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ABSTRACT

A study in eastern Ontario, Canada, evaluated a computer program, the Autoskill Component Reading Subskills Program, which was used to improve the reading comprehension of elementary school students identified as reading disabled. Subjects, 91 students from five school districts, were behind at least one grade in reading word recognition skills but were of average intellectual ability. They were trained on the Autoskill Program according to procedures specifically developed for three reading disability subtypes: oral reading, intermodal-associative, and sequential. Two control groups consisted of reading disabled students who did not receive any specific intervention except that which they were already obtaining in their schools, and students receiving alternate computer programs for remedial assistance. Results indicated that the Autoskill-trained students made significant gains in reading word recognition, phonetic skills, and paragraph reading. Findings also showed teacher and student evaluations of the program to be quite positive. These results replicated those of a previous field study, and additionally, represented more extensive benefits of the training procedures in that the transfer of training effects included paragraph reading and comprehension. (Comprehensive tables of data are included, and an extensive bibliography, a subject classification list according to school board and school, a qualitative analysis of silent and oral reading, and sample initial and final teacher evaluation forms are appended.) (NKA)

AN EVALUATION OF THE EFFECTIVENESS OF COMPUTER-ASSISTED COMPONENT READING SUBSKILLS TRAINING

Education and Technology Series

C.A.M. FIEDOROWICZ
R.L. TRITES

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ABSTRACT

In this study involving five school boards within the Eastern Region of Ontario, reading disabled students were trained on the Autoskill Component Reading Subskills Program according to procedures specifically developed for three reading disability subtypes: Oral Reading, Intermodal-Associative and Sequential. Two control groups were also included in the evaluation. One control group consisted of reading disabled students who did not receive any specific intervention, but rather were maintained on whatever management the schools had planned for them. The other control group received alternate computer programs for remedial assistance. The Autoskill trained students made significant gains in reading word recognition, phonetic skills and importantly, paragraph reading. In addition, teacher and student evaluations of the program were quite positive. These results not only replicated the findings of the first field study, but represented more extensive benefits of the training procedures. Implications with regard to theoretical issues, particularly the automaticity model of information processing, are discussed.

CHAPTER 1

Reading Disabilities

Definition

Epidemiological surveys have indicated that 10 to 30% of the total grade school population fail to acquire reading skills at a level commensurate with their intellectual ability (Eisenberg, 1966; Rabinovitch, Drew, DeJong, Ingram & Withey, 1954). One of the many specific groupings of reading failure has been described as developmental dyslexia and 4 to 8% of disabled readers are classified within this category (Rutter, 1978; Satz & Sparrow, 1970; Yule & Rutter, 1976). The literature is plagued by semantic confusion in both the nomenclature and the characteristics of the dyslexic child. Various labels have been used: "congenital word blindness" (Hinshelwood, 1904); "strephosymbolia" (Orton, 1928); "specific dyslexia" (Hallgren, 1950); "primary reading retardation" (Rabinovitch et al., 1954); "reading backwardness (Kinsbourne & Warrington, 1966); "specific reading disability" (Eisenberg, 1966); "specific developmental dyslexia" (Critchley, 1970), "unexpected reading failure" (Symmes & Rapoport, 1972); and "specific reading retardation (Yule & Rutter, 1976). The terms _reading disability_ or _reading disabilities_ will be used in this manuscript except when reporting studies in which other terms have been used. In such cases, the alternative terms will be used to be consistent with the published studies.

It has been generally acknowledged that reading disability refers to those children who fail to acquire normal reading proficiency despite average intelligence, socio-cultural opportunity, conventional instruction and freedom from gross sensory, emotional or neurological handicap (Benton, 1975, 1978; Critchley, 1970; Rourke, 1978). It has also been generally acknowledged that such a definition is problematic since it is one of exclusion and describes a residual syndrome, (Benton, 1978; Rutter, 1978). Recently, some investigators have emphasized a less restrictive approach (Doehring, Trites, Patel, & Fiedorowicz, 1981; Ross, 1976; Rutter, 1978; Satz & Morris, 1981). A redefinition following a more inclusive concept that recognizes variants such as children with neurological, intellectual, social, emotional or educational handicaps has been suggested as an alternative. The basic argument of those who support this position is that children diagnosed as reading disabled should not be distinguished from other failing readers along the dimensions included in the definition, specifically academic, neurological and emotional characteristics. They contend that reading disabled children, as a group, do not differ significantly from other failing readers on all of the dimensions specified in the current definition (Satz & Morris, 1981). However, Benton (1978) cautions that there is a risk of becoming so diffuse as to be no longer clinically or theoretically relevant. Some limiting descriptions of the condition are necessary for a meaningful basis of comparison in research.

Characteristics of Reading Disability

The characteristics associated with reading disability lack clarity of definition. A variety of cognitive, linguistic, perceptual, motor and neurological conditions have been investigated as correlates of the disorder. Several prominent characteristics have been reviewed by Benton (1975) and Rourke (1978) and include the following: (1) visuo-perceptual deficits in the form of defective figure-ground discrimination, visuo-motor performance, form perception, visual memory, spatial orientation, design copying, visual scanning and oculomotor reaction time; (2) directional sense impairment, especially lateral and right-left disorientation; (3) poor oral language skills, particularly speech-sound discrimination, articulation, verbal memory and vocabulary; (4) defects in intersensory integration, including auditory-visual cross-modal matching; (5) deficiency in sequential perception such as temporal sequencing and serial positioning; (6) disturbances of finger agnosia; (7) mixed lateral eye and hand preferences; (8) abnormal conceptual and symbolic thinking; and (9) such disturbances as general awkwardness, dyspraxia, hyperkinesis and other motor disorders. The numerous studies involving these correlations of reading disability have yielded a "melange of positive and negative findings" (Benton, 1975). Although all of these characteristics have been reported in various studies, not all children exhibit all of these deficits.

Several hypotheses, each representing a single explanation of reading disability, have been investigated. Doehring et al. (1981) have summarized some of these unitary deficit hypotheses and pointed out their failure to provide a comprehensive explanation of reading disabilities.

A deficit in some aspect of visual processing is one such hypothesis. However, the bulk of evidence suggested that abnormality of eye movements, visual attention, visual perception or visual memory do not characterize all reading disabilities. In fact, deficient visual processes that have been reported have been interpreted as interactive consequences of language deficits rather than primary visual deficits (Vellutino, 1979).

A deficit in auditory processing has been another focus of investigations. Doehring et al. (1981) concluded that research into auditory abilities has confounded auditory and linguistic deficits and that there is considerable controversy in the explanation of reading disability as a languag disorder versus deficits in nonverbal auditory perception.

With regard to visual-auditory association deficits, the assumption has been that there is a breakdown in the transformation of visual stimuli into a spoken language form. Studies reporting associative deficits have failed to rule out alternative deficits of attention, memory, strategy, or intramodal visual, auditory, or linguistic deficits (Bryant, 1975).

Deficiencies of language processing have also been proposed as the underlying problem of reading disability (Vellutino, 1979). There is considerable evidence that reading disabled children have difficulty with phonemic segmentation and that phonemic segmentation skills are important for phonological decoding during the early stages of reading acquisition. Such evidence supports the theory that reading is "parasitic" upon speech perception. Because speech perception is already linked to meaning, the acquisition of reading involves learning how to translate written language into spoken language (Liberman, Cooper, Shankweiler, & Studdert-Kennedy, 1967). Several other language processes have also been investigated, including morphological and morphophonemic levels of spoken language, syntactic usage, metalinguistic awareness, internal model of articulation, and naming colours, pictures and numbers. Doehring et al. (1981) suggested that the exact role of these linguistic processes in the acquisition of reading skills remains in question. This is particularly true in view of the controversy of direct access theorists (Smith, 1971) who hypothesize that an intermediary stage of coding printed language into spoken form is not necessary, since print has direct lexical access; and, therefore, learning the orthographic representation of words is more important than phonological recoding.

Doehring et al. (1981) point out further that memory plays an important role in many reading theories and memory deficits have been reported in reading disabled children, but there is no unequivocal evidence that memory deficits operate as causal factors in reading disability.

Single-Syndrome Research

It is possible that the inconsistencies reported in the literature regarding the associated characteristics of reading disability and the lack of clarity regarding the cause of reading disability are related to the fact that the traditional method of investigation was based on the assumption that all reading disabled children belonged to a homogeneous group. The focus of research was finding a single cause for a unitary form of reading disability. Over the last few years, this single-syndrome paradigm has been criticized as too simplistic a model which ignores the complexities of reading as a multidimensional process. An alternative multiple-syndrome paradigm has been suggested as a more appropriate model which allows for the investigation of a number of subgroups of reading disability (Applebee, 1971; Doehring, 1978; Doehring & Hoshko, 1977; Doehring et al., 1981; Satz & Morris, 1981; Wiener & Cromer, 1967). By changing the approach from one in which all reading disabled children are treated as a unitary group to one in which specific subgroups are examined separately, a number of inconsistencies may be explained. Different characteristics, as well as different causal factors, may correspond to various reading disability subgroups.

In the following sections, the development of this subgroup concept is reviewed.

CHAPTER 2

Subjective Approaches to the Subgroup Concept

Clinical Impressions: No Data-Based Studies

Johnson and Myklebust

Johnson and Myklebust (1965) initially described three syndromes of dyslexia, including visual, auditory and auditory-visual association disorders. Later, only the first two types were emphasized (Johnson and Myklebust, 1967). Visual discrimination difficulties, slow rate of perception, letter reversals and inversions, visual sequencing problems, and poor visual memory were the deficits associated with the visual dyslexics; while characteristics of the auditory dyslexic were poor auditory discrimination, speech sound perception, auditory memory, and auditory sequential skills. Myklebust (1978) further delineated these two types to include a categorization of the following types of dyslexia: inner-language dyslexia or "word calling" in which phoneme-grapheme coding skills are normal but comprehension is poor; auditory dyslexia in which "cognitively auditorizing", symbolizing and coding written language is poor but spoken language comprehension is not impaired; visual-verbal agnosia in which cognitive visualization of written language is poor; and intermodal or cross-modal dyslexia consisting of either auditory-intermodal dyslexia in which intraneurosensory learning is deficient due to poor auditory processing; and visual-intermodal dyslexia in which intraneurosensory learning is deficient due to poor visual processing. Unfortunately, experimental data were not presented; rather, the categorizations were based solely on clinical impressions. Since these subgroups were not experimentally or statistically verified, they must be interpreted with caution. However, the significance of these contributions by Johnson and Myklebust lies not in the method of distinguishing subgroups, but from an historical perspective as being among the first to suggest that disabled readers exhibited differential reading deficits.

Bannatyne

Bannatyne (1966) also identified two groups of dyslexics. Those with genetic dyslexia represented an inherited inability to use language fluently, and those with minimal neurological dysfunction represented a variety of deficits, depending on the locus and nature of the dysfunction. Once again, differentiation was not based on objective analysis but global clinical impression. Furthermore, although the question of the cause of dyslexia, i.e. familial origin versus acquired dysfunction, is in fact a valid distinction, it does not specify the patterns of deficits within each category. The characteristics of a dyslexic with a familial reading disability in contrast to the minimal neurological dysfunction dyslexic were not given. With this type of definition, thr characteristics of each subgroup is not necessarily mutually exclusive (Zangwill, 1962).

Clinical Impressions: Data-Based Studies

Following the introduction of the concept that not all of the reading disabled belong to one homogeneous group, several researchers attempted to define various subgroup characteristics based on studies in which actual data were collected. Homogeneous subgroups were determined by visual inspection of the data. There are important methodological and theoretical problems associated with this clinical-inferential approach. These limitations involve a *priori* consideration of how the disabled readers should be grouped which extends to the type of measures that are selected to assess the differences among the disabled readers (Satz & Morris, 1981) and the subjective classification of the disabled readers (Doehring & Hoshko, 1977). Nevertheless, such studies can be considered a step forward beyond completely subjective, global clinical impressions such as those of Myklebust and Johnson, and Bannatyne. Some of the representative contributions which have been made to the subgroup literature by the data- based clinical impression studies are presented below.

Kinsbourne and Warrington

Two subgroups of reading and writing backwardness were described by Kinsbourne and Warrington (1966). Both subgroups were based on the premise of developmental cerebral deficits, and a neuropsychological test battery was used to delineate the subgroups.

Performance on the Wechsler Intelligence Scale for Children (WISC)(Wechsler, 1955) or Wechsler Adult Intelligence Scale (WAIS)(Wechsler, 1949) was used as the major subject selection criterion. In the first syndrome, Verbal IQ (VIQ) was 20 points lower than Performance IQ (PIQ), and in the second, PIQ was 20 points lower than VIQ. There were six male subjects (Ss) in

Group I, and the seven Ss in Group II included five females and two males. The age range was 8 to 14 years, with one 31-year-old. Assessment consisted of reading, spelling, and arithmetic achievement testing, tests of finger differentiation and order, nonstandardized clinical impression of receptive and expressive verbal ability, right-left orientation, and construction skills. Group I (VIQ<PIQ) showed deficits on the clinical language assessment, with no impairment of arithmetic abilities or finger differentiation and order. In contrast, Group II (PIQ<VIQ) was impaired on arithmetic, right-left orientation and finger differentiation and order, but language skills were intact. The authors noted that the deficits of Group I were analogous to aphasic deficits in adults with verified left hemisphere dysfunction, and the deficits of Group II were comparable to the Gerstmann Syndrome in adults with cerebral damage. The Gerstmann pattern of deficits include right-left confusion, calculation difficulties, finger differentiation problems, and impairment in form perception (Gerstmann, 1924). As such, Group I was designated a Language Retardation Group and Group II a Gerstmann Group. The implication was that children with reading backwardness are afflicted with either one of two types of left cerebral dysfunction. Thus, on the basis of extreme discrepancy scores on intelligence tests, two groups were selected and on the basis of visual inspection of the pattern of performance on a neuropsychological test battery, two subgroups of reading disability were determined. Inferences regarding etiology were made in accordance with each pattern of

performance. Such methodology exemplifies the reasons for criticizing this clinical-inferential approach, particularly the a *priori* grouping of subjects and the subjective method of visual inspection of data.

In addition, there are other specific weaknesses in this study, the most obvious of which involves the subject selection. The total sample of 13 was very small and the sex distribution was biased. All males were included in one group and predominantly females in another which makes interpretation of the findings difficult. Although all Ss in Group I were delayed in reading by at least two years, one subject in Group II was delayed in reading by one year, (chronological age 12.1, reading age 11.0). Further, a control group of good readers was not included. Such a comparison group would have been valuable in determining whether the results were specific to disabled readers. Thus, although the speculation that dyslexic children may be subdivided on the basis of two types of left hemisphere dysfunction is an interesting hypothesis, its validity was not unequivocably demonstrated by this study.

Bateman

Bateman (1968) described three subgroups of reading disability on the basis of the profiles on the Illinois Test of Psycholinguistic Abilities (ITPA). The characteristics of the first group included poor auditory memory but good visual memory; the second group had poor visual memory but good auditory memory; and the last group had both poor auditory and visual memory. These subgroup classifications are quite limited in that they were derived based on one type of measure, i.e., psycholinguistic abilities, and the profiles were determined by visual inspection of the data. However, Bateman did suggest remedial approaches according to the strengths and weaknesses of each subgroup.

Smith

M. Smith (1970) also described three subgroups based on the profiles on one test. The WISC or WAIS was administered to 300 educationally handicapped boys and 74 boys attending regular classes. The first subgroup profile, representing 67% of the sample, included a strength in spatial organization and lower performance on symbol manipulation tasks and sequencing ability. The second pattern (15%) involved deficits in spatial organization and visual-motor coordination. The third group had the characteristics of both patterns. Again these subgroup classifications must be considered limited in their scope since they were based on one test and the profiles were determined by visual inspection.

Ingram, Mason and Blackburn

In a retrospective study of 82 children with problems in reading, three subgroups of reading disability were reported by Ingram, Mason and Blackburn (1970). The actual purpose of the investigation was to determine any neurological and psychological differences between two groups of learning disabled children. The first group (N=62) was restricted to children who were underachieving in reading and spelling by at least two years below chronological age expectation, and the second group (N=20) included children who were poor in arithmetic as well as reading and spelling. The former group was referred to as a specific reading disability group, and the latter as a general learning disability group. All Ss had IQ scores within at least the dull-normal range (IQ 80), had a normal educational experience, and did not have a psychiatric disorder. Children with a history of a neurological dysfunction or delayed milestones, i.e., possible brain damage, were included. The assessment consisted of a neurological examination, electroencephalogram (EEG) and psychological testing which included the Stanford Binet Intelligence Scale, the Schonell Test of reading, spelling and arithmetic, projective drawings, and measures of audio-phonic and visuo-spatial difficulty. Based on visual inspection of the results, it was determined that the "Specifics" had significantly less evidence of brain damage or dysfunction than the "Generals". It was further determined that 77% of the Specifics demonstrated audio-phonic difficulties, including inability to synthesize letters correctly, confusion of vowel sounds, poor knowledge of the sounds of diphthongs, and inability to analyse words into auditory units. The remaining 23% experienced visuo-spatial difficulties manifested by confusion of letter shapes, poor visual discrimination of closely associated words and directional errors. Among the Generals, only 11% had audio-phonic deficits, but the percentage of cases with visuo-spatial difficulties was not reported (Ingram et al., 1970).

The subgroups of audio-phonic and visuo-spatial deficits derived from the Ingram et al. study are likely limited in their scope, since a major source for subject referral was a Speech Therapy Unit. The probability of obtaining auditory deficits from such a sample would be high. In addition, one could also question the a *priori* subdivision of the Specific and General groups on the basis of arithmetic achievement, since long-term follow-up studies have shown that as a result of inability to read, achievement in other subjects is also affected (Trites & Fiedorowicz, 1976). It is, therefore, possible that the General group could be a more severely affected reading retarded group. Further, a control group of good readers was omitted.

Mattis, French, Rapin and Denckla

Mattis, French and Rapin (1975) initially described three reading disability subtypes. In a retrospective study, the results of the neuropsychological evaluation of 113 children aged 8 to 18 (mean age 11.47) were analysed. They were selected from a larger clinic sample of 252. A diagnosis of brain damage (BD) was made for 82 of the Ss by a pediatric neurologist, using the criteria of a history of an encephalopathic event and abnormal findings on a clinical neurological examination, EEG, and skull X-rays or other contrast studies. Within this group, 53 were subclassified as nonreaders (BDF dyslexic group) and 31 as readers (BD reader group). A third group of 29 children consisted of non-BD dyslexics, i.e., developmental dyslexics. Dyslexia was operationally defined as performance on the Wide Range Achievement Test (WRAT) (Jastak & Jastak, 1976) reading section as two or more grades below age-appropriate levels. All children had visual acuity and hearing within normal limits, had no psychosis or formal thought disorder, and demonstrated a VIQ or PIQ greater than 80 on the WISC. In addition, all were assessed on a battery of tests of attention, conceptual ability, receptive processes, language, memory, construction ability, motor skills, and academic achievement. In comparing performance levels across the three groups, the striking result was a consistent lack of differences between the developmental dyslexics and the BD dyslexics. Three distinct patterns of deficiencies common to both groups were differentiated: a Language Disorder Syndrome (N=29), an Articulatory and Dyscoordination Syndrome (N=30), and a Visuo-perceptual Disorder Syndrome (N=13). The first syndrome involved dysnomia (difficulty in naming) as the major critical factor, along with syntactic distortion. Blending of speech sounds was generally intact, even when there was speech sound discrimination difficulty. Some children within this classification also had comprehension deficits. Visual and constructional skills and graphomotor coordination were adequate. VIQ was significantly lower than PIQ. The second syndrome involved a group of children with a predominant buccal lingual dyspraxia with resultant poor speech and graphomotor dyscoordination, i.e., a deficit in rapid protrusion of the tongue and smooth movement in repetition of sounds. An assortment of gross and fine motor coordination problems was evident, including sloppy handwriting and an inability to reproduce a letter the same way twice in succession. Visuo-spatial perception, receptive language and nonverbal constructional skills were normal. VIQ and PIQ scores were approximately equal. Children classified into the final syndrome demonstrated a marked visuo-spatial perceptual impairment, as measured by tests requiring visual discrimination without complex motor manipulation of stimuli. Severely affected children could not discriminate letters. However, graphomotor coordination, speech blending, and language skills were intact. VIQ was greater than PIQ by at least 10 points. In all, 90% of the 82 subjects were classified into one of the three syndromes. No data were given regarding the profile of the remaining 10%, but it is assumed to be a mixed residual group.

Although this study is strengthened by the inclusion of a comparison group of BD normal readers, one possible criticism is the categorizing of the 82 children into the BD and non-BD groups. It was reported that "many of the developmental dyslexic children with a clear genetic history presented with neuropsychological findings which in adults would indicate a well localized lesion" (Mattis et al., 1975). By including these children within the developmental dyslexic category the differentiation of BD and non-BD dyslexic groups may have been confounded, and it would not, therefore, be surprising that differences were not obtained. However, this potential difficulty does not detract from the syndrome categorizations, since all disabled readers were treated as a single combined group for purposes of classfication.

Closely associated with the work of Mattis et al. is that of Denckla (1979). In a retrospective study of 52 dyslexic children aged 7 to 14 years, five syndromes were isolated. A Language Disorder subgroup in which anomia was a prominent feature, included 28 of the children (54%); six (12%) were diagnosed within the Articulation and Graphomotor Dyscoordination syndrome; two (4%) within the Visuo-Perceptual Disorder syndrome; seven (13%) within a Dysphonemic Sequencing Difficulty group, and five (10%) within a Verbal Memorization (learning) Disorder category. The first three syndromes were identical to the Mattis et al. classifications, except that the Visuo-Perceptual Disorder syndrome also included anomia. The fourth category was characterized by poor repetition, phonemic substitution and mis-sequencing occurring regardless of comprehension skills, with speech sound articulation and naming ability within the normal range. Children in the last syndrome presented with deficits in verbal paired associate learning and sentence repetition skills, although language abilities were generally otherwise adequate.

In a follow-up study, a cross-validation of the Mattis et al. and the Denckla syndromes was attempted (Mattis, 1978). Subjects included 163 children classified as dyslexic, aged 8 to 14 years, on whom extensive medical, neurological, and neuropsychological data had been obtained. Although the three main syndromes were verified, the percentage of children classified into each syndrome and the total number accounted for by these categories was at variance with the initial report, with 63% being classified into the Language Disorder syndrome, 10% into the Articulatory and Graphomotor Dyscoordination syndrome, and 5% into the Visuo-Perceptual Disorder syndrome. The discrepancies in percentages were attributed to sampling differences, since the cross validation study involved a younger population (modal age range between 8 to 10 years versus 11 to 12 years), different ethnicity (black and hispanic versus white) and different class (lower versus upper middle class). Another difference between studies was that in the original research, each child had been classified into only one syndrome group, but in the cross validation study, 9% were classified into two syndromes. Among the 22% who were not classified into one of the three original groups, the test results of four (2.5%) resembled the Visuo-Perceptual Disorder with Anomia syndrome of Denckla's Dysphonemic Sequencing difficulty group.

