	0	40	16
14	9.5	5	1	0	53	3
15	13.5	3	2	1	46	10
16	10	1	2	3	51	5
17	14.5	5	1	0	53	3

LDO Group

1	15	3	0	3	33	23
2	12	3	2	1	56	0
3	36.5	2	0	4	36	20
4	26	4	2	0	54	2
5	13	0	0	6	33	23
6	16	2	2	2	37	19
7	20	4	0	2	32	24
8	31.5	6	0	0	26	30
9	37	3	3	0	23	33
10	9.5	1	4	1	55	1
11	33	3	1	2	32	24
12	35.5	3	2	1	55	1
13	25	2	1	3	44	12
14	7	1	2	3	21	35
15	8	1	0	5	31	25
16	15	0	4	2	26	30
17	11	3	1	2	51	5

LDMI Group

1	11	2	1	3	46	10
2	26	4	2	0	32	24
3	31	3	0	3	32	24
4	6.5	0	0	6	31	25
5	35	4	1	1	45	11

6	15.5	4	2	0	54	2
7	28.5	1	4	1	20	36
8	21	4	1	1	42	14
9	65	3	3	0	51	5
10	15.8	3	3	0	35	21
11	12	4	0	2	39	17
12	18.5	2	4	0	55	1
13	20	4	1	1	49	7
14	18	3	2	1	35	21
15	15	5	0	1	49	7
16	14	4	1	1	36	29
17	13	6	0	0	55	1
18	7	2	9	0	49	7
19	17	4	2	0	26	30
20	20.5	2	0	4	31	25
21	19	0	0	6	25	31
22	14.5	5	0	1	14	42

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