The replication of these subgroups added strength to their reliability. However, the criticisms of a clinical-inferential approach can be applied to these studies. Satz and Morris (1981) pointed out that it is unclear whether the subgroup characteristics were initially determined in accordance with a *priori* theoretical expectations or after visual inspection of the data. Both approaches are problematic. With the former approach the data are made to fit predetermined theoretical classifications and with the latter, visual inspection of multidimensional data are too simplistic and subjective. In addition, Satz and Morris pointed out that the classifications are based on a rigid division of characteristics such that a set of features is unique to each subtype and that any member of the subtype must possess all of the features that are used to define that group. Such monothetic groupings are at risk for misclassification. This may account for the varying frequencies of subgroup membership across studies, as well as the fact that some children remained unclassified.

Although there are methodological problems associated with these subgroups, the studies do illustrate the feasibility of a multiple profile approach to reading disabilities.

Subgroups with Causal Inferences

The derivation of the different subgroups of reading disability just described, was based on clinical inferences drawn on neuropsychological patterns of performance. The rationale for applying neuropsychological tests is that a variety of cognitive, linguistic and perceptual skills are thought to be involved in the complex process of reading. Reading disabled children have been found to differ from children without a reading disability on several of these cognitive, linguistic and perceptual skills. Subgroups were formed, therefore, by differentiating the patterns of performance on these neuropsychological measures and forming various homogeneous clusters. In some of the studies, inferences were made about underlying cerebral functioning on the basis of these different neuropsychological profiles. Kinsbourne and Warrington (1966) implied that left cerebral dysfunction was involved in the two subgroups of reading disability that they described. Ingram et al. (1970) reported that there was less evidence of brain damage or dysfunction among the children described as having a specific reading disability in comparison to the general learning disability group. Benton (1978) postulated that the Language Disorder Syndrome identified by Mattis et al. (1975) could be the result of dysfunction in the posterior parietal region, and that their Dyscoordination Syndrome might involve Broca's area. Keefe and Sweeney (1979) described left and right hemisphere dysfunction in reading disabilities. Aaron (1982) differentiated three subgroups of dyslexia in college students according to posterior, anterior and central cerebral dysfunction.

Studies in which measures of cerebral functioning other than neuropsychological test batteries have been used have suggested various areas of cerebral dysfunction among disabled readers. It could be postulated that each of the areas in which abnormal cerebral functioning has been noted represents different subgroups. Therefore, since the parieto-occipital area has been implicated as dysfunctional in some disabled readers, as determined by means of postmortem findings (Drake,1968), CT Scan (Hier, Lemay, Rosenberger & Perlo, 1978), EEG recordings (Sheer, 1976; Tuller & Eames, 1966), and ERP results (Conners, 1971; Preston, Guthrie & Childs, 1974; Preston, Guthrie, Kirsch, Gertman & Childs, 1977; Symann-Lovett, Gascon, Matsumiya & Lombroso, 1977), dysfunction in this area may be characteristic of one subgroup. Similarily dysfunction in the temporal area (Galaburda, Lemay, Kemper & Geschwind, 1978; Levine, Hier & Calvanio, 1981) and the various regional differences described by Duffy, Burchfiel & Lombroso, 1979; Duffy, Denckla, Bartels &

Sandini, 1980; Duffy, Denckla, Bartels, Sandini & Kiessling, 1980) may be characteristic of other subgroups.

The reason for the variation in the results of genetic studies, particularly the family pedigree investigations may also be interpreted according to the subgroup concept. Some subgroups may be determined on the basis of hereditary factors, while others may be the result of other noninherited causal factors. In addition, different modes of transmission may be underlying different subgroups, such that some subgroups are the result of polygenic transmission, and others, autosomal, recessive inheritance, or sex-linked (DeFries and Decker, 1982; Finucci, Guthrie, Childs, Abbey & Childs, 1976).

Subgroup Classifications Based on Achievement Measures

Different subgroups have been suggested on the basis of neuropsychological profiles, as well as according to various causal factors. Another basis of subgroup formation involves performance on achievement measures.

Boder

Boder (1973) delineated three subtypes of atypical reading-spelling patterns in children classified as dyslexic. Her classification differed from that of the investigators previously cited, since it consisted of a detailed qualitative evaluation of the child's ability to read and spell, rather than a simple determination of academic achievement grade level. An analysis of the number and kinds of reading and spelling errors was accomplished by Boder's Diagnostic Screening Procedure (Boder, 1971). This procedure involved a reading test to determine sight vocabulary and "word analysis-synthesis skills"; and a spelling test to assess revisualization skills in writing to dictation words within sight vocabulary, and to assess phonetic skills in writing unknown words. The classification also involved supplementary tasks such as reciting and writing the alphabet to test auditory and visual sequential memory, and paragraph reading to assess reading skills in context. On the basis of this assessment, three characteristic reading-spelling patterns were differentiated. Group I, Dysphonetic Dyslexia, involved a deficit in grapheme-phoneme (symbol-sound) integration, resulting in an inability to develop phonetic word analysis-synthesis skills. Words were read as a global visual gestalt rather than by a process of analytically sounding out and blending the syllables of words. Word substitutions were so prevalent as to be considered pathognomic. Spelling levels were consistently below reading levels and were limited to sight vocabulary, indicating poor phonetic skills and inability to analyse the auditory gestalt of the spoken word. Group II, Dyseidetic Dyslexia (visual-discrimination difficulty), was somewhat of the reverse of the first group in that the deficit involved the inability to perceive auditory or visual gestalts in spelling and reading, while analytic skills were unimpaired. Group III, mixed Dysphonetic Dyseidetic, as the name implies, involves both the inability to develop either phonetic word analysis-synthesis skills, as well as deficits in perception of auditory and visual gestalts. These were the most severely impaired readers with the worst prognosis.

A total of 107 dyslexic children, 92 boys and 15 girls, aged 8 to 16 years, and with a varied socioeconomic status (SES), were included in a preliminary survey by Boder (1971) to determine the distribution of the three subtypes. They were selected from a larger group of 300 children. The diagnosis of dyslexia was determined by: WRAT reading and spelling scores at least 2 years below age appropriate levels, an IQ score of 90 or above on either the VIQ or PIQ of the WISC or Stanford Binet; normal hearing, vision and general health; and no evidence of a gross neurological defect or primary psychiatric disorder. The results indicated that 67 (62.6%) fell within the Dysphonetic Dyslexic group, 10 (9.3%) in the Dyseidetic Dyslexic group, and 23 (21.4%) in the Dysphonetic-Dyseidetic Dyslexic group, and 7 (6.5%) were unclassified. Long-term observation indicated that these patterns persisted despite improvement in reading and spelling achievement grade levels. In addition, none of the patterns was found among normal readers and spellers indicating that the deficits were not simply exaggerations of normal reading patterns (Boder & Jarrico, 1982).

Thus, Boder has presented evidence of the existence of subgroups defined by reading-spelling performance alone. Her population was well-defined, the assessment procedures were carefully described and a comparison group of normal readers and spellers was included. However, classification into the three patterns appeared to be based on clinical diagnosis, since there was no mention of an objective statistical analysis. The rules for the subtype classification were obscure and required more definitive criteria. Boder's procedures have since been published as a screening instrument with standardized scoring criteria: Boder Test of Reading/Spelling Problems (Boder & Jarrico, 1982). Boder and Jarrico summarized findings concerning the subtypes from investigations of similarities in the distribution of the subtypes, and measures of cognitive abilities such as intelligence, memory, auditory processing, and dichotic listening, correlations with other reading tests and electrophysiological correlates. They concluded that there was strong evidence that the three subtypes represent three different neuropsychological syndromes.

Satz and Morris (1981) have summarized the strength of Boder's work as a detailed clinical analysis of each child's approach to written material. They criticized the validity and reliability of the subgroups, however, since they were derived from clinical impressions, were lacking in statistical derivation or verification, and were not replicated.

These criticisms were made prior to the 1982 publication. However, three recent studies provided only partial support for the Boder subtypes. Nockleby and Galbraith (1984) reported that in their sample the Boder nonspecific subtypes were as impaired as dysphonetics on the Lindamood Auditory Conceptualization Test suggesting similar difficulties in processing the internal phonemic structure of words. Boder, however, contended that the nonspecific subtype has no cognitive skill deficits.

Hooper and Hynd (Felton & Campbell, 1985) found that the sequential processing factor discriminated normal versus dyslexic readers, but not dyslexic subtypes. They concluded that the concept of reading and spelling patterns providing evidence of cognitive deficits was faulty and that the validity of Boder's model required a closer evaluation.

Van den Bos (1984) reported that the three dyslexic subtypes differed significantly from controls, but not from each other on a letter processing task and concluded that accessing phonetic representations was characteristic of all the dyslexics. This suggested that more similarities among subjects existed than would be predicted by the Boder model.

Felton and Campbell (1985) have also challenged the validity of the Boder subtypes. Non-reading disabled children were distinguished from reading disabled children on measures of naming and word retrieval but not between subtypes as predicted by Boder. Further, a large proportion of the subjects changed Boder subtype categories in a test-retest evaluation over an 18-month period.

Aaron

Aaron (1982) initially identified two reading disability subgroups on the basis of reading test performance: a sequential deficient group and simultaneous deficient group. A total of 46 reading disabled children from grades 2, 3 and 4 were included in the first study. These children were of at least average intelligence, free from any noticeable emotional or neurological impairment and were reading at least one grade level below expectation. The children were subdivided into two groups based on *a priori* classification rules. The first category was the sequential deficient group and the criteria included poor sequential order of elements within a word, omissions, reversals, and displaced letters within a word. Phonetic spelling was the primary characteristic of the simultaneous deficient group. Determination of subgroup membership was made by performance on Boder's diagnostic screening procedure. Each child in one group matched with a child in the other group on the basis of chronological age, mental age and sex. Another matched group of 14 normal readers was selected. All were given four tests to determine nonreading characteristics; memory for faces, WISC digit span, reproduction of paired letter stimuli and individual letters and shapes. Results indicated that dyslexic children deficient in one information processing strategy (eg. simultaneous) were normal in the other strategy (eg. sequential), and that normal readers did not have this "imbalance".

In a second study, 15 reading disabled children in Grades 3 and 4 were evaluated on a battery of tests of comprehension, language ability, and sequential and simultaneous information processing abilities (Aaron, 1982). This time three theoretical profiles were determined *a priori* for a sequential deficient group, a simultaneous deficient group and a comprehension deficient group. Following the assessment, three children were categorized as belonging to the first group, two to the second group and six to the last one. Four children were unclassified. None of the five normal readers matched any of the profiles and only one of four profiles of low IQ poor readers matched the profiles. The sequential group reading errors included omissions, substitutions or added words which were more often function words than content words. The simultaneous group reading errors consisted of few syntactic or semantic errors but mainly misreading of unknown words, letter by letter decoding, and substituting known for unknown words. The comprehension deficit group did not pay much attention to semantics. There were several word substitutions which resulted in meaningless sentences. Children in each of the three subgroups performed well on some tests and poorly on others, which the authors interpreted as indicative of imbalances in information processing strategies.

Individual case studies (Aaron, Baxter & Lucenti, 1980), "psycho-historical" case studies (Aaron, 1982) and a study investigating simultaneous and sequential processing using logographic script (Aaron, 1982) were cited by Aaron as further evidence to support his imbalance hypothesis and his subgroups.

The strength of the studies presented by Aaron and his colleagues include the fact that both reading and nonreading tests were used, comparison groups of normal readers were included to verify that their profiles were different from the disabled readers, and the findings were replicated. The sample size, particularly in the second study can be criticized. Although Satz and Morris (1981) have presented criticisms in using a *priori* theoretical classification rules, it could be argued that starting from a theoretical framework is a superior methodology than "data snooping" as was the case in several studies of subgroup classifications. The theoretical framework from which Aaron and his colleagues started was an imbalance in information processing strategies, namely sequential and simultaneous strategies as well as comprehension deficiencies which were evaluated on both reading and nonreading types of tasks.

Theoretical Subgroups

Vernon

Vernon (1977) is another advocate of the approach that reading problems are not the result of a single inherent deficiency. Her approach, however, was much more theoretical. In her review of the literature, the series of complex skills that the child successively develops from the early stages of learning to the final stage of fluent reading were outlined. Vernon hypothesized that dyslexia was the result of deficiency at those various stages. Four subgroups of dyslexics were described in terms of the presumed deficiencies in the acquisition of reading skills. The first deficient area is in the ability of the child to analyse complex sequential visual and/or auditory linguistic structures which in turn prevents encoding in short- and long-term memory. The second type of failure involves the linking of visual and auditory linguistic structures. Skills in this category progress from a simple level of picture naming to the more complex process of matching the symbolic grapheme with the corresponding phoneme. The inability to discover the regularities in grapheme-phoneme correspondences is considered the third deficiency, as well as the most frequent cause of poor reading. Grapheme-phoneme associations are not acquired by rote learning, but by rules based on regularities between the printed or written visual presentation and the phonemic information of the spoken sound. Invariant grapheme-phoneme associations are easiest to learn, while those with varying associations are described as the source of the third type of deficiency. The fourth and final deficient area is the inability to group words into meaningful phrases despite correct recognition of single words. It is speculated that failures of this type are caused by a lack of automatization of grapheme-phoneme correspondences. An overlapping of one type of deficiency to another was recognized, particularly deficiencies in ordering in the second and third subtypes and inadequate grapheme-phoneme processing affecting the third and fourth subtypes.

A positive feature of Vernon's subtyping is that the categories were based on a task analysis of the reading process. However, the categories she has defined remain purely hypothetical, since tests to measure the deficient areas were not described, and most importantly no studies have been carried out to determine if the subgroups do in fact exist. These classifications may be valuable guidelines for future research.

Summary of the Subjective Approaches to the Subgroup Concept

The traditional approach of a single syndrome paradigm in the study of reading disability has been criticized as too simplistic and ignores the complexities of reading as a multidimensional process (Applebee, 1971; Doehring, 1978; Wiener and Cromer, 1967). The application of this model in reading disability research had resulted in a vast array of symptoms and etiological factors associated with the disorder and little understanding of what the disability is, but rather what it is not.

An alternative to investigating reading disability as limited to a single antecedent condition with a single consequence is the multiple-syndrome paradigm. The subgroup concept was gradually introduced to the reading disability literature 15 to 20 years ago. The first discussions of different types of reading problems were simply based on clinical impressions from having worked with reading disabled children. Since then, several studies have reported different subgroups of reading disability. The subgroups have been based on theoretical constructs; academic achievement data, particularly reading and spelling patterns; neuropsychological test profiles; and data from other types of investigative procedures from which inferences about etiological factors have been drawn. A summary of the studies reviewed thus far can be found in Table 2.1. Although it is apparent that many of the classifications must be considered tentative and require further research (Benton, 1978), it is equally evident that the multiple syndrome paradigm is a realistic alternative to the unitary concept of reading disability. Much of the criticism of these studies has been focused on the attempts to reduce complex data sets into homogeneous subtypes based on a *priori* assumptions, and subjective classification methods including the visual inspection technique (Doehring & Hoshko, 1977; Satz & Morris, 1981). In the next section, studies will be reviewed which have attempted to deal with these criticisms.

Table 2.1
Subjective approaches to the subgroup concept.

I Clinical Impressions: No Data-Based Studies

Myklebust and Johnson

1965	1967	1978
1. visual	1. visual	1. inner-language dyslexia
2. auditory	2. auditory	2. auditory-dyslexia
3. auditory-visual		3. visual-verbal agnosia
		4. intermodal or cross-modal dyslexia
		a) auditory-intermodal dyslexia
		b) visual-intermodal dyslexia

Bannatyne
1966
1. genetic dyslexia
2. minimal neurological dysfunction

II. Clinical Impressions: Data-Based Studies

Kinsbourne and Warrington
1966
1. language retardation group
2. Gerstmann group

Bateman
1968
1. ITPA profile: good visual memory, poor auditory memory
2. ITPA profile: good auditory memory, poor visual memory
3. ITPA profile: poor auditory and visual memory

M. Smith
1970
1. Wechsler profile pattern I (sequencing)
2. Wechsler profile pattern II (simultaneous)
3. Wechsler profile pattern III (mixed)

Ingram and Associates
1970
1. audio-phonic
2. visuo-spatial
3. mixed

Table 2.1 continued

<u>Mattis and Associates</u>	
<u>1973</u>	1978
1. language disorder	1. language disorder
2. articulatory and dyscoordination disorder	2. articulatory and graphomotor dyscoordination disorder
3. visuo-perceptual disorder	3. visuo-perceptual disorder
	4. dysphonemic sequencing
<u>Denckla</u>	
<u>1972</u>	1979
1. language disturbance	1. language disorder
2. visuo-spatial disability	2. articulation and graphomotor dyscoordination disorder
3. dyscontrol	3. visuo-perceptual disorder
	4. dysphonemic sequencing
	5. verbal memorization disorder

III <u>Subgroups Based on Achievement Measures</u>

<u>Boder</u>
<u>1973</u>
1. dysphonetic dyslexia
2. dyseidetic dyslexia
3. dysphonetic-dyseidetic dyslexia

<u>Aaron and Associates</u>
<u>1978, 1982</u>
1. sequential deficient group
2. simultaneous deficient group
3. comprehension deficient group

IV <u>Theoretical Constructs</u>

<u>Vernon</u>
<u>1977</u>
1. Stage 1 deficiency
2. Stage 2 deficiency
3. Stage 3 deficiency
4. Stage 4 deficiency

CHAPTER 3

Objective Classification of Subgroups

A major criticism of the subgroup classifications which have been described thus far is that the method of subgroup formation was based on "direct observation of inter-related test scores" (Doehring and Hoshko, 1977) rather than objective classification. Multivariate statistical procedures have been suggested as an alternative method of classification.

Two early studies have been reported which employed cluster analytic techniques for subgroup classification of reading disabled children (Naidoo, 1972; Smith and Carrigan, 1959). However, these studies had several methodological problems, including small sample size (Smith and Carrigan, 1959), no normal control comparison groups, and unsophisticated use of cluster analysis (Satz and Morris, 1981).

The first major study in which multivariate statistical procedures were used to determine homogeneous subgroups of reading disability was reported by Doehring and Hoshko (1977).

The Subgroups Type O, Type A and Type S

Doehring (1976) devised a battery of 31 tests of rapid reading skills to measure reading subskills. Component reading skills were determined on the basis of a task analysis of the reading process. A set of tests was then constructed to estimate these component skills of reading. The theoretical rationale upon which the task analysis was based was in keeping with LaBerge and Samuels (1974), who postulated that the reading of letters, syllables and words must be overlearned to the point of rapid automatic responding, so that the reader could attend to higher level comprehension and reasoning. In this battery, individual letters, pronounceable nonsense syllables and one syllable words were presented by four different procedures. The first task was visual matching to sample in which the subject had to match an item presented visually with one item of a visual array of three printed choices. The second involved auditory-visual matching to sample in which the subject, upon hearing a spoken item had to identify that item from a visual array of three printed choices. Reading aloud a relatively long series of printed items, referred to as oral reading, was the third task. The fourth task was visual scanning to identify a target stimulus embedded in an array of similar visual stimuli. Normative data for this test battery were obtained on a sample of 150 normal prereaders and readers in Kindergarten through Grade 11. An increase in accuracy and a decrease in latency of response was observed with increasing grades. There was no suggestion of a hierarchical sequence of development of skills, but rather all the skills tested appeared to be developing at the same time although at different rates (Doehring, 1976).

In the first study utilizing the reading battery, (Doehring & Hoshko, 1977), a group of 34 children, aged 8 to 17 years, enrolled in a summer program for reading problems was assessed. The data were analysed by the Q-technique of factor analysis, which is an inverted variation of the standard R-technique of factor analysis and is based on product moment correlations between the test profiles of pairs of individual subjects

(Nunnally, 1967; Overall & Klett, 1972). The more similar the test profiles of two subjects, the higher the correlation. To determine which subjects had similar profiles, the profile of every child was correlated with that of every other child to form a matrix of intercorrelations. The factor analysis enhances the clustering of similar profiles and separates the similar from dissimilar profiles by a statistical rotation of the matrix. This defines the set of factors in which each factor can represent the ideal profile of scores for each subgroup. The factor loading indicates the extent to which each subject's test profile can be classified into each subgroup (Doehring et al., 1981).

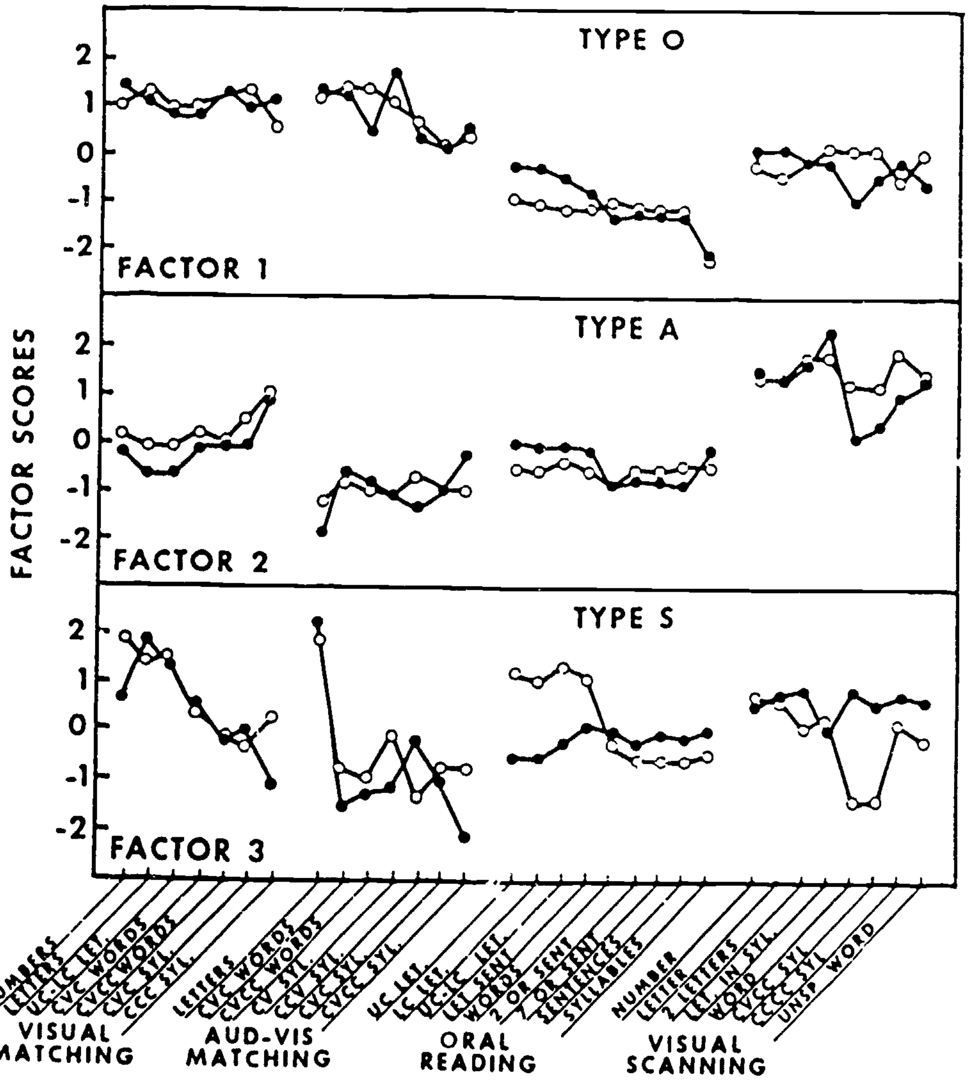
Three subgroups of reading disability were defined. Type O, (N=12) designated the oral reading deficit subgroup, was characterized by poor oral reading of words and syllables, while visual and auditory-visual matching-to-sample skills were close to normal. The predominant impairment of Type A (N=11), the group with intermodal association problems, was in auditory-visual matching of letters, syllables and words, while children of Type S (N=8), a sequential relation deficit subgroup, were notably poor in visual and auditory-visual matching of syllables and words but not letters. Three of the subjects did not have a high loading on any of the factors.

When this group of 34 children with reading problems was included in an analysis involving 31 children with mixed learning problems (21 learning disabled, 5 childhood aphasics, 5 mentally retarded), as well as another analysis involving 34 normal readers matched for age and sex, the three subtypes were consistently differentiated. A fourth profile Type V was found with the mixed learning problem group. Seven of the children were notably poor in visual matching. This group was designated the visual perceptual problem group. Further, when other statistical methods, such as cluster analysis were applied to analyse the data, the Q-technique results were substantiated (Doehring, Hoshko & Bryans, 1979).

A second sample of 88 reading disabled subjects, aged 8 to 27 (71 of the subjects were aged 8 to 14), referred to a neuropsychology laboratory was evaluated on the Component Reading Subskill tests and, following a Q-technique analysis, essentially the same three subgroups were found, thus replicating the findings of the first study (Doehring, et al., 1981). Good visual and auditory-visual matching and very poor oral reading, with visual scanning intermediate, characterized Type O. This profile was interpreted as representing difficulty in reading aloud orinted material ranging from letters to sentences. The poor visual scanning scores in comparison to visual matching suggested a more general problem with sequential visual-motor tasks. For the Type A profile, the scores ranged from high to low respectively for the following tasks: visual scanning, visual matching, oral reading and auditory-visual matching with the latter two being considered poor. It was noted that auditory-visual matching for letters was very poor. This profile was interpreted as representing difficulty in intermodal association between visual-verbal and/or auditory-verbal stimuli. The notable deficit for the Type S profile was that visual matching, but particularly auditory-visual matching for letters was good in contrast to the other subtests. This type seemed to reflect difficulty in responding to pronounceable sequences of letters as units. There were 33 subjects classified as Type O, 22 as Type A, 17 as Type S, and 16 were unclassified. However, 7 of the 16 unclassified were relatives of the reading disabled subjects who had been included in the study to look for familial trends. They were normal or near normal in reading. Therefore the factor analysis differentiated them from the total group. Figure 3.1 illustrates the differential reading skill profile of each subgroup and in addition, a comparison of the results of the 1977 and 1981 sample is given.

To assess the stability of the classifications, several other analyses were carried out on smaller samples, different age ranges, different subject selection criteria, effects of retesting and classification by cluster analysis. In all cases, the three types were identified. This stability of the subgroups was considered evidence for the validity of the subtypes. However, Doehring and his colleagues pointed out that it could not be concluded that there are only three subgroups of reading disabilities, and further that all subjects within each type did not exhibit exactly the same profile.

The neuropsychological characteristics of each subtype were determined (Fiedorowicz, Trites & Doehring, 1980) based on a variety of cognitive, sensory and motor measures sensitive to cerebral functioning from the Trites Neuropsychological Test



●——● Doehring & Hoshko (1977) N = 34

o——o Doehring, Trites, Patel & Fiedorowicz (1981) N = 88

Figure 3.1 Comparison of the factor score profiles of the 1981 study with the 1977 study. Factor scores were derived from three-factor solutions by the O technique of factor analysis.

Battery (Trites, 1977). There were a number of common characteristics among the three subgroups. Verbal IQ (WISC or WISC-R) scores were lower in comparison to Performance IQ; visual short-term memory was at least average or above average, but auditory short-term memory was below average. Concept formation skills were above average for nonverbal material. Copying skills for letter symbols were slow despite good motor skills.

In addition to these common characteristics, each subgroup exhibited differential profiles. Type O appeared to be the least impaired subgroup in terms of WISC subtest scores, tests of academic achievement and neuropsychological measures. Visual short-term memory was well developed in contrast to the poor auditory short-term memory. There was no evidence of any difficulty in verbal and nonverbal concept formation or psychomotor problem solving. Of interest, Type O was the only subgroup that did not do poorly on finger agnosia. There were a few mild asymmetries on the lateralized tests of motor and sensory functions, but in general, performance levels were above the clinic average and there was no evidence of cerebral dysfunction.

Type A was the most impaired group. WISC subtest scores were generally lower in comparison to the other subgroups. Vocabulary skills were particularly poor. There was evidence of poor auditory short-term memory and although visual short-term memory was above average, it was considerably lower in comparison to Type O and Type S. Psychomotor problem-solving skills were well developed. Nonverbal concept formation was below average. There were a number of asymmetries between dominant and nondominant body side performance among the lateralized tests of motor and sensory functions, especially on the dominant side. These were noted on tests of finger agnosia, stereognosis, fine manipulative skills, eye-hand coordination gross motor movement, and grip strength. The profile of Type A was interpreted as consistent with left hemisphere dysfunction.

The predominant deficit of Type S appeared to be spatial in nature. Performance on the Raven Progressive Matrices Test, tests of right-left orientation, and the spatial-location component of a psychomotor problem-solving task was poor in comparison to the other two subtypes. Visual short-term memory was well developed in contrast to a poor auditory short-term memory. Although concept formation skills for both verbal and nonverbal material were above average in comparison to the other subtypes, performance on the nonverbal concept formation task was relatively lower. Among the lateralized tests, there was evidence of particular difficulty with finger agnosia especially on the nondominant body side. There were a number of asymmetries on the motor measures but no consistent pattern emerged. The predominant spatial deficit, in conjunction with the agnosia deficit, particularly on the nondominant side was interpreted as compatible with cerebral dysfunction in the posterior region, possibly with greater right hemisphere involvement.

These neuropsychological profiles corresponding to the reading disability subtypes were determined on the basis of clinical interpretation of average score performance as well as the results of discriminant function analysis. Q factor analysis failed to yield interpretable results.

In addition, the subjects were assessed on twenty-two language measures to determine differential linguistic profiles for each subgroup. The set of language tests was selected from different sources. The wide variety of language abilities tested included phonemic segmentation-blending, serial naming, comprehension, short-term verbal memory, morphophonemic knowledge, complex syntactic usage, semantic fields, and complex syntactic-semantic relationships (Doehring et al., 1981). Normative data for these tests were obtained on a sample of 70 normally achieving children from Kindergarten through Grade 6. The analysis of the pattern of language deficit for the reading disabled sample as a whole suggested that the greatest difficulty was at relatively low levels of language skill, such as phonemic segmentation-blending, serial naming of months, following complex instructions, syntactic usage, and morphophonemic knowledge, while performance levels on tests involving higher levels of semantic knowledge were closest to normal. In general, the linguistic deficit was as severe as the reading deficit. There was a two- to five-year delay in comparison to the expected grade level performance for the group as a whole, however, some subjects performed at expected levels on some of the tests. When the profiles for each subgroup were examined, no clear cut differential patterns were found. The three subgroups had the same general pattern of impairment. When

Q factor analyses were carried out on the language tests alone as well as in combination with the reading tests, it was found that Type O was associated with a short-term verbal memory deficit in some subjects and a word retrieval deficit in others. Type A and Type S were associated with poor serial naming and following instructions.

Overview of Type O, Type A and Type S

Three specific subgroups of reading disability have been defined: Type O (oral reading); Type A (intermodal association); and Type S (sequential). These differential profiles were based on component reading skills determined by a task analysis of the reading process. The subgroups were originally based on a sample of 34 reading disabled subjects and the results were replicated with a second sample of 88 subjects. Neuropsychological characteristics specific to each subgroup were determined. Complex differential linguistic patterns were found in the three subgroups, along with deficits for the group as a whole. Thus, Doehring and associates have described reading, neuropsychologic, and linguistic characteristics of reading disabled children with specific reference to three subgroups of reading disability. These subgroups were determined by a completely objective multivariate statistical approach, the Q-technique of factor analysis. The strength of this approach is that once the subjects and tests have been selected, subjective biases cannot influence the outcome of the classification procedure. The results of the Q-technique remained quite stable when different samples and subsamples were analysed separately.

In addition, other statistical techniques such as cluster analysis also supported the stability of the classification. Normative data were obtained for all the tests in order to ensure that the subgroup profiles for reading, neuropsychologic, and linguistic characteristics of the disabled readers could be differentiated from the normal readers.

The Subgroups of Rourke and Associates

Subsequent to the first major statistical classification study by Doehring and Hoshko (1977), Petrauskas and Rourke (1979) reported reading disability subgroups determined by applying the Q-technique of factor analysis to neuropsychological test data.

In their study, 133 reading disabled subjects and 27 normal readers, all between the ages of 7 and 9, were selected from a neuropsychology clinic. The reading disabled sample met the usual criteria of the definition of reading disability. The 44 available neuropsychological measures were divided into six different skill areas and 20 tests were selected on the basis of low inter-test correlations, as well as the skill areas, which resulted in four tactile, two sequencing, two motor, four visual-spatial, five auditory-verbal and three abstract-conceptual tests. The total sample of subjects was then randomly divided into two subsamples of 80 subjects each. This was done to assess the reliability of the subgroups and is considered a unique feature of this study (Satz & Morris, 1981).

The data for each subsample were analysed by the Q-technique of factor analysis and five subtypes were revealed, three of which were considered reliable. Subtype 1 (N=40) was characterized by moderate to severe deficits in verbal fluency and sentence memory, and mild deficits in concept formation, word blending and short-term auditory memory. This group also had the largest VIQ/PIQ discrepancy and lower WRAT scores in reading and spelling as compared to arithmetic. This profile was interpreted as in keeping with left temporal lobe dysfunction. Subtype 2 (N=26) was characterized by moderate to severe impairment in finger recognition and short term visual-spatial memory, moderate impairment in sentence memory and mild impairment in verbal fluency and concept formation. In addition, no VIQ/PIQ or WRAT score discrepancies were noted. This profile was interpreted as involving the posterior left cerebral hemisphere. Subtype 3 (N=13) was characterized by moderate to severe impairment in concept formation, mild to moderate impairment in verbal fluency, sentence memory and short-term visual-spatial memory, and mild impairment in finger recognition. In addition VIQ was lower than PIQ. It was hypothesized that the left parietal cerebral region might be involved.

Although this study has several strengths, particularly the split-sample reliability method, Satz and Morris (1981) have discussed several weaknesses, including a small sample of normal readers; the inclusion of normal readers in Subtype 3; the method of reducing the number of neuropsychological test measures from 44 to 20, (factor analysis was suggested as an alternative); and failure to test WRAT and IQ data across subtypes to determine the significance of group differences.

A second study by the Rourke group (Fisk & Rourke, 1979) involved children as deficient in spelling and arithmetic as in reading. A large sample of 100 children aged 9 and 10, 100 aged 11 and 12, and 64 aged 13 and 14 were included. A total of 21 neuropsychological measures were selected according to the method described in the first study and the Q-technique was applied to these data. Two patterns of deficit were determined for all three age groups with one pattern common to the two older groups. The first type (N=52) was characterized by severe impairment in finger recognition (similar to Type 2 of the first study); the second (N=51) by poor speech perception (similar to Type 1 of the first study); and the third (N=39, age 11-14) by severe impairment on a task involving perception of numbers written on the fingertips. VIQ was lower than PIQ in all groups.

Doehring et al. (1981) have criticized this study on the basis of different selection criteria for subjects compared to the first study and particularly on the basis of important differences in the test batteries. The tests selected for this second study did not include sentence memory, verbal fluency and picture matching. These tests were important in differentiating the previous groups.

Satz and Morris (1981) have made the first detailed criticisms of the use of statistical techniques to classify reading disabilities. They outlined several problems associated with utilization of the Q-technique of factor analysis. The prime controversial issues in using this statistical method included the lack of objective rules for decisions relating to subjects with multiple factor loadings; the inability of correlational procedures to classify subjects on the basis of differences in absolute levels of scores, and problems related to the number of subjects per test ratio.

The Subgroups of Satz and Associates

Satz and his colleagues (Satz, Morris & Darby, 1979) used cluster analysis in their subgroup classifications of reading disability. Cluster analysis is a procedure which groups individuals into homogeneous clusters based on each subject's scores on the variables involved in the clustering (Satz and Morris, 1981). A unique feature of this study is that subjects were not preselected by subjective criteria. An unselected sample of 236 boys (mean age 11), who had been followed for 6 years, were given the WRAT at the end of Grade 5. Cluster analysis was applied to the WRAT reading, spelling and arithmetic data. Nine clusters emerged but in only two clusters (N=89) were the achievement scores low enough (mean discrepancy score between chronological age and age-equivalent score of 2 years) that these children could be considered learning disabled. Further cluster analysis of the performance of these 89 poor readers on two verbal measures (WISC, Similarities and Verbal Fluency) and two perceptual measures (visual-motor integration and recognition discrimination) resulted in five subgroups. In addition to the following individual characteristics of each subgroup, all subjects were equally poor in reading achievement. Subtype 1 (N=27) had poor performance on both verbal measures and was defined as a global language impairment group. Subtype 2 (N=14) had poor performance on WISC Verbal Fluency only and was defined as a specific language (naming) group. Subtype 3 (N=10) performed poorly on all of the measures and was defined as a mixed global language and perceptual impaired group. Subtype 4 (N=23) had poor performance on both perceptual tests and was defined as a visual-perceptual-motor impaired group. Subtype 5 (N=12) showed no impairment and was defined as the unexpected learning disabled group.

Other differences between the groups included a higher incidence of soft neurological signs for Subtypes 1, 3 and 4. In addition, a trend of lower SES and poorer WRAT scores for the parents of the children in these subtypes was noted.

There are several strengths in this study. The use of a multivariate statistical procedure to select the reading disabled sample represents a unique contribution. In addition, cluster analysis was also used to establish the reading subgroups. Such methodology removes subjective bias in the selection of subjects, as well as the classification of reading disabilities. However, it is interesting to note that the final sample of disabled children selected met one criteria that many investigators use in their subjective selection procedures, i.e., discrepancy scores on an achievement measure. No information is given as to whether this sample met the other criteria usually applied subjectively such as intelligence, presence of emotional problems, visual and auditory impairment, etc. Such information could have been helpful in critically evaluating all the criteria that are applied in the subjective selection of reading disabled children.

Although the nondisabled readers were included in the selection phase of the study, no data were reported to indicate how the other seven clusters performed on the neuropsychological variables. Therefore it is unclear whether Satz and his colleagues can be criticized on the very point on which they have criticized so many other investigators, i.e., a comparison on the test data with a nondisabled sample to determine if the profiles generated are unique to the disabled reader sample.

The authors point out several other criticisms of their own work as well as the limitations of cluster analysis as a multivariate classification method (Satz & Morris, 1981). Included in the list of caveats are: limitations of the WRAT which measures only one aspect of the reading process; the small number of neuropsychological variables used in the clustering; the restrictions of the sample in terms of age, race and sex, and the use of the Peabody Picture Vocabulary Test (Dunn, 1965) as a measure of intelligence.

The Subgroups of Lyon and Associates

Lyon and his colleagues (Lyon, Stewart & Freedman, 1982; Lyon & Watson, 1981) also used cluster analysis to identify subgroups of learning disabled readers.

In the first study (Lyon & Watson, 1981), 100 learning disabled readers and 50 normal readers matched for age (11-12 years) and IQ were assessed on a battery of language and perceptual tests. Six subgroups of learning disabled readers were identified following cluster analysis. Subgroup 1 had deficits in language comprehension, auditory memory, sound-blending, visual-motor integration, visual-spatial and visual memory skills. Subgroup 2 had mixed deficits including language comprehension, auditory memory and visual-motor integration. Subgroup 3 represented a language disordered group with deficits in language comprehension and sound-blending. Subgroup 4 had deficiencies in visuo-perceptive skills but no language-based deficits. Subgroup 5 resembled a profile similar to aphasic children with deficits in retention, synthesis and expression of sound and word sequences. Subgroup 6 had a normal diagnostic profile.

In a second study, 64 learning disabled readers and 42 normal readers were assessed on a battery of ten tests including neuropsychological and achievement measures. All subjects were between 6.5 and 9.9 years of age, had normal visual and auditory acuity, were predominantly middle class, and had normal intelligence. The learning disabled readers had significant deficits in oral reading of single words and reading comprehension. Five subgroups were identified by means of cluster analysis. Subgroup 1 had deficits in visual perception, visual-motor integration and visual spatial skills but linguistic skills were strong. Subgroup 2 had deficits in morphosyntactic skills, sound blending, receptive language comprehension, auditory memory, auditory discrimination and naming ability but visual perceptual skills were strong.

Subgroup 3 had a normal diagnostic profile and were thus an unexpected disabled reader group. Subgroup 4 had deficits in sound blending, receptive language comprehension, auditory memory, naming ability, and some visual-perceptual skills particularly sequencing. Subgroup 5 had mixed deficits in morphosyntactic skills, sound blending, visual-perception, visual-motor integration, visual-spatial analysis and visual-memory.

These investigators discussed the similarities of their subgroups to those of other researchers. They also made inferences about the integrity of brain functions specific to each subgroup based on the patterns of neuropsychological and reading deficits.

Summary of the Objective Classification of Subgroups

Multivariate statistical procedures were introduced as a method of determining reading disability subgroups in order to provide an objective method of classification. As pointed out in an earlier section, a major criticism of the studies on subgrouping was focused on the subjectivity of clinical impressions of complex data sets and the limitation of the visual inspection technique. Two multivariate techniques have been used in subgrouping studies: the Q-Technique of Factor Analysis and Cluster Analysis. Doehring and his colleagues were the first to carry out a major study using a multivariate statistical procedure as the method of classification. The technique that they applied was the Q-technique. Rourke and his group also applied this method. Satz and his associates and Lyon and his associates applied cluster analysis to their data. A summary of the subgroup classification determined by these researchers can be found in Table 3.1.

The limitations and problems associated with utilization of these multivariate procedures has been addressed by Doehring and his colleagues (Doehring et al., 1981) and more comprehensively by Satz and Morris (1981) and Morris, Blashfield and Satz (1981). Despite these difficulties it appears evident that multivariate procedures are a viable procedure to be used with the multiple-syndrome paradigm.

In evaluating the major contributions to the subgroup literature in which the multivariate statistical classification procedure has been used, there are several points of interest. The classifications of the Rourke group were limited to neuropsychological variables and the Satz group incorporated both achievement and neuropsychological variables. However, the number and types of tests used by the latter group have been criticized. Although the classifications of the Doehring group were based on a wide variety of reading tests, extensive neuropsychological and language assessments were also included in the evaluation of the second sample of reading disabled children. The aim of such a comprehensive approach was to investigate the interaction of reading, neuropsychologic, and language deficits.

With regard to replication of results, the Satz subgroups still need to be put to the test. The split-half sample of the first study by the Rourke group is one reliability check and in

Table 3.1
Objective approaches to the subgroup concept.

I Q-Technique of Factor Analysis

Doehring and Associates
1977, 1979, 1981
1. Type O Oral Reading
2. Type A Intermodal Associative
3. Type S Sequential

Rourke and Associates
1979
1. Verbal fluency, and sentence memory deficits
2. Finger agnosia, visual-spatial memory deficits
3. Concept formation deficit

II Cluster Analysis

Satz and Associates
1981
1. Global language impairment
2. Specific language (naming) impairment
3. Mixed global language and perceptual impairment
4. Visual-perceptual-motor impairment
5. Unexpected learning disabled

Lyon and Associates
1981
1. Linguistic and visual perceptual deficits
2. Mixed deficits
3. Linguistic deficits
4. Visual perceptual deficits
5. Severe auditory comprehension and sequencing deficits
6. Normal diagnostic profile

1982
1. Visual perceptual deficits
2. Linguistic deficits
3. Normal diagnostic profile
4. Memory analysis, synthesis and sequencing deficits
5. Mixed deficits

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addition, although the same measures were not used in a second study which would allow greater comparability, there was an apparent overlap of two groups in both studies. Doehring and his colleagues have replicated their findings on two different samples of reading disabled children, included comparison groups of normal readers, children with other types of learning problems, used external criteria of teacher evaluations, and used discriminant function analysis and cluster analysis to verify the findings. The stability of the three subgroups was upheld across these various comparisons.

Overview of the Subgroup Literature

The major studies concerned with the investigation of reading disability subgroups have been reviewed. Although it is apparent that a great deal more research must be carried out before a definitive classification system is developed, it is evident that progress has been made over the last 15 to 20 years. Although there are still many investigators who continue to be "optimistic about the possibility of finding a single cause for a unitary form of reading disability" (Doehring et al., 1981), there is a growing consensus that the multiple syndrome paradigm is a realistic alternative to the unitary concept of reading disability.

An obvious difficulty with the many subgroups that have been proposed is their apparent diversity. One motivation in looking for an alternative way of investigating reading disabled children was the great range and variation in reading and nonreading deficits. It was anticipated that a multiple syndrome paradigm would be helpful in ordering the presenting symptoms and providing clarification to a confusing disorder. However, it would appear that the researchers have been successful in generating a variety of subgroups each with their respective list of reading and/or nonreading strengths and deficits. The question that arises is: "Are we any further ahead?"

In attempting to condense the various subgroups, there appears to be a certain amount of agreement among the subtypes. Two major categories involve visuo-spatial skills and language functions. Other categories involve a combination of these two aspects, or a further differentiation of these skills. The exact description of these major areas of deficits seems to be largely a function of the particular tests involved in the assessment, and the type of analysis applied. A more consistent pattern of subgroups across studies could possibly be obtained by an investigation of one researcher's population with another's methodology, or the development of a battery of tests that included all major skills applied by the various investigators. Some researchers are attempting the former approach, e.g., Doehring and his group have used Boder's classification system with their sample (Doehring et al., 1981) and Aaron (1982) has also used Boder's system.

Several authors have attempted to compare their own subgroups with others reported in the literature with the implication that if there are similarities, their own groups are more valid. Satz and Morris (1981) have criticized this approach as "subject to serious error of interpretations and logic".

Examples are cited in the work of Boder, Doehring and Mattis of how superficial comparisons may be erroneous. However, comparisons on the basis of similar evaluations may be of value. Another major concern related to the value of subgrouping is remediation programs. Remediation of reading disabilities is overwhelmingly unsuccessful. It was anticipated that by carefully defining strengths and weaknesses according to subgroups, programs could be developed to meet the specifications of each subgroup.

CHAPTER 4

Remediation of Reading Disability

In addition to the potential of providing clarification about the characteristics of reading disabilities, the application of the subgroup classification approach may also be of value in the development of effective treatment programs.

Success of Treatment Programs

In a critical review of follow-up studies of primary reading/learning disabled children, Schonhaut and Satz (1981) reported that most of the 17 studies had not focused specifically on the effects of treatment, although it was presumed that many of the children had been exposed to treatment programs of varying length, intensity and method. One of the conclusions of this survey was that academic outcome for children with primary reading/learning problems was poor. There were some indications that children from high SES families and/or those involved in intensive treatment programs had a better academic outcome. However, there were several methodological problems with the studies showing better outcome, and as a result it was suggested that the conclusions should be interpreted with caution.

Vernon's (1971) review of research related to treatment effects, indicated that severe reading disability is "highly resistant to instruction". Some children acquire basic reading skills, but do not read fluently. Several other investigators have also concluded that treatment of reading disability is not effective (Balow, 1965; Bateman, 1977; Benton, 1978; Botel, 1968; Buerger, 1968; Guthrie, 1978; Johnson, 1978; Zigmond, 1978). This finding led some authors to speculate that the disorder itself is intractible (Balow, 1965; Buerger, 1968), while the majority contended that the methods of evaluating the effectiveness of treatment per se were inadequate.

Process-Oriented Versus Task-Analytic Approaches

Arter and Jenkins (1979) have critically evaluated a common treatment model used in special education, the Differential Diagnosis - Prescriptive Teaching (DD-PT)model. DD-PT involves the assessment of various psycholinguistic and perceptual motor abilities which are presumed to be necessary for the acquisition of basic academic skills, then, based on the pattern of strengths and weaknesses, treatment programs are prescribed. The assumption of this process-oriented approach is that the disability is the result of deficiencies in one or more of the basic psychological processes required for learning (Estes, 1974; Werner, 1937). The general psychological processes include various auditory, visual, cross-sensory perceptual, and psycholinguistic abilities (Arter and Jenkins, 1979). Instruction is then matched to the individual learning needs (Kirk, 1972). This approach has been described as the "majority position within the field of learning disabilities over the past 20 to 30 years" (Haring and Bateman, 1977). Arter and Jenkins (1979) criticized this approach as failing to validate several assumptions inherent in the DD-PT model. Their overall conclusions included: poor reliability and validity of the DD-PT tests used in measuring psychological processes; poor success rate in training the underlying psychological process; poor success rate in improvement in academic skills following training in the underlying psychological process; and that modality instructional matching failed to improve achievement. Although their review cast doubt on the validity of the DD-PT model, they suggested that their results do not mean that this approach is theoretically untenable, but that the current instructional programs and tests are not successful.

Torgeson (1979) also criticized the effectiveness of treatments based on process-oriented theories. He raised questions similar to Arter and Jenkins regarding whether or not psychological processes necessary for learning could in fact be identified and measured. He concluded that although specifically defined subprocesses can be trained so that performance on a given task is improved, generalization to other academic skills is poor. He contrasted the process-oriented approach with the task-analytic approach. There are no inferences about processing problems with the task-analytic model, but rather the assumption is that poor performance on tests of a prerequisite skill, is secondary to a lack of practising the skill (Smead, 1977). A major advantage of this approach is that information directly relevant to instruction in academic skill is provided. On the other hand, task analysis does not consider individual differences in cognitive functioning, while process-oriented theories recognize sources of variance other than practice. Torgeson, therefore, suggested an integration of both approaches beginning with an analysis of the academic task into component skills and then a development of tests to assess the processes required to learn the skills. This view is supported by others (Doehring et al., 1981; Wong, 1979).

In the development of treatment programs that are effective in the remediation of reading disabilities, it is essential that future studies address the problems of process-oriented and task-analytic theories. An approach integrating these two positions may offer an important contribution.

There are opposing views regarding whether the rationale for treatment should be based on training to the strengths or to the weaknesses (Torgeson, 1979). The underlying assumption of the task-analytic approach is that specific reading deficits are the result of inadequate practice and the focus of training is extra instruction in the deficient skills, i.e. training to the weaknesses. There are two underlying conflicting assumptions of the process-oriented approach. On the one hand it is assumed that training of deficient nonreading skills will eliminate reading problems, while on the other hand, the method of reading instruction should be matched with the strongest process of the poor reader (Arter and Jenkins, 1979). Therefore, training to both the strengths and to the weaknesses is advocated. Future training studies using an integrated process-oriented/task-analytic rationale for treatment will have to consider training to strengths or weaknesses in a systematic way as part of the evaluation of the effectiveness of any one training program.

The Arter and Jenkins finding that there is a poor success rate in improving reading skills following training in the underlying psychological processes raises another important point which must be dealt with in future treatment research. The poor transfer of training may be a result of poor transference *per se*, or it may be secondary to the fact that there is a poor success rate in training the underlying psychological process in the first place. Guthrie (1973) has suggested that reading disability is characterized by a lack of generalization of new skills that are learned. Doehring et al. (1981) have suggested that the lack of generalization may be restricted to specific subgroups. Further they recommended that integrated assessment-training research methods based on interactive theories of reading acquisition would be more suitable for assessing assessing transfer of training.

Treatment According to Subgroup

The subgroup concept is another issue on which future treatment should focus. It is feasible that different treatment programs, developed in accordance with the different reading disability subgroups may be more effective than currently available techniques. (Aaron, Grantham and Campbell, 1982; Benton, 1978; Doehring et al., 1981; Guthrie, 1978; Malatesha and Dougan, 1982; Rourke, 1985; Satz and Morris, 1981). Few studies have been reported which evaluate the effectiveness of treatment procedures based on specific subgroups of reading disability.

Training of Boder's Subgroups

Aaron, Grantham and Campbell (1982) reported on the effectiveness of differential treatment programs administered to children classified according to Boder's subgroups. Seven boys and one girl were included in the first experiment, four classified as dysphonetic and four as dyseidetic. Two of each set of four subjects were trained through a phonetic-sequential method, and two through a gestalt-whole-word method. The children were taught by a videotape instruction program in the presence of a tutor for 25-minute sessions once a day for a 4-week period. The Gates-MacGinitie Reading Test was administered pre- and posttraining.

The second experiment was carried on for most of the academic year. The training sessions were 30 minutes per day, 3 times a week. Of the nine Grade 3 subjects, four were dyseidetic, three of whom received the phonetic-sequential method; and five were dysphonetic, three of whom received the gestalt-whole-word method. The remaining subjects in each subtype received the alternative training program. A control group matched for age, sex, and reading achievement scores attended the conventional remedial classes for 45 minutes, 3 days per week.

Both experiments yielded the same results. Vocabulary and comprehension improvement scores were greatest for the dyseidetic Ss trained by the phonetic-sequential method, and the dysphonetic Ss trained by the whole-word method. This was interpreted as evidence for training to the strengths rather than by an attempt to strengthen the weaker processes. There are major problems with these experiments including the small sample size and the fact that gains were interpreted by visual inspection alone (no statistical analyses were done). In addition, a control group was not used in the first experiment. In spite of these problems, the subjective observation of improved reading for the two subtypes, depending on the type of treatment, warrants further investigation in more carefully designed studies.

Summary of the Treatment of Reading Disability

In general, the treatment of reading disability is largely ineffective. Some researchers have interpreted this poor outcome as indicative of an intractable disorder, although many others consider the treatments to be inadequate, or the methods of evaluating the effectiveness of treatment to be lacking. The predominant model of treatment over the last 20 to 30 years has been the DD-PT model which involves the prescription of a treatment program based on the pattern of strength and deficits in psychological processes. This process-oriented model has been strongly criticized (Arter and Jenkins, 1974; Doehring et al., 1981; Torgeson, 1979; Wong, 1979). An alternative task-oriented model has also been found to be inadequate, however, an integration of both models has been suggested as an alternative to be investigated in future research (Doehring et al., 1981; Torgeson, 1979; Wong, 1979).

One possible factor contributing to the poor outcome of treatment, then, could be an inadequate model of instruction. Another possibility is the overuse of a single-syndrome paradigm. The development of different treatment programs corresponding to different subgroups may be more effective. One series of investigations has been reported which focused on this latter point. Aaron et al. (1982), provided some evidence that training procedures developed according to Boder's subgroup classifications may be an effective treatment approach for reading disability. However, the results must be interpreted with caution since there were methodological problems with these investigations and replication is necessary. It would appear that a great deal more research is necessary before definitive statements can be made regarding the effectiveness of treatment of reading disability.

The present study investigated the effectiveness of computer-assisted training procedures which were developed utilizing a model that integrated features of both the process-oriented and task-analytic models and which were developed according to the reading disability subtypes defined by Doehring and his colleagues. This study, therefore, attempted to address two issues which are currently considered major factors in the treatment of reading disability. These points will be elaborated on in a later section. A third major theoretical position which was integrated in the training procedures involves automaticity theory. This subject will be reviewed in the following chapter.

CHAPTER 5

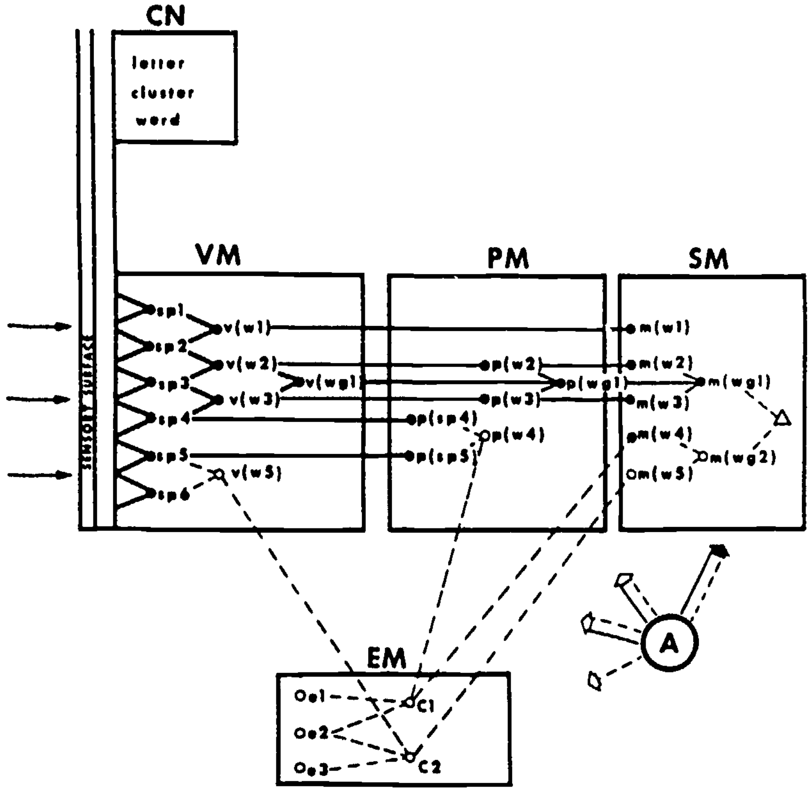
Theoretical Rationale for Rapid Automatic Responding in Reading

The Laberge and Samuels Model

The theoretical rationale on which this research is based closely agrees with the LaBerge and Samuels theory of automatic information processing in reading (LaBerge & Samuels, 1974). LaBerge and Samuels proposed a model of reading in which it was hypothesized that component skills for reading letters, syllables, and words must be overlearned to a level of rapid automatic responding so that the reader can concentrate on higher level comprehension and reasoning. They suggested that in order to execute such a complex skill as reading, it is essential that there be a coordination of several stages of information processing within a fraction of a second. If each stage or component process required attention, the capacity of attention would be overloaded. Therefore, it seemed logical to assume that some automatic processing must occur so that the load on attention is within tolerable limits to allow successful performance of the reading skill.

According to this model, there are four major stages of processing involved in the transformation of written symbols into meaning: visual memory, phonological memory, episodic memory, and semantic memory. In addition to associative links among these four major stages, each consists of many substages and alternative routes within its own system. Figure 5.1 is a schematic representation of the overall model.

Within the visual memory system, visual-perceptual coding



E	TEMPORAL-SPATIAL EVENT CODE
C	EPISODIC CODE
SP	SPELLING PATTERN CODE
V(W)	VISUAL WORD CODE
V(WG)	VISUAL-WORD-GROUP CODE
P(SP)	PHONOLOGICAL SPELLING-PATTERN CODE
P(W)	PHONOLOGICAL WORD CODE
P(WG)	PHONOLOGICAL WORD-GROUP CODE
M(W)	WORD-MEANING CODE
M(WG)	WORD-GROUP-MEANING CODE
	CODE ACTIVATED WITHOUT ATTENTION
	CODE ACTIVATED ONLY WITH ATTENTION
	CODE MOMENTARILY ACTIVATED BY ATTENTION
	MOMENTARY FOCUS OF ATTENTION
	INFORMATION FLOW WITHOUT ATTENTION
	INFORMATION FLOW ONLY WITH ATTENTION
CN	CONTEXT NODE
VM	VISUAL MEMORY
PM	PHONOLOGICAL MEMORY
SM	SEMANTIC MEMORY
EM	EPISODIC MEMORY
A	ATTENTION

Figure 5.1 Representation of the LaBerge and Samuels model of automatic information processing in reading. The LaBerge context node is also represented.

takes place for letters, spelling patterns, words, and word groups. In the initial stage of analysis, feature detectors analyse the physical stimuli of printed information including such features as hues, angles, intersections, curvature, and openness as well as relational features such as left, right, up, and down. Analysis of graphemes by the feature detectors activates letter codes, which in turn activate spelling pattern codes, which then activate word codes, which finally then may activate word-group codes in a hierarchical fashion. Alternatively, some features activate spelling patterns and words directly.

Early in the learning of the graphemic code, the role of attention is assumed to be critical. However, it is expendable in later stages of learning. If a visual code stored in long term memory is well learned, there is a two-way activation system set up with attention such that attention can activate these codes and be activated by them. Visual codes which are not well learned cannot activate attention, but attention can activate the code in a unidirectional activation system of information flow.

Attention activation is important in the development of a new code, e.g. the successive activation of two features in the development of one letter code. Attention activation is also important in the rate of processing. Activation of a letter code prior to the presentation of the letter reduces the length of time for letter recognition. Finally, attention activation is important in arousing other codes to which an activated code has been previously associated, e.g. the association of the visual letter "a" with its phonological representation.

Within the phonological memory system, features, phonemes, syllables and words are structured in a hierarchy. Input to this system comes from auditory stimulation, articulatory response feedback, semantic memory, episodic memory and, of prime concern to reading, visual memory. Associations between visual codes and their phonological counterparts are generated when attention is activated. However, attention is not necessary once the associations are automatic. The episodic memory system codes temporal and physical events, which are organized into a superordinate code representing associations in the earliest stages of learning. Attention is activated in the association of visual with phonological codes by means of the superordinate coding in episodic memory. Once the association between visual and phonological codes is learned, the association is direct and it is no longer necessary that episodic memory be activated. The semantic memory system contains the meaning of words. Activation of the meaning of a word can be elicited by a direct associative connection between the phonological system and the semantic system once the visual code has been associated with the phonological code system. Many connections between phonological word codes and semantic meaning codes have been well learned to a level of automaticity through spoken communication experience. In such a situation, attention does not have to be directed to memory since it is well established. When the meaning of words is first learned, however, the association between the phonological and semantic code may be initially accomplished indirectly through a linkage via episodic memory. The association between the phonological and semantic system may go in the opposite direction such that activation of the meaning unit could elicit a phonological unit. In addition, it is possible that the visual word code may be associated directly with a semantic meaning code.

LaBerge (1979) modified this original model with the addition of a mechanism by which a particular unit level, i.e., letter, syllable or word unit, could be selected. The mechanism consisted of context nodes. This modification was based on experiments in which it was determined that the context in which familiar and unfamiliar bigrams were presented affected the way a given stimulus pattern was processed (Peterson & LaBerge, 1975). When familiar bigrams or clusters such as "sl, ph, sh, and br" and unfamiliar letter bigrams such as "ls, hp, hs and rb" were embedded in lists of letters, there were no significant differences in time to match them indicating that both familiar and unfamiliar bigrams were likely processed in a letter-by-letter mode of matching. However, when these same bigrams were embedded in lists of clusters or familiar bigrams, there were significant differences in response latencies with the unfamiliar bigrams requiring more time to process. This was interpreted as indicating that the familiar bigrams were processed as clusters, but the unfamiliar bigrams were processed by a letter-by-letter method. The influence of these differing contextual conditions on perceptual processing was represented by the context nodes. It was hypothesized (LaBerge, 1979) that a context node could activate the entire set of pattern codes at one level of processing for letters, syllables or clusters and words. This means that when the letter context node is activated, it activates all letter codes so that incoming stimuli are processed individually letter by letter and not in higher units of letter clusters.

In a study designed to investigate the role of attention with regard to the context nodes (LaBerge, Peterson & Norden, 1977) it was found that attention could not be easily focused on a specific context. This indicated that for the visual system at least, selection of a unit of processing by direct attention to that level was not easily done.

Part of Figure 5.1 was presented by LaBerge and Samuels (1974) to illustrate the many alternative routes in which a visually presented word may be processed into meaning. They included the following descriptions of some of these possible routes as a further exemplification: 1) It can be seen that the graphemic stimulus may be automatically coded into a visual word code V(W1) which automatically activates the meaning code M(W1); 2) The graphemic stimulus may be automatically coded into a visual word code V(W2) which automatically activates the phonological word code P(W2), which then automatically activates the meaning code M(W2); 3) The graphemic stimulus is automatically coded into a visual word group V(Wg1) which automatically activates the phonological word-group code P(Wg1), which in turn automatically activates the meaning code of the word group M(Wg2); 4) The graphemic stimulus is automatically coded into two spelling patterns Sp4 and Sp5 which activate the phonological codes P(Sp4) and P(Sp5). Attention is activated and the two codes are blended into the phonological word code P(W4), which activates the episodic code C1. This code is then activated by attention to excite the meaning code M(W4); 5) The graphemic stimulus is coded with attention into the visual word code V(W5). Attention activates this code to excite episodic code C2. When attention is shifted to C2, it generates the meaning code M(W5). (LaBerge & Samuels, 1974: 312, 313). The LaBerge modification of the context mode was added to the model in 1979 to indicate that context of the incoming visual stimuli could influence the level of processing.

In summary, with fluent reading, attention can be focused on the meaning units of semantic memory and all decoding is done automatically. If attention must be focused at all stages of decoding in the visual, phonological, and episodic systems before the semantic system stage is reached, the capacity of attention would be exceeded. Therefore, processing of component reading subskills must become automatic.

Automaticity and Working Memory

Perfetti and Lesgold (1979) also emphasized the importance of automaticity in the development of reading skills, primarily for decoding. The importance of the function of automaticity is incorporated in what they referred to as the "bottleneck hypothesis". They suggested that reading comprehension was limited by momentary data handling requirements and that working memory was a potential bottleneck in reading comprehension. One component of the reading process that could contribute to this working memory bottleneck involved speed and automation of decoding. Perfetti and Lesgold reasoned that if print mapped automatically to the phonological representation of the word, working memory would not have to focus on decoding and there would be greater efficiency in processing. They considered the relationship between coding and reading comprehension as one of shared processing resources, and that deficiencies in comprehension could be a function of the extent to which decoding used an excessive share of the resources.

This theoretical rationale for automaticity presented by Perfetti and Lesgold is quite similar to that of LaBerge and Samuels. Although the former authors refer to working memory and the latter to an attention centre, the processing mechanism of each is similar. Both working memory and attention centre have limited resources and the less demand on these resources for such processes as decoding, the greater the resources for other subskills of reading such as comprehension.

A second component of the reading process that could contribute to the working memory bottleneck involved rapid access to long-term memory. Perfetti and Lesgold described access to long-term memory as tied to the structure and content of the reader's knowledge. They considered that improving rapid access to word meanings and prior conceptual structures would make less demands on working memory since knowing the meaning of a word would prevent a cognitive load that would occur if measuring had to be derived from context. Rapid access would make comprehension less a problem-solving task and more a recognition task.

Although Laberge and Samuels did not incorporate long-term memory into their model, they did describe a route from visual representation directly to semantic understanding which through rapid automatic processing decreased the demands of attention. However, Perfetti and Lesgold did not focus on competing demands for this part of their theory, but rather focused on speed of access (Lesgold & Resnick, 1981).

The third component in reading that would relieve the working memory bottleneck is processing strategies, particularly those that utilize the structure of language. Knowledge of syntactic or semantic constraints, such as use of sentence and clause boundaries, could aid in chunking printed text, which in turn would reduce the demands on working memory by processing greater amounts at a time.

LaBerge and Samuels also incorporated a chunking process in their theory. They hypothesized that reading the same passage repeatedly would reorganize visual perceptions into higher-order units even before lower-order units achieved a high level of automaticity. In other words by reading the same words in a text over and over, some of the words are organized into larger chunks of groups of words and phrases. These larger units are then read at a higher level of automaticity with experience in reading. In addition, it was hypothesized that a considerable amount of attention is necessary for this higher-order chunking process, but once it becomes automatic, the demands for attention would be greatly reduced and could be focused on comprehension.

Thus, there are several similarities between the Perfetti and Lesgold theoretical position and the LaBerge and Samuels model. As discussed, the primary differences appear to be related to the working memory versus the attention centre constructs, and the focus on rapid access as opposed to a competing demands mechanism.

Fisher's Modification of the LaBerge and Samuels Model

Fisher (1979) made some attempt to apply the LaBerge and Samuels model to brain functioning. He hypothesized that the grapheme-phoneme transformation point was in Broca's or Wernicke's area. This represents a very simplistic association of brain functioning with an information processing model, but at least it is an attempt to recognize the neurological basis of cognitive processes. Fisher also made an attempt to expand the visual perceptual process beyond feature detectors in the sensory surface to include the function of foveal and peripheral processing. Evidence is cited supporting the notion of greater dependence on peripheral processing with age, indicating that older children can process larger units of information. With foveal vision, a letter by letter or word by word strategy is all that can be processed. With peripheral processing, there is an expansion of the perceptual scan and other contextual cues can be utilized and are sent to a "cognitive search guidance" for integration and meaning extraction. Fisher proposes that this preprocessing of the periphery becomes more proficient through exposure as less attention must be directed to decoding. The phonological and visual memory system become more efficient, which reduces the foveal processing load that must go on and improves peripheral retinal processing. Thus, Fisher is in agreement with the basic model of LaBerge and Samuels, but included a mechanism by which context and typography affect peripheral retinal processing and rapid information search skills.

The Sternberg and Wagner Model

Sternberg and Wagner (1982) also proposed that failure to acquire fluent reading may be the result of slow or limited automatization of subskills. They suggested that conscious attention must be directed to tasks and task components that are not automatized, resulting in processing resources not being free to master new tasks. The hypothesis which they developed extends beyond reading disabilities to incorporate learning disabilities in general. In addition, their "mini-theory" of automatization failure in the learning disabled is derived from their subtheory of intelligence and is based on an information processing model.

Sternberg and Wagner described three information processing components: metacomponents, performance components and learning components. Metacomponents refer to higher order executive processes that control cognitive functioning by a two-way flow of information from other components regarding cognitive performance. Performance components are lower order processes that execute metacomponent commands and provide feedback. Learning components are involved in the acquisition, retention and transfer of information about task performance by direct two-way communication with metacomponents. Performance and learning components communicate with each other indirectly via the metacomponents. The metacomponents are therefore involved in decisions on what and how to, the performance components carry out the decisions and the learning components form the basis for acquisition of new information.

A great deal of attention is required in the controlled execution of components involved during the performance of a new task. This controlled processing is hypothesized as being serial and centrally processed. In normal development, automatic processing replaces controlled processing and there is a transfer of function from a central processor to a local peripheral processing subsystem. Attentional needs are greatly reduced to carry out functions at the local level. In addition, local processing is parallel in contrast to central serial processing. This allows for simultaneous functioning of a number of local subsystems.

Sternberg and Wagner emphasized that failure of automatization did not represent a single antecedent cause of reading disability. Rather, they specified that multiple antecedents could lead to failure of automatization, which in turn could result in multiple consequences. In addition, deficienies in the activation, execution, feedback or monitoring of one or more of the components could produce the reading disability. The emphasis here is on the interactive nature of the processing components, and is referred to as the componential deficit scheme. This view concurs with the subgroup concept of reading disabilities.

The difficulty with this description of information processing as it applies to reading is that the specific processes within each component that would be necessary in word recognition reading skills have been omitted. This model is quite general in contrast to the more detailed model of LaBerge and Samuels, which is more specifically applicable to the reading process. Both models are limited in that they are restricted to the realm of cognition and are therefore functional. Neither attempts to deal with the biological basis of reading. In this aspect information processing models are not yet adequately developed.

However of prime concern to this research, both models emphasize the role of automaticity in skill acquisition to reduce the amount of conscious attention necessary in completing one task and therefore freeing attention to focus on other tasks or task components.

Investigations of the Automaticity Theory

Regardless of the model in which the concept of automaticity is incorporated, when this concept is applied to the practical training of reading subskills there is a basic assumption that automaticity is a learned process. Extensive practice is assumed to improve the subskill to an automatic level of response. In order to test this assumption, LaBerge and

Samuels carried out a number of studies.

One study was concerned with the visual recognition of familiar and unfamiliar letters in college-age readers (LaBerge, 1973). A comparison of latencies of successive letter matches indicated that the times required to make an unfamiliar letter match was equal to the time required to make a familiar letter match under conditions when the subject was attending to the respective familiar and unfamiliar letters. However, under conditions when the subject was attending elsewhere (nontarget letter patterns) at the time of presentation, there was a greater latency for unfamiliar letters. Over five days of practice this difference was no longer evident. It was concluded that what was learned with the practice sessions was a "perceptual process that operates without attention, namely an automatic perceptual process" (LaBerge & Samuels, 1974).

Using a paradigm similar to the visual perceptual task, a test of automatic associative processing was carried out (LaBerge & Samuels, 1973). In this study the task required naming out loud a visually presented familiar or unfamiliar letter, under conditions in which the subjects (again college-age average readers) had to match common words presented successively. It was assumed that the overall latency included association time, perceptual coding time, and residual response time. Since the interest was on association time only, control conditions were set up for the perceptual coding and residual response times. Initially there was a large latency discrepancy for familiar and unfamiliar letters. However, following 18 days of training there was a significant convergence of scores. It was concluded that there was a gradual learning of automatic naming associations. It was noted that even with college subjects, the rate of learning naming of unfamiliar letters was slow. An implication drawn from this finding was that, for children, the process of learning the letter names or sounds of the alphabet to a level of automaticity was a lengthy one.

These studies were carried out during the formulation of the automaticity theory and the samples consisted of adult fluent readers. In developing a technique of teaching fluent reading skills to children, with direct application of the automaticity theory, a review of studies of automatic activity was carried out (LaBerge & Samuels, 1974). LaBerge and Samuels reported that by 1974, no studies had been reported which systematically compared training methods that facilitated the automaticity of verbal skills. Most of the studies dealt with automatic motor tasks. The essential aspect of developing automaticity in skilled motor tasks was practice and repetition.

From this basis the method of repeated readings emerged (Samuels, 1979). This method consists of rereading a brief, meaningful passage over and over until a satisfactory level of fluency is reached. The procedure is then repeated with a new passage. Samuels emphasized that this technique was intended as a supplement to a reading program which could be useful for average readers, but was particularly suitable for the reading disabled.

In a study of mentally retarded children who were experiencing great difficulty in reading acquisition, the subjects were instructed to select short (50 to 200 words), easy, high-interest stories. These stories were read aloud and the reading speed and word recognition errors were recorded and graphed. An 85 word per minute criterion was reached before the next passage was presented. It was found that as reading speed increased, word recognition errors decreased. In addition, the initial speed of reading each new selection was faster than the initial speed of each previous passage, and the number of rereadings to reach criterion decreased.

The data for this research were very poorly described, e.g. the number of subjects, their characteristics, the type of statistical analysis and the use of controls were omitted. As a result, it is difficult to assess the efficacy of this technique based on this study. A similar problem exists with the reference to a second study in which the repeated readings technique was applied and significant gains were made in reading speed, as well as comprehension (Samuels, 1979). The information given included the following: the subjects were the poorest readers in an elementary school, were of normal intelligence and a control group was used.

Other authors have reported on the effectiveness of techniques very similar to repeated readings. Terry (1974) illustrated the potential effectiveness of repeated readings in a college reader sample. Improved speed and comprehension were noted for stories typed in mirror-image print after a week of repeated reading practice. Gonzales and Elijah (1975) reported a

5.3% improvement in errors on a second reading of the same passage among a group of students at the third grade reading level.

Chomsky's approach (Chomsky, 1978) involved having the reading disabled child follow along in the text, while listening to a tape recorded storybook. The reading and listening were repeated until fluency was achieved. Once rote recognition was attained in this manner, teaching of orthographic features was made explicit. This study included five Grade 3 children who worked on this technique daily on their own and were monitored by means of a half-hour session twice weekly over a four-month period. Pre- and posttests included both word recognition and paragraph comprehension. All children made significant progress. The initial speed of reading each new selection was faster than that of each previous passage. In addition, motivation and interest in reading was considerably improved.

A limited number of studies have investigated the repeated readings method and those that have been done can be criticized as lacking in many aspects of good research methodology, including such basic issues as sample size, careful selection of subjects, and statistical analysis. Their weaknesses are such that they cannot be considered adequate evaluations of the automaticity theory as applied in the repeated readings method. However, the results suggested that future research should more carefully consider this technique as a means of achieving automaticity and improved reading fluency.

Accuracy Versus Speed of Response in Word Recognition

Reading fluency is defined as consisting of two components: accuracy of word recognition and reading speed (LaBerge & Samuels, 1974; Samuels, 1979). The emphasis in the repeated readings method, in the studies described so far, was placed on speed of response. It was hypothesized that if accuracy was emphasized before the reader could move on to a new passage, the fear of making an error would slow down the reading rate (Samuels, 1979) or motivation would decrease (Chomsky, 1978). Results of these studies indicated that when the focus of the methods was reading rate, accuracy scores were inadvertently improved in successive passages.

Chall (1979) reported that decoding skill could be separated into two stages: one of accuracy and one beyond the accuracy stage in which automaticity is accomplished by practice and drill. Once word recognition skill is at an automatic level, then a "ready-for-learning" stage follows during which new information is learned through written material. This latter stage requires comprehension of written text.

Perfetti and Lesgold (1979) also described three stages in the sequence of developing decoding skills. The first was a stage of inaccurate performance during which the skills had to be taught. The second stage was accurate performance. After accuracy had been established practice and drill would be effective ways of going beyond accuracy to an automatic level. The final stage was automated performance. Practice and drill at this level were considered to be of no help, since no conscious processing would be required for performance and they considered conscious processing to be essential for skill refinement. Their description of stage development of decoding skills did not de-emphasize reading rate, but rather specified the time at which reading speed should be emphasized. In fact, Perfetti and Lesgold suggested that speed of response was a better index of the extent to which the decoding process was using an excessive share of working memory resources. Therefore reading rate was considered an important measure of verbal coding efficiency. Accuracy was a prerequisite for utilizing drill and practice to improve reading speed. Several suggestions for making drill and practice an effective and meaningful teaching and/or remedial technique are given by Perfetti and Lesgold to maintain motivation. One of the suggestions included the use of computer-assisted instruction, since it is an efficient method for delivering immediate reinforcement, and keeping detailed records of accuracy and importantly, latency of response. Instruction in tactics for word recognition during drill practice sessions was also recommended.

In summary, there are two approaches recommended for training programs concerned with improving speed of word recognition. The first emphasizes speed of response and the second emphasizes speed of response after a specific accuracy criterion has been attained. The repeated readings method studies described so far utilized the former approach in their training. The following study incorporated accuracy as an important focus of the training procedure.

Carver and Hoffman (1981) investigated the effectiveness of a computer-based adaptation of the repeated readings method in general reading ability. The subjects included 8 girls and 4 boys from 99 students in Grades 9 and 10. Reading achievement scores were at the fourth, fifth or sixth grade level according to the National Reading Standards (NRS) and Gates-MacGinitie Vocabulary Test. The reading training involved two-hour sessions, three times a week for a total of 50 to 70 hours. The training sessions consisted of interaction with the Plato IV computer, utilizing a specially designed computer program: Programmed Prose. This program incorporated the basic features of the repeated readings method. Ten passages, each 100 words in length, were selected for each grade level from Grades 2 to 9 for a total of 80 passages, to comprise one set of reading material. A comparable second set of 80 passages was also selected. In each passage, the subject was required to choose one correct word from a pair of words that best fit into the sentence. Such pairs of words were randomly dispersed through the passage. The subject responded by pressing an appropriate key corresponding to the position of the correct word. Immediate feedback for correct and incorrect responses was given. Performance was measured by a Rate of Good Reading (RGR) score which is a reading efficiency score computed from a formula combining accuracy, rate and grade level difficulty. The subjects started the training program with the first passage of Grade 2 and proceeded in order of difficulty through the first set then began the second set. Pre- and posttest measures included the NRS and Gates-MacGinitie reading tests.

The results indicated that practice improved efficiency by 15% on tests that were similar to the type of material on which the subjects were trained. On a paper and pencil version of the programmed prose, (NRS), gains were 3.4 to 3.6 grade levels. However, the Gates-MacGinitie Test, a test which the authors considered to be more indicative of general reading ability, showed little or no gain. The authors therefore concluded that their computer-based program of repeated readings was effective in increasing fluency and that there was a transfer effect to new material where the same type of performance is required. However, transfer effect of training to reading ability in general was only minimal.

The methodology of this study was very good in many aspects. However, one major flaw was that the data were not statistically analysed. The interpretation of gains or no gains made as a result of the training was based on subjective interpretation of the results alone. In addition, there was no reporting of a control group. The extensive time involvement required by the training would make a second experimental group costly. However, half of the students were trained in the first part of the academic year and the remaining half in the second semester. The second group could have served as a waiting list control if appropriate testing had been done for the total group prior to and following the training of the first group.

The authors describe the training procedure as an adaptive version of the repeated readings method because it is adapted to an interactive computer program. However, there is another difference. In the typical method as outlined by Samuels, the task involves reading an entire passage. In this study, word choices had to be made, which alters the task from the typical reading process. In addition the training appeared to be based on silent reading and the main test of general reading skills was an oral reading task. These differences may account in part for the lack of generalizability to the reading task.

Efficient Word Recognition and Reading Comprehension: A Causal Relationship

The work of Lesgold and Resnick (1981) has suggested how automation of word recognition may have an effect on reading comprehension. They have reported preliminary data on an ongoing longitudinal study of children in an urban-suburb school, with a large proportion of working-class families. One group of 127 students was assessed in the fall of their first grade and followed to the end of the third grade. Only 46 children remained by that time, predominantly due to families moving out of town. Tests of component reading skills were administered to each child as he or she reached a pre-established mastery landmark in the reading curriculum of the Houghton Mifflin basic reading program. These included measures of reading comprehension, sight vocabulary, a phoneme-grapheme test, auditory discrimination and visual discrimination as well as measures of word efficiency, semantic judgments, letter detection, and a simple response-time task. Both accuracy and speed of response were measured. On the basis of the second and third grade reading comprehension scores, the sa ple of children was divided into three groups of high, medium and low reading skill. Some of the main findings were that on the simple speed of performance and the letter detection tasks, there were no significant differences in speed or accuracy among all three groups. In oral reading of words in isolation, the low- and medium-skills groups took longer per word than the high-skills group at initial testing, but this difference disappeared by the final testing. The low-skills group was significantly less accurate than the other two groups. Speed of semantic judgements as measured by a word category matching task was found to be slower for the low- and medium-skills groups and accuracy was significantly lower for the low-skills group. In the oral reading of passages with familiar words, there were substantial differences in rate for all groups with the low-skill group being the slowest readers even though this group had the greatest amount of practice at each level. The reading rates were stable from the initial testing in the fall of Grade 1 to the final testing at the end of Grade 3. For passages with unfamiliar words, the rate for the low-skill group was so slow as to hinder comprehension. Accuracy was lowest for the low-skill group and they showed the least graphemic sensitivity. Thus, the low-skill readers were weak in every component, but they were especially weak in individual word recognition skills. They were slower and less accurate in reading text and individual words, but they were not slower in general reaction time or visual letter search tasks.

A second sample of 40 children was similarly evaluated. These children, however, were in a direct-instruction code emphasis reading program in contrast to the basal reading curriculum of the first sample. A major finding of this comparison group was that speed of reading response increased and there was a positive transfer effect of training in that each level's performance was better than that of earlier levels even for more difficult material. It was tentatively concluded that the code oriented instruction encourages word recognition fluency to a degree that the basal program does not. However, regardless of the program, low-skill readers remained slow readers in contrast to the other groups.

Structural equation modeling, which is a form of path analysis, was carried out on the data (from the first sample) in order to determine a causal relationship between speed of response and comprehension. Using this method, it was determined that early word recognition automaticity predicted later comprehension to a greater extent than early comprehension predicted later automaticity. Since the reliability of the former was greater than the latter, causality was inferred. It was concluded that early weakness in word automaticity is a signal of later comprehension difficulties and that automaticity is a cause of more adequate overall reading skill rather than an artifact of better readers having more practice.

This study has contributed to the further development of the theory of automaticity in word recognition skills. By carrying out a longitudinal study with multiple measurements on the same subjects over time, a causal relationship was tested utilizing a statistical procedure which permits such an inference. Lesgold and Resnick demonstrated that an early absence of accurate and automatic word recognition skills caused deficient reading comprehension later. Several authors had assumed a strong relationship betweem the two, but this study indicated the nature of that relationship is not correlational, but causal. In addition, specific recommendations for reading instruction were made on the basis of preliminary results of a comparative evaluation of code oriented and basal instruction programs. Lovett (1983) has interpreted the relationship of accuracy and rate of responding as reflecting two distinct subtypes of reading disabilities: accuracy disabled or rate disabled. Further she postulated that these two types of disabled readers and their fluent normal controls represented three different points along a theoretical continuum of normal reading development.

Summary of Theoretical Rationale for Rapid Automatic Responding in Reading

LaBerge and Samuels developed a theoretical model of information processing in reading in which words in print are transformed into meaning through a series of processing stages involving visual, phonological episodic memory and semantic systems. It was hypothesized that if each stage or component process required attention, the capacity of attention would be overloaded. Therefore, automatic processing must occur in order to execute such a complex skill. Automaticity at the level of recognition of letters, syllables, and words would allow for a greater amount of attention to be available for higher level aspects of reading such as comprehension. It was suggested that the method of achieving automatic responding or fluent reading was through overlearning, practice, repetition or drill. Fluent reading was defined as consisting of two components including accuracy of word recognition and reading speed. The issue of establishing accuracy before training reading speed has been approached differently in various studies.

LaBerge and Samuels were the first to describe the process of automaticity in the development of reading skills. Several authors have since concurred with the importance of automaticity in reading although the theoretical rationale may have been modified in comparison to the original model. For example, Perfetti and Lesgold referred to working memory as opposed to an attentional centre as having limited capacity. Nevertheless they contended that since several sources of information must be integrated during reading, speed of access of lower level information was essential for higher level skills such as comprehension.

Lesgold and Resnick developed the theory of automaticity even further by presenting evidence suggesting that the early absence of fast and accurate word recognition skills would result in deficient reading comprehension later. Other proponents of the role of automaticity had theorized about a correlational relationship between word fluency and comprehension, but Lesgold and Resnick proposed that the relationship is a causal one.

In applying the theory to instruction of reading to children, the efficacy of the repeated readings method was investigated. This method involves the rereading of the same passage to a specific level of reading fluency. Although these studies can be criticized on the basis of methodological issues, the results were promising. In general, it was found that the initial speed of reading each new section was faster than that of each previous passage and as reading speed increased, word recognition errors decreased. In a recent study by Carter and Hoffman an adapted version of the repeated readings method utilizing computer-based instruction was investigated. The results were comparable to earlier findings, but there was a poor transfer of training effect to other reading tasks. However, again, this study was marred by methodological problems.

CHAPTER 6

Theoretical Rationale of the Present Research Project

In the review of the literature, several issues have been presented which are relevant to the present research study. The primary goal of this research was to investigate the effectiveness of computer-assisted training procedures based on the theoretical rationale of rapid automatic responding, in the treatment of reading disabled children classified according to reading disability subtypes.

An initial factor to be dealt with in carrying out such a project is the definition of reading disability, and more specifically, whether the exclusionary definition, as outlined in Chapter 1, should be applied. In Chapters 2 and 3, the development of the subgroup concept in reading disability was presented in detail to emphasize the relevance and importance of the introduction of the multiple-syndrome paradigm. It was shown that the trend away from viewing reading disability as limited to a single antecedent condition with a single consequence was begun on the simple basis of clinical impressions. Several studies soon followed which reported different subgroups according to theoretical constructs, academic achievement data, particularly reading and spelling patterns, neuropsychological test profiles, and etiological factors. These later studies were criticized for utilizing subjective classification methods, including the visual inspection technique. Objective classification methods involving multivariate statistical procedures, specifically cluster analysis and the Q-technique of factor analysis, were introduced. This last development is a recent one and represents the most current approach to subgroup classification.

The importance of the contribution of the Doehring group, including Trites and Fiedorowicz, has been summarized in Chapter 3. Doehring and Hoshko (1977) were the first to carry out a major study utilizing multivariate statistical procedures to determine homogeneous subgroups of reading disability. Three subtypes were defined: Type O (Oral reading), Type A (Intermodal Associative), and Type S (Sequential). These classifications were based on a wide variety of component reading skills determined by a task-analysis of the reading process. These subtypes remained stable across two different samples (N=34, N=88 respectively) of reading disabled subjects. Extensive neuropsychological and language assessments were added to the evaluation of the second sample to investigate the interaction of reading, neuropsychologic, and language deficits. In addition to the fact that the subtypes were replicated in two separate samples, there are several other strengths of these investigations. Comparison groups of normal readers and children with other types of learning problems were included. External criteria of teacher evaluations, other multivariate statistical procedures, cluster analysis and discriminant function analysis were used to illustrate the stability of the subtypes. Several analyses on subsamples also yielded consistent results. Although the Type O, A, and S subtypes are considered a definitive subtype classification of reading disability, there is sufficient evidence to suggest that these subtypes are viable. A logical extension of the development of the subgroup concept in reading disabilities beyond a clear definition of subtypes and their associated characteristics, is in the area of treatment. In Chapter 4, it was pointed out that different treatment programs developed in accordance with the different subgroups may produce more effective results than currently available techniques. In Chapter 5, the development of the automaticity model was described, a model which may also have important implications in more effective remedial programs.

Autoskill Component Reading Subskills Training Program

Several advances in the development of treatment procedures have been made with the Autoskill Component Reading Subskills Training Program. Three training procedures: oral reading, auditory-visual matching-to-sample and visual matching-to-sample have been developed in accordance with the reading disability subtypes, Type O, Type A and Type S. In keeping with the current recommendations in the literature (Arter and Jenkins, 1979; Torgeson, 1979; Wong, 1979), an integration of the task-analytic and process-oriented models have been incorporated into the training procedures. All procedures involve training component reading skills as opposed to other psychological processes, and a task-analytic method was used to determine the component reading skills. These features are in keeping with the task-analytic model. Performance levels on the three procedures can be defined in terms of strengths and weaknesses and training can proceed according to either the strengths or the weaknesses.

This feature is similar to the process-oriented model in that individual characteristics can be treated differentially. However, a major difference of this procedure and the typical process-oriented procedure is that the differential profile is based on component reading skills and not psychological processes.

The skills defined for training are the same skills defined for the assessment procedures that were used initially for the subtype classification. The training procedure, therefore, incorporates an assessment-training research method which is suitable for measuring transfer of training effects.

The training, regardless of which of the three procedures is used, consists of improving rapid automatic responding through practice. This feature is in keeping with a task-analytic approach, as well as the theory of automatic information processing. The appropriateness of computer-assisted instruction as an efficient method for measuring latency of response, delivering immediate reinforcement, keeping detailed records of accuracy, and presenting the training stimuli rapidly are important in a method emphasizing skill and practice (Carver and Hoffman, 1981; Perfetti and Lesgold, 1979).

Two preliminary investigations of the efficacy of these training procedures have been carried out. Johnson (1981) carried out a pilot investigation of the potential of rapid automatic responding as applied in the training procedures. Twelve subjects, aged 8 to 18, were classified as reading disabled according to the usual exclusionary criteria following an extensive neuropsychological assessment. They were divided into three matched groups of 4 subjects each, including a nontrained control group, and two groups that received training. All subjects were assessed on the reading subtest of the WRAT and certain of the subtests from the computerized version of the component reading subskills tests, including single letter names and sounds, three-letter nonsense syllables and words (cvc) and four letter nonsense syllables and words (cvvc and cvcc) presented according to the three procedures, visual matching-to-sample, auditory-visual matching-to-sample and oral reading. In addition, the oral reading subtests phrases and sentences were administered. All tests were given to all subjects prior to and following the training period. One group received 7.5 hours of training (1.5 hours per day for 5 days) on the visual matching-to-sample procedure using cvcc nonsense syllables as stimuli. The second group received 12 hours of training on the same procedure, but using cvcc words as stimuli. Training was given in 20 blocks per session with 15 trials per block. The temporal sequence of presentation was simultaneous matching until a 90% accuracy criterion was reached and then changed to a delay condition with a long visual sample and a minimal delay between the visual sample and the choices. The initial emphasis in training was therefore placed on accuracy and response latency was secondary. The results indicated a nonsignificant increase in WRAT reading scores for all groups. There was a significant decrease in median response latency for the nonsense syllable group and a nonsignificant decrease for the word group and the control group. This illustrated the effect of training when the test stimuli were the same as the training stimuli. There were significant decreases in response latency for nontrained stimuli for both trained groups, but not the control group. This indicated a positive transfer of training effect to other types of stimuli in the visual matching procedure and, more importantly, to the oral reading procedure. The greater effect for the nonsense syllable group was interpreted as suggesting that training in coding skills may be more helpful than training in whole word recognition.

No definite conclusions could be reached about the efficacy of the training procedure in general due to the limited training period and the small number of subjects. However, this preliminary investigation indicated that the computer-assisted instruction could improve skills trained both in terms of accuracy and latency and that generalization of trained skills to untrained skills, especially oral reading, was feasible.

The first major study investigating the effectiveness of these computerized training procedures was carried out at Walter Zadow Public School, Renfrew County Board of Education during the academic year 1981-82 (Fiedorowicz, 1983).

The children who participated in training were 15 boys (mean age 11.0 years) referred by school personnel each of whom met rigorous criteria of reading disability. Following an assessment of component reading skills, the subjects were classified into subtypes. There were five subjects in each of Type O, Type A, and Type S. An additional reading disabled subject participated in the pre- and posttesting, but not the training. Training procedures were selected on the basis of the predominant deficit of the subtype classification. Therefore,Type O subjects were trained on the oral reading procedure, Type A subjects, auditory-visual matching-to-sample procedures and Type S on the visual matching-to-sample procedure. The training stimuli included single letters, cv-vc syllables, and cvc, cvvc, cvcc syllables and words. Each subject received half-hour sessions 4 to 5 days per week for a total of 21.5 hours of training over 11 weeks. Eight subjects were trained during the first half of the academic year on Schedule One, and seven subjects during the second half of the year on Schedule Two. Schedule One consisted of pretest, training, posttest, no train, posttest and Schedule Two consisted of pretest, no train, pretest, train, posttest with an approximate interval of 2.5 to 3 months for the train and no train periods. This design allowed the subjects on Schedule Two to serve as an untrained control group, and for follow-up data to be obtained for subjects on Schedule One. The assessment battery, administered at all pre- and posttraining periods, consisted of tests measuring accuracy and latency of response to trained stimuli on trained and untrained procedures, untrained stimuli on trained and untrained procedures, as well as a variety of reading achievement measures of word recognition and connected text. An average reader sample of 45 boys in Kindergarten to Grade 8 inclusive were also assessed to determine their performance on the battery of tests of component reading skills.

Significant improvement specific to subtype classification and corresponding training procedures were obtained for trained stimuli presented according to training procedures. Significant transfer of training effects was obtained on measures of reading word recognition grade level and the development of phonetic skills in word recognition. These results were consistent for the total sample of trained subjects and the trained versus untrained group comparisons. The improvement was maintained at follow-up. The results indicated that the training procedures were not only effective in improving component reading skills, but in addition there was transfer of training to reading achievement measures of word recognition with an increase in one grade level after 21.5 hours of training. Although there was improvement noted in both accuracy and latency for trained stimuli presented according to untrained procedures, untrained stimuli presented according to trained and untrained procedures, and on measures of reading connected text, the improvement was not sufficient to reach statistical significance. It was considered that training over a longer period of time would produce a generalization to these tasks.

Aims of the Present Study

The training strategies implemented in the first field trial appeared to be effective in improving some aspects of reading skills in a reading disabled sample of children. Although the results were most encouraging, there were limitations both with regard to the methodology of this study and secondly with the expected outcome. It became apparent that there were important issues to explore further in a more extensive investigation.

Several features of the training program itself were altered and expanded. In addition it was necessary to adapt the program to computers that would be more readily accessible to the schools. These modifications were carried out with the financial support of the Computers in Education Branch of the Ministry of Education in Ontario. The assistance was most gratefully appreciated and without it, the present research study could not have been undertaken. The new program was entitled the Autoskill Component Reading Subskills Testing and Training Program.

In addition to revising the testing and training program, it was considered important to evaluate the effectiveness of the training strategies on a larger sample of reading disabled children for a longer period of training than had been previously investigated. It was also considered important to include two control groups in the design of the study. Further, the use of the program by teachers was another feature that needed to be evaluated. The aims of the present study, therefore, were to implement these methodological changes and evaluate the effectiveness of the Autoskill Component Reading Subskills Testing and Training Program.

Hypotheses

1. It was predicted that the results of the first field trial would be replicated in the present study with an Autoskill Trained group of reading disabled subjects. Specifically, it was

predicted that reading word recognition skills and phonetic knowledge would be significantly improved for the total Autoskill Trained group. Accuracy in performance on the Autoskill Component Reading Subskills Test Program would be significantly improved on the oral reading procedure and the auditory-visual matching-to-sample procedure for Type O and Type A subjects respectively, and latency would be significantly improved on the visual matching-to-sample procedure for the Type S subjects.

These predictions were based on significant findings of the first field trial.

2. There were trends of improvement in the first field trial that did not reach statistical significance, but were considered to be possible benefits of training. In the conclusions of that study, it was suggested that a longer training period would have an overall greater beneficial impact. Further, it was suggested that if the reading of paragraphs was specifically included in the training, there would be a greater transfer of training effect to standardized measures of paragraph reading fluency and comprehension. In the conclusions of the first field trial, it was considered that the small sample size may have reduced the statistical power. The inclusion of a larger sample could be a factor in demonstrating these trends at a statistically significant level. In view of the incorporation of these factors in the present study, the following predictions were made. First, Type O and Type A subjects would be significantly improved in latency on their

respective training procedures, oral reading for Type O and auditory-visual matching-to-sample for Type A. This would mean that the training duration would be sufficient to improve not only accuracy, but also latency on the particular procedures on which the subjects were directly trained.

Secondly, all subjects would significantly improve in reading fluency and comprehension of paragraphs, particularly Type O subjects since they would have the additional benefit of direct training on paragraphs.

3. Based on the findings in the first field trial in which it was found that the untrained waiting list control group did not make significant improvement on any of the reading measures compared to the Autoskill Trained group, it was predicted that similar results would be obtained in the present study.

4. It was considered important to compare the performance of the Autoskill Trained subjects with a group of reading disabled subjects trained on other computer-based programs. Such a comparison would serve to rule out the possibility that the improvement in the various reading tasks was not secondary to the use of computer programs in reading remediation, but was the specific effect of the Autoskill Component Reading Subskills Training Program. It was predicted that the effectiveness of the Autoskill training was not secondary to the use of computer programs, and that overall the Autoskill Trained group would perform significantly better than the subjects trained on other computer-based programs.

5. The effect of teachers administering the Autoskill training procedures had not been possible previously since training was carried out by the primary investigator and a research assistant, both highly trained in the procedures. The revised program was designed allowing for maximum ease of administration by teachers given the complexity of the training strategies. The program is highly structured and the administration follows an organized stepwise format. Further, detailed instructions were included in the program. Training in the administration of the program seemed mandatory, however, due to the overall complexities in understanding the theoretical approach and to ensure that the methodology was followed precisely. It was anticipated that with appropriate preparation the teachers could readily administer the training procedures.

CHAPTER 7

Method

Subject Selection

Autoskill Trained Group and Untrained Control Group

All of the school boards in the Eastern Region of Ontario were sent a letter (in February 1985) describing the proposed study and requesting their participation. Three of the boards volunteered, including the Ottawa Roman Catholic Separate School Board, the Renfrew County Board of Education, and the Renfrew County Roman Catholic Separate School Board. Each of these three boards had a sufficient number of ICON computers available. It was requested that each of the boards submit a list of names of students who could be considered as potential candidates for the study. The criteria for subject selection, based on school records, included the following: average intellectual ability; a delay in reading word recognition skills of at least one grade level; reading word recognition skills less than Grade 6.0; no major visual or hearing problems; no major neurological conditions (e.g. cerebral palsy); no major emotional/behavioural problems; and parental consent to participate in the year-long study should the child be selected as a candidate. A total of 150 subjects were recommended for the screening assessment which was carried out in the schools between April and June, 1985.

The initial screening assessment consisted of the Wechsler Intelligence Scale for Children - Revised (WISC-R) to determine level of intellectual functioning, and the Slosson Oral Reading Test (SORT), as well as the reading subtest of the Wide Range

Achievement Test - Revised (WRAT-R), both of which were used to determine reading word recognition grade delay. Some of the children had been given the WISC-R within the last academic school year and it was not necessary to readminister this test. In such cases parental consent was provided in order to obtain the data from school personnel. All of the subjects were administered the SORT and the reading subtest of the WRAT-R. The selection criteria for WISC-R performance was one of the Verbal IQ, Performance IQ, or Full Scale IQ at least 90 or greater with none of the other scores below 80. The reading grade delay of at least one grade was determined by the difference between projected grade placement based on chronological age expectation and the word recognition reading score on the SORT and the WRAT-R. If the subject met these selection criteria, the Autoskill Component Reading Test Program was administered to determine subtype of reading disability. The entire assessment required approximately three to four hours to administer. Each subject was individually tested by a research assistant trained in test administration. This phase of the study was carried out between April and June, 1985. Of the 150 subjects referred as candidates, 59 were rejected: 10 of the subjects would be moving away over the summer and would not be enrolled in a participating school board; 23 did not meet the one grade level delay criterion; 22 did not meet the intellectual ability criterion; 2 had a history of truancy; and 2 of the children were in classes for English as a second language and did not speak English sufficiently well. For this latter group it did not appear that the reading delay was due to a specific reading problem, but due more to generally poor English language skills. Therefore 91 subjects were selected.

The subtype analysis was independently carried out by four judges using the rules of classification for Type O, Type A and Type S reading disabilities (Fiedorowicz, 1983). A concensus of all judges was independently obtained for each subject's subtype classification. This resulted in 26 Type O, 22 Type A, and 26 Type S subjects accepted for the Autoskill Trained group. The remaining 17 subjects for whom a concensus of subtype classification was not independently obtained by all four judges were designated as the Untrained Control group. This phase of the study was completed by August, 1985.

The initial goal was to include 25 subjects in each of the 4 groups. Since it was essential to begin the pretesting as soon as school began in September, 1985 so that training could begin by late September or early October, 1985, it was not feasible to screen more candidates in September. Therefore, it was necessary to maintain the groups as described despite the uneven numbers of subjects per group.

<u>Alternate Computer Trained Control Group</u>

The Carleton Board of Education and the Stormont, Glengarry and Dundas Board of Education agreed to participate in the study as part of the Alternate Computer Trained Control group. The identical criteria for subject selection were applied. The Autoskill Component Reading Test Program was not administered to this group. There were 32 subjects referred as candidates and 24 met the selection criteria. The rejected candidates did not meet the one grade level delay criterion. This phase of the study was carried out in December, 1985.

Matched Controls for the Alternate Computer Trained Control Group

A subsample of the designated Autoskill Trained group was selected and matched with the Alternate Computer Trained Control group on the variables: projected reading grade delay, sex, and age.

Characteristics of the Total Autoskill Trained Group and the Untrained Control Group

All of the subjects met the usual exclusionary criteria for defining reading disability. Table 7.1 summarizes the characteristics of the total Autoskill Trained group, each subgroup, and the Untrained Control group. The average age for the total Autoskill Trained group (AT) was 11.2 years, 11.8 years for Type O (O), 10.8 years for Type A (A), 11.0 years for Type S (S), and 11.0 years for the Untrained Control group (UC). The youngest subject was 7.9 years and the oldest 14.6 years. Both males and females were included. There were 58 males and 16 females (AT), 21 males and 5 females (O), 18 males and 4 females (A), 19 males and 7 females (S), and 10 males and 7 females (UC) within each respective group. All subjects were delayed in reading word recognition skills in comparison to chronological age expectation by at least one grade level with an average grade delay of 3.0(AT), 3.4(O), 2.6(A), 3.0(S), and 2.5(UC), respectively. The minimum projected reading grade level delay

Table 7.1
Characteristics of the total Autoskill Trained group and subgroups and the Untrained Control group.

Variable	Total Autoskill Trained Group	Autoskill Type O	Autoskill Type A	Autoskill Type S	Untrained Control Group
Sample Size	74	26	22	26	17
Age M (SD)	11.2(1.5)	11.8(1.4)	10.8(1.2)	11.0(1.7)	10.7(1.7)
Range	7.9-14.4	9.25-14.4	8.8-14.0	7.9-14.2	7.3-14.6
Sex	M 57 F 16	M 21 F 5	M 18 F 4	M 19 F 7	M 10 F 7
Prgd M (SD)	3.0(1.0)	3.4(1.1)	2.6(0.8)	3.0(1.0)	2.5(1.0)
Range	1.2-6.2	1.8-6.2	1.3-4.2	1.2-4.3	1.3-5.7
WRAT-R					
Grade M(SD)	3.0(1.1)	3.3(1.0)	3.0(1.3)	2.8(1.0)	3.1(1.1)
Range	1.2-5.8	1.8-5.8	1.5-5.8	1.2-4.8	0.8-5.8
%ile M (SD)	7.2(8.8)	6.6(5.8)	8.4(9.6)	6.8(10.7)	9.4(8.2)
Range	0.1-47.0	0.6-21.0	0.5-37.0	0.1-37.0	0.7-25.0
SS N (SD)	73.3(10.4)	74.4(8.2)	74.8(10.4)	71.0(12.1)	77.6(8.7)
Range	47-99	58-88	57-95	47-99	59-90
WISC-R					
VIQ M (SD)	93.0(8.6)	91.9(7.8)	92.5(8.4)	94.5(9.5)	90.2(7.3)
Range	80-118	80-107	80-108	82-118	81-112
PIQ M (SD)	101.3 (10.9)	100.0 (10.3)	100.8 (11.4)	103.1 (11.1)	102.8 (12.1)
Range	80-130	86-121	82-124	80-130	80-120
FSIQ M(SD)	96.3(8.5)	95.1(8.1)	95.9(7.3)	98.0(9.9)	95.4(8.2)
Range	85-123	85-115	86-111	87-122	80-109
SES M(SD)		4.3(1.3)	4.4(1.0)	4.4(1.5)	
Range		2.8-6.6	2.9-5.8	2.4-[illegible].2	

was 1.2 and the maximum was 6.2. The average reading word recognition level as measured by the WRAT-R was 3.0(AT), 3.3(O), 3.0 (A), 2.8(S), and 3.2(UC), respectively. All of the subjects read at least at 0.8 grade level and none of the subjects read above a grade 5.8 level. The corresponding percentile ranking and standard scores for the WRAT-R are provided in Table 7.1 as well.

All of the subjects were of average intelligence with at least one of the Verbal IQ, Performance IQ, and Full Scale IQ 90 or greater and none of the other scores below 80. The average Verbal IQ was 93.0(AT), 91.9(O), 92.5(A), 94.5(S), and 90.2(UC) for each respective group. The average Performance IQ was 101.3(AT), 100.0(O), 100.8(A), 103.1(S), and 101.6(UC), respectively. In addition none of the subjects had major visual, hearing, neurological, or emotional/behavioural conditions. The breakdown of the subjects according to school board and school can be found in Appendix 7.1.

The SPSSx Subprogram Oneway (SPSSx Inc., 1983) was used to determine if there were any significant differences among the groups for age, projected reading grade delay, WRAT-R reading levels for grade level, percentile and standard score, Verbal IQ, Performance IQ, and Full Scale IQ. It was found that there were no significant differences among the two groups. Further there were no significant differences on these variables among the Type O, Type A, Type S, and Untrained Control group comparisons. The socioeconomic status (SES) of the Autoskill subtypes was obtained and it was found that overall the SES level was lower middle class with a range representing all levels (Blishen and McRoberts, 1976).

Characteristics of the Alternate Computer Trained Control Subjects Matched with the Subsample of Autoskill Trained Subjects

Table 7.2 summarizes the characteristics of the Alternate Computer Trained Control subjects matched with the subsample of Autoskill Trained subjects. As indicated earlier, each of the subjects in the former group was matched with each of the subjects in the latter group for projected reading grade delay, sex, and age. The average age of the subjects was 11.0 years for the Autoskill Trained subsample and 11.3 years for the Alternate Computer Trained Control group. There were 14 males and 10 females in each group. The average projected reading grade delay was 3.0 grade levels and the average reading word recognition grade level was 2.8 for the Autoskill Trained subsample and 3.3 years for the Alternate Computer Trained Control group.

The Verbal IQ scores were 95.0 and 95.8; the Performance IQ scores were 101.2 and 100.3; and the Full Scale IQ scores were 97.4 and 94.8 respectively for the Autoskill Trained subsample and the Alternate Computer Trained Control group. The SPSSx Subprogram (SPSSx Inc., 1983) was used to determine if there were significant differences for WISC-R and WRAT-R scores and it was found that there were no significant differences.

The breakdown of the subjects according to school board and school can be found in Appendix 7.1.

Table 7.2
Characteristics of the Alternate Computer Trained Control group and matched subsample of the Autoskill Trained group.

Variable	Autoskill Trained Subsample	Alternate Computer Trained Control Group
Sample Size	24	24
Age M (SD)	11.0(1.2)	11.3(1.2)
Range	9 - 14	9 - 14
Sex	M 14 F 10	M 14 F 10
Prgd M (SD)	3.0(0.8)	3.0(0.9)
Range	1.8 - 5.3	1.6 - 5.3
WRAT-R		
Grade M (SD)	3.2(0.7)	3.3(0.8)
Range	1.8 - 3.8	1.8 - 4.8
%ile M (SD)	9.7(7.3)	8.3(7.6)
Range	0.1 - 19.0	0.5 - 22.0
SS M (SD)	77.3(9.2)	78.3(8.3)
Range	47 - 87	57 - 93
WISC-R		
VIQ M (SD)	95.0(9.9)	94.8(8.7)
Range	80 - 118	81 - 101
PIQ M (SD)	101.2(12.2)	100.3(12.9)
Range	82 - 124	86 - 124
FSIQ M (SD)	97.4(10.1)	94.8(8.7)
Range	85 - 123	85 - 112

Procedure

Design of the Study

Table 7.3 shows the testing and training schedule for all groups. The Autoskill Trained and Untrained Control groups were assessed for subject selection between April and June, 1985, with final determination of group assignment between July and August, 1985. Pretesting was carried out in September, 1985 and posttesting in May and June, 1986. Training for the Autoskill subtypes was carried out between October, 1985 and May, 1986. This aspect of the design of the study allowed for a comparison of performance of the Autoskill Trained subgroups with the Untrained Control group over the same time period. In addition the second control group, the Alternate Computer Trained Control group was included to allow for a comparison of performance with a matched subsample of the Autoskill Trained group. The Alternate Computer Trained Control group was selected and pre-tested in December, 1985 and January, 1986 and post-tested in May and June, 1986 following 30 hours of training. The matched subsample of the Autoskill Trained group was tested in February, 1986 following 30 hours of training.

Assessment Battery of Tests

I. Autoskill Trained and Untrained Control Groups

The pretest and posttest battery of assessment measures for the Autoskill Trained and the Untrained Control groups is outlined in Tables 7.4 and 7.5.

Table 7.3
Testing and training schedule for all groups.

April - June, 1985	Screening of Autoskill Trained and Untrained Control groups. N = 150.
July - August, 1985	Subject selection of Autoskill Trained and Untrained Control groups. N = Type O 26, Type A 22, Type S 26, Untrained 17.
September, 1985	Pretest of Autoskill Trained and Untrained Control groups.
October, 1985 - May, 1986	Training of Autoskill Trained subtypes. M number of hours = 56.4.
December, 1985 - January, 1986	Screening and selection of subjects for Alternate Computer Trained Control group. N = 24. Pretesting of Alternate Computer Trained Control group.
January - May, 1986	Training of Alternate Computer Trained Control group. M number of hours = 30.
February, 1986	Posttesting of matched Autoskill Trained Control group following 30 hours of training.
May - June, 1986	Posttesting of all groups (Autoskill Trained groups, Untrained Control group, Alternate Computer Trained Control group).

Table 7.4
Subtests in the Autoskill Component Reading Subskills Test Program.

Oral Reading Procedure	Auditory-Visual Matching Procedure	Visual Matching Procedure
*letter names	letter names	letter names
letter sounds	letter sounds	
**cv-vc syllables	cv-vc syllables	cv-vc syllables
cvc syllables	cvc syllables	cvc syllables
cvc words	cvc words	cvc words
cvvc syllables	cvvc syllables	cvvc syllables
cvvc words	cvvc words	cvvc words
cvcv syllables	cvcv syllables	cvcv syllables
cvcv words	cvcv words	cvcv words
ccvc syllables	ccvc syllables	ccvc syllables
ccvc words	ccvc words	ccvc words
cvcc syllables	cvcc syllables	cvcc syllables
cvcc words	cvcc words	cvcc words
real words at reading word recognition grade level		
real words at projected reading word recognition grade level		

Conditions: Simultaneous presentation of sample item and choices, 15 trials per subtest
10 sec. latency limit per trial
0 sec. intertrial interval

* both upper- and lower-case letters
** c = consonant, v = vowel

TABLE 7.5
Summary of information obtained from the WRAT-R, SPIRE, QASOR and G-E tests.

WRAT-R

Reading subtest — Grade Level Equivalent
Standard Score

SPIRE

1. Reading Text at the Word Recognition Grade Level
   Paragraph read aloud: reading rate, retention, comprehension
   Paragraph read silently: reading rate, retention, comprehension

2. Reading Text at the Projected Word Recognition Grade Level
   Paragraph read aloud: reading rate, retention, comprehension
   Paragraph read silently: reading rate, retention, comprehension

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QASOR

1. Cloze passage at the Word Recognition Grade Level
   meaning, graphic sense, rate.

2. Cloze passage at the Projected Word Recognition Grade Level
   meaning, graphic sense, rate.

G-E

I. Sounds
1. Single Consonants
2. Short Vowel Sounds
3. Common Consonant Combinations
4. Long Vowel Sounds
5. Soft c,g,s; tch dge sounds
6. Common Vowel Combinations
7. Combinations of Vowel with R
   Total Percentage

II. Words
1. Closed Syllable - Single Consonants, e.g. can
2. Closed Syllable - Consonant Combinations, e.g. chest
3. Silent E and Open Syllables, e.g. tame
4. Soft c,g,s; tch, dge, e.g. cent, rage, catch
5. Vowel Team Syllables, e.g. toil
6. Vowel R Syllables, e.g. cart
7. Words with Easy Endings, e.g. s, ed, ing, er, est, y
8. Common Suffixes, e.g. candle, nation
9. Multisyllabic words
   Total Percentage

---

1. Autoskill Component Reading Subskills Test Program

All of the measures of the Autoskill Component Reading Subskills Test Program were administered (Table 7.4). This included the Visual Scanning Test, as well as the computerized oral reading, auditory-visual matching-to-sample, and visual matching-to-sample procedures.

The Visual Scanning Test, a paper and pencil task, consisted of one subtest in which the subject had to underline as many rectangles as possible on a page of rectangles, and subtests in which the subject had to underline a target item mixed with similar nontarget items. Examples of the stimuli from each of the subtests are presented in Table 7.6. Each target item was presented on a separate page of 18 lines of stimuli. Responses were scored in terms of the number of items of each type underlined within a specified time limit. The purpose of the task was to compare scanning rates for nonletter stimuli, single letters and numbers and letter strings in words and nonwords. Age and percentile norms have been developed for each subtest (Doehring & Hoshko, 1977). The testing time was approximately 15 minutes per subject.

All subtests of each of the oral reading, auditory-visual matching-to-sample and visual matching-to-sample procedures were administered, which are listed in Table 7.4. The conditions selected for the testing sessions are also outlined. The maximum duration of each trial was 10 seconds. The intertrial interval, i.e., the time lapse between the end of one trial and the beginning of the next was set at 0 msec. The number of trials

Table 7.6
Examples of stimuli from each of the subtests of the Visual Scanning Test with target items underlined.

Target Item	Type of Stimulus	Example
▭	Simple Shape	▭ ▭ ▭ ▭ ▭
4	Single Number	1 8 9 4 2 7 6 4 3 5
✚	Greek Cross	☽ ✚ △ ▭ ✚
s	Single Letter	v u s p f t s e u c
e	Letter in Syllable	geyg fing hbjs
bm	Two Letters	m o p r b s c d b k a z
fsbm	*cccc Letter String	sfmb bfms sbmf fsbm
narp	**cvcc Syllable	apnr narp parn aprn
spot	Word	post tops spot sotp
s-p-o-t	Spaced Word	t o p s s t o p s p o t s

* c = consonant
** v = vowel

per subtest was 15.

For the oral reading procedure, each item was presented singly on the screen and the subject was required to read it aloud as quickly as possible. The examiner pressed the space bar as soon as the oral response had been completed to end the automatic timing, and one of two other keys to register the correctness or incorrectness of the response.

Figure 7.1 illustrates the auditory-visual matching-to-sample procedure. The auditory target item was presented and at the same time, three visual choices were displayed on the screen until the subject responded. The subject was required to select the visual choice that matched the auditory target item. Touching the corresponding keys ended the trial and both the latency and accuracy of response were automatically recorded.

The visual matching-to-sample procedure was similar to the auditory-visual matching-to-sample procedure, but instead of an auditory target item, a visual target item was displayed above the choice items. Figure 7.2 illustrates this procedure.

The number of trials, correct responses, errors, and non-responses, the experimental conditions for that particular run, and the median latency of correct responses were automatically recorded by the computer. The two scores of prime concern were the median latency of correct responses in msec., and an error score consisting of the number of actual errors plus the number of nonresponses expressed as a percentage value of the total trials. This testing required approximately 1.5 hours.

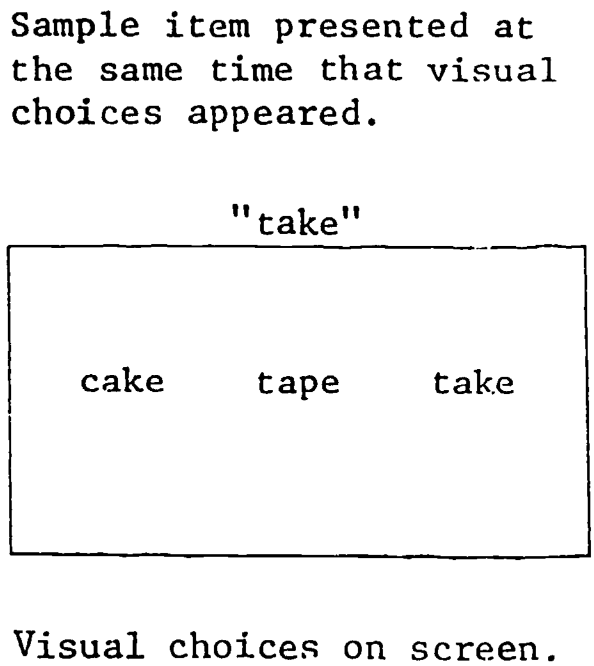
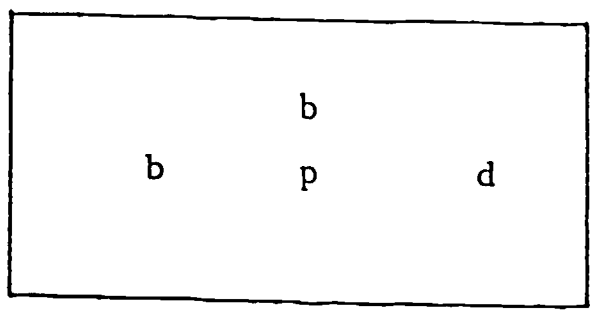


Figure 7.1
Example of the auditory-visual matching-to-sample procedure for the cvcv words subtest



Sample item and choices appeared simultaneously on touch sensitive screen.

Figure 7.2
Example of the visual matching-to-sample procedure for the single letters subtest

Apparatus

The Autoskill Component Reading Subskills Test and Train Programs were run on an ICON computer including a lexicon with a minimum 10 megabyte hard disk storage capacity, and a workstation with 512 K memory. The software required 1 megabyte of memory. The auditory stimuli were presented by means of a digitized speech component and the latencies were measured by the real time clock component. In addition a printer was used for hard copies of graphs, profiles and results. The software was written in C language.

2. Wide Range Achievement Test - Revised Reading Subtest

The Wide Range Achievement Test - Revised (WRAT-R) reading subtest was included to assess reading word recognition grade levels (Jastak and Wilkinson, 1984). Both the grade equivalent scores and the standard score were determined. The grade equivalent score was used to give an indication of grade placement. A grade level score is generally used more frequently by educators in referring to a child's level of progress. The standard score, however, may be a more accurate and appropriate score for the statistical analyses (Siegal, 1984).

3. Student Problem Individual Reading Evaluation

The Student Problem Individual Reading Evaluation (SPIRE I, grades primary to Grade 6, SPIRE II, Grades 4 to 10) is a standardized reading measure (Alpert and Kravitz, 1971) which was included to assess fluent and accurate reading of prose passages read aloud; comprehension of what is read aloud based on recall or retention only; comprehension of what is read silently based on recall or retention only; comprehension of what is read aloud with the benefit of having the text available for reference in answering questions; and comprehension of what is read silently with the benefit of having the text available for reference in answering questions. In the typical administration of this test, a basal and ceiling method is applied and three grade levels are attained including an Independent, Instruction, and Frustration grade level. However, in this study passages were given at the corresponding reading word recognition grade level as determined by WRAT-R as well as at the projected reading grade level. This method of administration was adopted to ensure that both the word recognition level and the projected grade level were assessed. This test took approximately 30 minutes to administer. The summary of information obtained from this measure can be found in Table 7.5.

4. Qualitative Analysis of Silent and Oral Reading

The Qualitative Analysis of Silent and Oral Reading (QASOR) (Aulls, unpublished) was included to assess patterns and kinds of reading errors in the silent and oral reading of connected prose. After the prose passage of the SPIRE was read aloud, the SPIRE silent reading passage at the same grade level was then read, followed by a cloze passage. The cloze passages were written by D.G. Doehring as a continuation of the first two passages and were at an equivalent grade difficulty level. Words were systematically deleted from the cloze passage to be well-spaced and to include a representative portion of function and content words. The subject had to fill in the blank by saying the appropriate word. This required some retention of the two previous passages as well as proper use of syntax. The subject had to read the passage aloud and fill in the blanks by saying the missing word (reading cloze).

The pattern of errors and reading fluency for the passages read aloud were evaluated according to the criteria determined by Aulls (see Appendix 7.2). The emphasis is placed primarily on phonetic and graphic errors as well as rate of fluent reading. Performance on the cloze passage was indicated by the number of correct substitutions. This test took approximately 15-20 minutes to administer. The information obtained from this measure is also included in Table 7.5.

5. Gallistel-Ellis Test of Coding Skills

As can be seen in Table 7.5, the Gallistel-Ellis Test of Coding Skills (G-E) (Gallistel & Ellis, 1974) consists of seven measures of the ability to identify different sounds associated with letters and letter combinations and nine measures of skill in reading different types of real and nonsense words. A percentage correct score is determined for each subtest, as well as total percentage scores for sounds and a total percentage score for words. The G-E took approximately 15 to 20 minutes to administer. The total percentage score for sounds and the total percentage score for words were the scores applied in the statistical analyses.

Rationale for Test Selection

The procedure in this study involved the training of component reading skills using a variety of stimuli presented according to three different procedures. In order to evaluate the effectiveness of treatments, several forms of assessment were necessary.

1. A direct sampling of performance with the stimuli used for training presented by the procedure used in training. This provided a direct measure of whether or not repeated presentation of specific stimuli by a specific procedure would improve performance.

2. A sampling of performance using trained-stimuli presented by a procedure not used for training. This provided a measure of transfer of training from one type of procedure to another, but using the same stimuli that had been used in training.

Administration of all of the subtests of the Autoskill Component Reading Subskills Test Program provided the sampling of performance required to meet these two classes of assessment.

3. The inclusion of a word recognition test provided a measure of transfer of training of component reading skills to the reading of words in isolation on a standardized reading word recognition task (WRAT-R reading subtest).

4. The G-E provided qualitative information about the types of errors made in reading words in isolation, including phonetic knowledge of letters and syllables and phonetic knowledge of words. There might be improvement in reading certain types of

words even when there was no improvement in the posttraining grade level for isolated word recognition. For example, a subject might still be recognizing words at the Grade 3 level after training, but there might be an improvement in the phonetic knowledge of letters.

5. Tests of reading comprehension skills provided measures of transfer of training of component reading skills to reading words in text and deriving meaning from what is read. The SPIRE I & II tests provided achievement scores and the QASOR provided qualitative information about the pattern and kinds of errors that were made in reading words in context. It was considered possible that there might be improvement in fluency and kind of errors made in reading passages, even when there was no increase in skill in reading higher grade levels for reading comprehension. Both the SPIRE and the QASOR were administered at a level in keeping with word recognition skills and at the projected grade level.

II. <u>Alternate Computer Trained Control Group and Matched Subsample of Autoskill Trained Group</u>

The pretest and posttest battery of assessment measures for the Alternate Computer Trained Control group and the matched subsample of the Autoskill Trained group included the WRAT-R reading subtest, SPIRE, QASOR, and G-E as outlined in Table 7.5.

<u>Training Procedures</u>

1. <u>Autoskill Trained Group</u>

<u>Strategy</u>

The strategy used in the training procedures was based on the assumptions that instruction in the deficient component reading skills would improve reading (Torgeson, 1979), and that training to a level of automaticity would improve reading (Laberge & Samuels, 1974). The training strategy, therefore, involved increasing the accuracy of response and decreasing the latency of response for the most deficient component reading skills, as determined by the Autoskill Component Reading Subskills Test Program. The subjects classified as Type O were trained on the oral reading procedure. Type A subjects were trained on the auditory-visual matching-to-sample procedure, and Type S on the visual matching-to-sample procedure. Type O and Type A subjects were initially trained on the subtest letter names, followed by letter sounds, and Type S on the subtest letters. (Although Type S subjects were not, by definition, as deficient in single letter identification, the training procedure did include single letters to reduce response latency). Then all subjects were trained in a sequential order on subtests cv and vc syllables, cvc, cvvc, cvcv, ccvc, and cvcc syllables and words, and words from Grades 1 to 8 consecutively according to the respective procedures. The oral reading procedure was the most extensive and included phrases, sentences and paragraphs from Grades 1 through 10 consecutively. Table 7.7 outlines the training stimuli for each procedure.

Certain conditions for the presentation of the various subtests were held constant. The number of trials per subtest was 50. The duration of correct response signal was 300 msec. and of the incorrect response signal was 1500 msec. The duration

Table 7.7
Subtests in the Autoskill Component Reading Subskills Training Program.

Oral Reading Procedure	Auditory-Visual Matching Procedure	Visual Matching Procedure
*letter names	letter names	letter names
letter sounds	letter sounds	
**cv-vc syllables	cv-vc syllables	cv-vc syllables
cvc syllables	cvc syllables	cvc syllables
cvc words	cvc words	cvc words
cvvc syllables	cvvc syllables	cvvc syllables
cvvc words	cvvc words	cvvc words
cvcv syllables	cvcv syl'ables	cvcv syllables
cvcv words	cvcv words	cvcv words
ccvc syllables	ccvc syllables	ccvc syllables
ccvc words	ccvc words	ccvc syllables
cvcc syllabl₍s	cvcc syllables	cvcc syllables
cvcc words	cvcc words	cvcc words
words Grade 1-8	words Grade 1-8	words Grade 1-8
phrases Grade 1-8		
sentences Grade 1-8		

Conditions: Simultaneous presentation of sample item and choices,
50 trials per subtest
10 sec. latency limit per trial
0 sec. intertrial interval
300 msec. correct response signal
1500 msec. incorrect response signal

* both upper- and lower-case letters
** c = consonant, v = vowel

of the correct and incorrect response signal could be varied, however, according to the needs of each individual subject. A sufficient length of time was given to ensure that the subject understood clearly what the correct response should have been. The latency limit per trial was 10 seconds and the intertrial interval was set at 0 msec. The sample item and the three choice items were presented simultaneously for the auditory-visual matching-to-sample and the visual matching-to-sample procedures. One stimulus item was presented per trial for the oral reading procedure. After an incorrect visual matching-to-sample response, the sample item and the three choices reappeared on the screen with the correct choice outlined in a rectangle. After an incorrect auditory-visual matching-to-sample response, the three visual choices reappeared on the screen with the correct choice outlined in a rectangle and the sample item was repeated. For the oral reading procedure, the subject was requested to try again when a mistake was made or the trainer would read the sample item correctly. All subjects were thus made aware of every error and given the correct response.

Training to Criterion

The subjects were trained to criterion on one subtest before moving on to the next subtest. Since increased accuracy and decreased latency of response were two goals of training, a criterion for each was selected. The accuracy criterion was 96% correct. The latency criterion was a 100 msec. spread of median latency response over 3 consecutive sets of 50 trial runs. This meant that three consecutive median latency scores, each based on 50 trial runs, had to be within a range of 100 msec. Both criteria were rather stringent, but it was considered important to reduce errors to a minimum and latency to a stable level on a 50 trial run to ensure that the task was learned well. During training the accuracy goals were emphasized until the accuracy criterion was reached. Then the speed of response was emphasized. It was considered that this latency criterion would approximate an asymptote in rapid responding specific to each individual subject. The accuracy criterion had to be maintained for the three consecutive trials in which the latency criterion was attained. These criteria appeared appropriate for the majority of subjects. However, the progress of some subjects on particular subtests was slow, and in order to ensure that they had been given experience on several of the subtests during the training period, another criterion was needed. If the accuracy and latency criteria were not attained after a given number of sessions, the subject was moved to the next subtest. The number of sessions depended upon the individual progress of the subject. It was noted, however, that some subjects expressed disappointment when "moved on" rather than being allowed to achieve a different level on the basis of their own accomplishments, while others were relieved.

The rate of progress of the individual subjects varied considerably. None of the Type O subjects completed the entire training stimuli available for the oral reading procedure. Some of the Type A and Type S subjects completed their respective training on the auditory-visual matching-to-sample and visual matching-to-sample procedures. When this occurred, a comparison of their performance to age norms was made and the subtests on which performance was below age expectation were repeated. Further, a few of the Type A and Type S subjects began training on the oral reading procedure after having completed their own respective procedures. Prior to this, however, they were assessed on the Autoskill procedures to determine transfer of training effects.

Training Schedule

The specification for the training schedule included three half-hour training sessions per week for a total of 1.5 hours weekly. Each subject was trained individually. Most of the subjects were maintained on this training schedule. There were several factors, however, that altered the original scheduling plan for some of the subjects. These included truancy, sick days, professional development days, field trips, special events and holidays. In addition, there were some problems with computer breakdown and computer thefts. In all cases attempts were made to maintain 1.5 hours of training weekly but, it was necessary to make up time over a two- or three-week period. Three subjects were truant (2 Type A and 1 Type S subjects), not just from the Autoskill training but from school generally, and these three did not complete the required number of training hours. They completed approximately 30 hours and were not included in the final statistical analyses. Table 7.8 summarizes the total number of training hours for each group.

TABLE 7.8
Training hours for the Autoskill Trained group.

	Total Autoskill Trained Group	Autoskill Type O	Autoskill Type A	Autoskill Type S
M (SD)	56.4(2.7)	56.4(1.8)	55.2(3.8)	57.3(1.8)
Range	42 - 60	52 - 60	42 - 60	55 - 60
3 subjects dropped from analyses			2 31.5 38.5	1 31.5 hours

Trainers

In September, 1985, the teachers to be included in the study were given a one-day workshop as an introduction to the training procedures. A separate workshop was provided for each board to allow for as much individual assistance and to provide "hands on" experience with the computer program. In addition, each teacher was assigned a research assistant who had been well trained with the procedures. Each research assistant supervised the teacher training over the entire school year. Regular meetings and observations of training sessions were maintained. A teacher questionnaire was given following the major training phase to evaluate the ease of learning the program and another questionnaire evaluating many aspects of the program was given at the end of the study. These questionnaires can be found in Appendix 7.3.

In addition to the teachers involved in the training, four research assistants also provided training. Many students received training only from teachers (with supervision by the research team); some students received training from teachers and the research assistant, and some students were trained only by the research assistant. The assignment of research assistants to work with the students was made on the basis of teacher availability. In addition, the research assistant would "cover" for the teacher due to sick days, meetings, etc., for the occasional training session. Table 7.9 summarizes the number of students who were teacher or research assistant trained. In total there were 56 subjects who were trained predominantly by

Table 7.9
Breakdown of number of Autoskill subjects trained by teachers versus trained by research assistants.

	Teacher Trained	Research Assistant Trained
Ottawa Roman Catholic Separate School Board	12	11
Renfrew County Board of Education	20	5
Renfrew County Roman Catholic Separate School Boarad	24	2
Total	56	18

teachers and 18 trained by a research assistant. The teacher availability of the Ottawa Roman Catholic Separate School Board was particularly limited and more research assistant time was necessary for that board.

2. Untrained Control Group

There was no specific intervention for this group. The subjects were pre- and posttested at the same time of the academic year as the Autoskill Trained groups and in the interim period they proceeded normally within the school system. The purpose of this group was to define a group of reading disabled students and follow their progress based on whatever programming the school board typically provided for them. Some of the students did not receive any extra remediation by the school; some were in resource withdrawal for remedial reading, and some were in learning disability classes.

3. Alternate Computer Trained Control Group

These subjects were provided with computer programs concerned with some aspect of language arts development for three half-hour sessions per week (1.5 hours weekly) for a maximum of 30 hours. All were teacher trained. The list of programs made available to the teachers involved is provided in Table 7.10. These programs were selected following consultation with specialists within each board. Further, the teachers were permitted to use whatever other programs for language arts they preferred. It was not specified that the training had to be given individually. The reason for including this group was predominantly to control for the placebo effect of working on

Table 7.10
List of programs made available for the Alternate Computer Trained Control group.

Bank Street Writer
Fay's Word Rally
Missing Links
The Puzzler
Reading Development
Sesame Street
Spelling A-M
Square Pairs
Wordflash
Word Man
Word Master
Wordrace
Write One
Writing a Narrative

computer programs related to language arts develoopment.

Ethical Considerations

The initial approval to carry out this study was given by the Ministry of Education, Ontario. Informed, written consent for individual children to participate was obtained from the parents. This involved consent for the initial screening phase, and consent to participate in the training procedures. An explanation of the assessment and training procedures was provided. Written results of testing of all children were made available to the board contact person to be provided to each school principal. A final written report of the results of the study will be given to each participating board.

There were no requirements for participation in the study other than those described above. This permitted all subjects (Autoskill Trained, Untrained Controls, and Alternate Computer Trained Controls) to be maintained in their regular school program, including any type of remedial assistance deemed necessary by the respective school personnel.

CHAPTER 8

Results

Comparison of the total Autoskill Trained group and the Untrained Control group.

Reading tests

It was predicted *a priori* that the Autoskill Trained subjects would be significantly improved on the reading tests in comparison to the Untrained Control subjects. These planned comparisons were based on theoretical rationale as well as results from the pilot field trial study as described in the Introduction section. Simple difference scores were calculated for each of the reading variables for both groups by subtracting the pretest from the posttest for each subject on each variable (Kirk, 1968; Miller, 1966). The t-values were computed using the SPSSx procedure T-TEST for independent samples (SPSSx Inc., 1983). The T-TEST program tests for homogeneity of variance, and where the variance for the two samples was found to be unequal, an approximation to "t" was calculated based on a separate variance estimate of the population variance. Since the direction of the expected differences was also predicted a *priori*, one-tailed probability levels were selected.

Table 8.1 summarizes the results of these analyses: In contrast to the Untrained Control group, the Autoskill Trained group was significantly improved on measures of reading word recognition ($t=3.98$, $p=0.000$); phonetic knowledge of letters and syllables ($t=2.63$, $p=0.005$); paragraph reading at the reading word recognition level, specifically reduction of errors

Table 8.1
Simple difference score means and standard deviations for the reading tests for the total Autoskill Trained group and the Untrained Control group with significant t-scores.

Reading Tests		Total Autoskill Trained Group M	(SD)	Untrained Control Group M	(SD)
WRAT-R Reading Subtest					
Grade Equivalent ***		1.2	(0.9)	0.3	(0.9)
Standard Score ***		7.8	(6.4)	0.7	(7.1)
G-E Phonetic Knowledge					
Phonic Syllables **		8.6	(7.5)	3.4	(6.8)
Phonic Words		12.7	(8.7)	9.2	(9.9)
SPIRE Paragraphs					
Word Recognition Level					
Oral	Errors *	- 5.1	(5.2)	- 2.5	(5.1)
	Latency *	- 57.5	(72.3)	-27.8	(46.3)
	Retention **	2.3	(1.9)	1.0	(1.4)
	Comprehension	1.5	(1.6)	0.9	(1.2)
Silent	Latency *	- 36.4	(44.6)	-14.2	(39.5)
	Retention	2.2	(2.2)	1.5	(2.5)
	Comprehension *	1.3	(1.8)	0.4	(1.1)
Projected Grade Level					
Oral	Errors *	- 8.8	(8.1)	- 4.7	(8.7)
	Latency **	-102.5	(73.3)	-56.5	(53.9)
	Retention **	1.9	(2.1)	0.3	(2.6)
	Comprehension ***	1.5	(1.7)	- 0.5	(1.5)
Silent	Latency **	- 42.5	(47.0)	-13.5	(33.6)
	Retention **	1.8	(2.2)	0.3	(2.4)
	Comprehension **	1.3	(1.8)	- 0.1	(2.0)
QASOR CLOZE					
Word Recognition Level					
Meaning **		11.7	(25.4)	- 7.6	(23.9)
Graphic Sense		- 9.7	(34.6)	- 1.7	(27.8)
Fluency ***		32.6	(17.5)	17.3	(15.5)
Projected Grade Level					
Meaning		1.1	(10.4)	- 3.7	(7.9)
Graphic Sense *		4.9	(15.3)	- 3.4	(18.6)
Fluency *		26.6	(12.2)	18.7	(14.6)

*** $p \leq 0.001$ ** $p \leq 0.01$ * $p \leq 0.05$

(t=-1.85, p=0.034) and greater speed (t=-2.10, p=0.021); improved retention of the paragraph read aloud (t=2.67, p=0.005); greater speed (t=-1.88, p=0.032), and comprehension (t=2.51, p=0.008) of the paragraph read silently; paragraph reading at the projected grade level, specifically reduction of errors (t=-1.72, p=0.046), greater speed (t=-2.25, p=0.014), retention (t=2.55, p=0.007) and comprehension (t=4.03, p=0.000) of the paragraphs read aloud, as well as greater speed (t=-2.23, p=0.015), retention (t=2.26, p=0.015) and comprehension (t=2.72, p=0.004) of paragraphs read silently. Finally on the cloze passages, there was a significantly greater number of meaningful inserted words (t=2.83, p=0.003) and speed (t=3.29, p=0.000) at the word recognition level. At the projected grade level there was greater speed (t=2.08, p=0.020) and the inserted words closely approximated the graphic representation of the appropriate word (t=1.74, p=0.045), and there were greater meaningful insertions (t=1.62, p=0.056). The raw score means and standard deviations for both groups at pre- and posttesting are provided in Table 8.2.

Word recognition reading skills were improved by 1.2 grade levels for the Autoskill Trained group from a mean of 3.0 to 4.2 grade levels versus 0.3 of a grade level for the Untrained Control group from a mean of 3.2 to 3.5 grade levels indicating approximately four times improvement in word recognition reading skills for the Autoskill trained group. The corresponding standard score improved by 7.8% for the Autoskill Trained group which represents half a standard deviation. Phonetic knowledge

Table 8.2
Means and standard deviations for the reading tests for the total Autoskill Trained group and the Untrained Control group.

Reading Tests	Total Autoskill Trained Group Pre M(SD)	Total Autoskill Trained Group Post M(SD)	Untrained Control Group Pre M(SD)	Untrained Control Group Post M(SD)
WRAT-R Reading Subtest				
Grade Equivalent	3.0 (0.9)	4.2 (1.4)	3.2 (1.1)	3.5 (1.4)
Standard Score	72.9 (9.6)	80.6(10.5)	77.6 (8.7)	78.3 (10.9)
G-E Phonetic Knowledge				
Phonic Syllables	55.8 (12.0)	64.4 (9.7)	56.3(13.4)	59.7 (14.6)
Phonic Words	47.7 (21.4)	60.5(20.5)	48.3(27.1)	57.5 (23.4)
SPIRE Paragraphs				
Word Recognition Level				
Oral				
Errors	8.8 (7.8)	3.7 (3.9)	8.1(10.5)	5.5 (5.9)
Latency	132.3(106.3)	74.8(42.0)	110.3(90.7)	82.5 (49.5)
Retention	5.7 (2.2)	8.0 (1.8)	5.9 (2.4)	6.9 (2.7)
Comprehension	7.8 (2.1)	9.3 (1.3)	7.7 (2.5)	8.6 (2.1)
Silent				
Latency	111.1 (76.0)	74.6(40.3)	82.1(36.2)	67.9 (29.8)
Retention	5.3 (2.5)	7.5 (1.7)	5.2 (2.7)	6.7 (2.3)
Comprehension	8.0 (2.2)	9.2 (1.6)	8.6 (2.3)	9.0 (2.2)
Projected Grade Level				
Oral				
Errors	22.9 (13.3)	14.1(12.5)	19.1(15.1)	14.4 (8.6)
Latency	270.4(118.7)	167.9(57.7)	226.2(92.1)	169.7(108.7)
Retention	4.3 (2.0)	6.2 (2.1)	4.6 (2.1)	4.9 (2.4)
Comprehension	6.6 (2.4)	8.1 (1.8)	7.6 (1.8)	7.1 (2.1)
Silent				
Latency	171.5 (64.3)	136.2(69.1)	128.9(32.6)	122.7 (49.8)
Retention	3.8 (2.3)	5.7 (2.3)	4.9 (1.7)	5.3 (2.1)
Comprehension	5.7 (2.3)	7.1 (2.1)	6.7 (2.2)	6.5 (2.4)
QASOR Cloze				
Word Recognition Level				
Meaning	17.9 (11.8)	29.5(23.5)	24.7(18.9)	17.0 (14.9)
Graphic Sense	41.1 (20.2)	31.4(29.3)	51.3(20.0)	49.6 (24.8)
Fluency	61.6 (26.8)	94.4(32.7)	72.8(24.6)	90.1 (34.9)
Projected Grade Level				
Meaning	11.8 (7.3)	12.9 (8.5)	11.7 (6.6)	8.0 (7.1)
Graphic Sense	30.3 (10.0)	35.2(14.3)	40.1(16.7)	36.6 (13.9)
Fluency	52.3 (20.3)	78.8(24.2)	55.1(22.9)	73.8 (29.7)

of letters and syllables was improved 8.6% for the Autoskill Trained group versus 3.4% for the Untrained Control group, again indicating better performance for the Autoskill Trained group. Phonetic knowledge of words was improved by 12.8% for the Autoskill Trained group which is a good gain, however, the Untrained Control group also improved by 9.2% and the difference was not statistically significant. With regard to paragraph reading skills, the Autoskill Trained group was significantly improved on five of the seven measures at the word recognition level, while the Untrained Control group made no significant gains. The striking finding was with performance of the Autoskill Trained group on paragraphs at the projected grade level, and all seven measures were significantly improved in contrast to no significant gains for the Untrained Control group. Further, the Autoskill Trained group performed significantly better on cloze passages on two of the three measures for both the word recognition level passages and all three measures at the projected grade level.

The Autoskill Trained group, therefore, made significant gains in performance on a variety of reading tasks in contrast to the Untrained Control group. It had been anticipated that the Autoskill Trained group would do significantly better than the Untrained Control group, however, it was not expected that the contrast in performance of the two groups would be so remarkable. Even though the sample size differences were accounted for in the statistical analyses, it was a concern that this may have been a factor in the obtained results. In order to rule out this possibility completely, a subsample of the Autoskill Trained group was selected and matched with the Untrained Control group on the variables: Full Scale IQ, age, sex, and projected reading grade delay in reading word recognition. The same analyses as in the first set of comparisons were carried out. There were no significant differences in Verbal IQ (91.6 versus 90.2), Performance IQ (100.5 versus 101.6), and WRAT-R reading grade level at pretest (2.8 versus 3.1) for the matched Autoskill Trained subsample and the Untrained Control groups, respectively. The same pattern of significant improvement for the Autoskill Trained group was obtained with the matched Control comparisons as with the total Autoskill Trained group comparisons. The single exception was on the QASOR test. Rate of reading cloze passages at the word recognition level was the only significant improvement for the matched Autoskill Trained group (35.8 versus 17.3 for the Untrained Control group, t=3.38, p=0.001).

Comparison of the three Autoskill Trained subtypes and the Untrained Control group

Reading Tests

There were no specific predictions as to which of Type O, Type A, or Type S would perform better than the Untrained Control group in relation to each other on the reading tests.

A series of ANOVAs on the difference scores were carried out using the SPSSx subprogram ONEWAY (SPSSx, Inc., 1983). Even though the comparisons of each respective subtype with the Untrained Control group were planned and a more powerful statistical procedure could have been applied, it was considered that because the same means would be used again for the comparison of the three subtypes to each other, it would be preferable to set a more stringent level of protection against Type 1 errors. Therefore all pairwise comparisons were made using Tukey's Honestly Significant Difference test (HSD) after attaining an overall significant F ratio (Kirk, 1968).

Table 8.3 summarizes the simple difference score mean and standard deviations for Types O, A, and S and the Untrained Control group. Overall significant values were obtained on the measure of word recognition (both grade equivalent ($F=5.8$, $p=0.001$) and standard score ($F=5.1$, $p=0.003$), phonetic knowledge of syllables ($F=3.3$, $p.=0.025$); word recognition paragraph reading errors ($F=3.3$, $p=0.025$) and retention ($F=3.4$, $p=0.021$) for oral reading, speed ($F=2.9$, $p=0.042$) and comprehension ($F=5.2$, $p=0.003$) for silent reading; projected grade level oral reading retention ($F=3.8$, $p=0.015$) and comprehension ($F=5.8$,

Table 8.3
Simple difference score means and standard deviations for the reading tests for Types O, A, and S and the Untrained Control group with overall significance from ANOVAs indicated as well as the results of the pairwise comparisons.

Reading Tests	Type O(O) M (SD)	Type A(A) M (SD)	Type S(S) M (SD)	Untrained(UC) M (SD)	Pairwise Comparison
WRAT-R Reading Subtest					
Grade Equivalent**	1.4 (0.8)	1.0 (0.8)	1.1 (1.0)	0.3 (0.9)	O,A,S>UC
Standard Score ***	9.0 (6.6)	7.5 (5.6)	6.6 (6.8)	0.7 (7.1)	O,A,S>UC
G-E Phonetic Knowledge					
Phonic Syllables*	10.3 (7.1)	6.7 (7.9)	8.4 (7.4)	3.4 (6.8)	O>UC
Phonic Words	12.4 (8.9)	13.2 (7.8)	12.8 (9.5)	9.2 (9.9)	
SPIRE Paragraphs					
Word Recognition Level					
Oral					
Errors *	-3.3 (4.2)	-5.5 (5.0)	-6.8 (5.8)	-2.5 (5.1)	S>UC
Latency	-36.0(32.5)	-67.1(93.6)	-72.8(80.2)	-27.8(46.3)	
Retention *	1.8 (1.7)	2.4 (1.8)	2.7 (2.1)	1.0 (1.4)	S>UC
Comprehension**	1.2 (1.5)	1.4 (1.2)	1.9 (2.0)	0.9 (1.2)	
Silent					
Latency *	22.0(24.1)	-41.3(39.7)	-48.0(60.3)	-14.2(39.5)	
Retention	1.8 (1.8)	2.0 (2.7)	2.7 (2.3)	1.5 (2.5)	
Comprehension**	0.8 (1.6)	0.8 (1.2)	2.2 (2.2)	0.4 (1.1)	S>UC,O,A
Projected Grade Level					
Oral					
Errors	-9.0 (8.6)	-8.7 (8.5)	-8.8 (7.3)	-4.7 (8.7)	
Latency	-105.4(78.5)	-98.8(60.9)	-102.6(84.4)	-56.5(53.9)	
Retention *	1.2 (2.1)	2.1 (2.1)	2.8 (1.6)	0.3 (2.6)	S>UC
Comprehension***	1.2 (1.7)	1.6 (1.5)	1.8 (2.0)	-0.5 (1.5)	O,A,S>UC
Silent					
Latency	-35.4(50.5)	-52.3(44.0)	-40.8(46.7)	-13.5(33.6)	
Retention	2.1 (2.3)	1.4 (2.5)	2.1 (1.8)	0.3 (2.4)	
Comprehension*	1.6 (1.8)	1.3 (2.0)	1.0 (1.6)	-0.1 (2.0)	O>UC
QASOR Cloze					
Word Recognition Level					
Meaning **	5.5(32.2)	19.9(25.3)	11.2(14.1)	-7.6(23.9)	O>UC
Graphic Sense	-10.7(33.9)	-14.2(32.1)	-4.9(38.0)	-1.8(27.8)	
Fluency *	32.3(20.5)	31.8(16.5)	33.5(15.5)	17.3(15.5)	O,S>UC
Projected Grade Level					
Meaning	-1.7 (7.2)	4.4 (9.8)	1.0(14.9)	-3.7 (7.9)	
Graphic Sense	6.7(15.4)	5.7(12.5)	0.2(19.4)	-3.4(18.6)	
Fluency	25.4(12.0)	27.7(14.6)	27.0 (9.0)	18.7(14.6)	

*** p=<0.001 ** p=<0.01 * p=<0.05

p=0.001) as well as silent reading comprehension (F=2.7, p=0.05); and finally word recognition level cloze passages meaning (F=4.0, p=0.011) and fluency (F=3.6, p=0.018).

The pairwise comparisons indicated that all three subtypes were significantly improved in comparison to the Untrained Control group on the measures of word recognition and comprehension of orally read passages at the projected grade level. There were no significant differences among the three subtypes on these tests. Type O was significantly improved in comparison to the Untrained Control group on measures of phonetic knowledge of syllables, comprehension of silently read passages at the projected grade level and fluency of cloze passages at the word recognition grade level. Type S was significantly improved on several measures in comparison to the Untrained Control group including greater accuracy and retention of orally read paragraphs and comprehension of silently read paragraphs at the word recognition level, retention of orally read paragraphs at the projected grade level, as well as fluency of cloze passages at the word recognition level. The only significant subtype difference was obtained on comprehension of silently read paragraphs at the word recognition level. Type S was more improved on this measure than Type O and Type A. There were no group differences in rate of silent reading of paragraphs at the word recognition level even though the overall F was significant.

Table 8.4 summarizes the pretest and posttest mean scores for the three Autoskill trained subtypes and the Untrained

Table 8.4
Pretest and posttest mean scores and standard deviations for reading test for the three Autoskill Trained subtypes and the Untrained Control group.

Reading Tests		Type O M (SD)	Type A M (SD)	Type S M (SD)	Untrained M (SD)
WRAT-R Reading Subtest					
Grade Equivalent	Pre	3.3 (1.0)	2.8 (0.7)	2.7 (1.0)	3.2 (1.1)
	Post	4.7 (1.3)	3.9 (1.2)	3.8 (1.7)	3.5 (1.4)
Standard Score	Pre	74.4 (8.2)	73.8 (9.9)	70.5 (10.8)	77.6 (8.7)
	Post	83.3 (8.4)	81.3 (9.2)	77.1 (12.6)	78.3 (10.9)
G-E Phonetic Knowledge					
Phonic Syllables	Pre	57.2 (10.9)	59.3 (12.4)	51.4 (11.8)	56.3 (13.4)
	Post	67.5 (7.0)	66.0 (9.7)	59.8 (10.8)	59.7 (14.6)
Phonic Words	Pre	53.7 (16.1)	49.2 (21.1)	40.0 (24.9)	48.3 (27.1)
	Post	66.1 (15.4)	62.4 (22.3)	52.8 (22.1)	57.5 (23.4)
SPIRE Paragraphs					
Word Recognition Level					
Oral					
Errors	Pre	7.0 (5.3)	8.1 (6.9)	11.4 (10.1)	8.1 (10.5)
	Post	3.7 (3.0)	2.7 (3.3)	4.6 (5.0)	5.5 (5.9)
Latency	Pre	106.2 (48.8)	141.2 (123.6)	153.3 (131.8)	110.3 (90.7)
	Post	70.2 (31.6)	74.1 (33.2)	80.4 (56.9)	82.5 (49.5)
Retention	Pre	6.3 (2.2)	6.0 (2.0)	4.7 (2.2)	5.9 (2.4)
	Post	8.2 (1.3)	8.4 (1.8)	7.4 (2.2)	6.9 (2.7)
Comprehension	Pre	8.3 (1.5)	8.0 (2.0)	7.0 (2.6)	7.7 (2.5)
	Post	9.6 (0.9)	9.3 (1.3)	8.9 (1.7)	8.6 (2.1)
Silent					
Latency	Pre	96.6 (40.2)	113.2 (67.6)	125.0 (106.8)	82.1 (36.2)
	Post	74.6 (32.5)	71.9 (34.5)	7[illegible].0 (52.2)	67.9 (29.8)
Retention	Pre	5.6 (2.0)	5.6 (2.7)	4.8 (2.8)	5.2 (2.7)
	Post	7.4 (1.7)	7.5 (2.1)	7.5 (2.1)	6.7 (2.3)
Comprehension	Pre	8.6 (1.3)	8.4 (1.8)	7.0 (3.0)	8.6 (2.3)
	Post	9.3 (1.1)	9.2 (1.7)	9.1 (1.9)	9.0 (2.2)
Projected Grade Level					
Oral					
Errors	Pre	25.3 (16.3)	22.3 (11.4)	19.8 (10.0)	19.1 (15.1)
	Post	16.3 (13.8)	13.6 (14.2)	11.1 (6.7)	14.4 (8.6)
Latency	Pre	285.7 (136.0)	266.1 (100.2)	251.3 (116.8)	226.2 (92.1)
	Post	180.3 (67.0)	167.3 (57.0)	148.7 (37.1)	169.7 (108.7)
Retention	Pre	4.5 (2.1)	4.6 (1.8)	3.7 (1.5)	4.6 (2.1)
	Post	5.7 (2.4)	6.7 (1.7)	6.5 (1.9)	4.9 (2.4)
Comprehension	Pre	6.4 (2.8)	6.8 (1.6)	6.7 (2.6)	7.6 (1.8)
	Post	7.6 (2.3)	8.4 (1.2)	8.5 (1.5)	7.1 (2.1)
Silent					
Latency	Pre	167.2 (68.5)	180.3 (67.2)	166.5 (57.4)	136.2 (69.1)
	Post	131.8 (30.2)	128.0 (37.5)	125.8 (31.5)	122.7 (49.8)
Retention	Pre	3.5 (2.5)	3.9 (1.7)	4.3 (2.6)	4.9 (1.7)
	Post	5.6 (2.7)	5.3 (2.3)	6.4 (1.7)	5.3 (2.1)
Comprehension	Pre	5.5 (2.4)	5.5 (2.1)	6.5 (2.6)	6.7 (2.2)
	Post	7.1 (2.1)	6.8 (2.4)	7.5 (1.6)	6.5 (2.4)

Table 8.4 continued

Reading Tests		Type O M (SD)	Type A M (SD)	Type S M (SD)	Untrained M (SD)
QASOR Cloze					
Word Recognition Level					
Meaning	Pre	21.8 (10.8)	15.8 (8.9)	15.5 (14.2)	24.7 (18.9)
	Post	27.3 (26.4)	35.7 (24.9)	26.7 (18.9)	17.0 (14.9)
Graphic Sense	Pre	44.9 (20.3)	35.7 (17.0)	41.7 (22.4)	51.3 (20.0)
	Post	34.2 (27.6)	21.6 (29.8)	36.8 (29.8)	49.6 (24.8)
Fluency	Pre	68.1 (22.0)	60.1 (29.3)	56.6 (28.9)	72.8 (24.6)
	Post	100.4 (28.9)	91.9 (34.1)	90.1 (35.6)	90.1 (34.9)
Projected Grade Level					
Meaning	Pre	12.7 (7.3)	9.1 (5.9)	14.6 (8.4)	11.7 (6.6)
	Post	11.0 (6.9)	13.5 (8.6)	15.6 (10.8)	8.0 (7.1)
Graphic Sense	Pre	27.1 (8.5)	31.4 (10.3)	34.5 (11.0)	40.1 (16.7)
	Post	33.8 (12.8)	37.1 (13.9)	34.7 (18.3)	36.6 (13.9)
Fluency	Pre	51.8 (19.5)	52.6 (20.4)	52.5 (23.5)	55.1 (22.9)
	Post	77.3 (26.7)	80.2 (25.3)	79.4 (19.0)	73.8 (29.7)

Control group. Worthy of note is the consistent trend of greater improvement for each of Type O, A, and S in contrast to the performance of the Untrained Control group.

Autoskill Component Reading Subskills Test Program

In order to determine if the training resulted in significant improvement in performance on the measures of the Autoskill Component Reading Subskills Test Program on the respective procedures on which each subtype was trained in contrast to the Untrained Control group, a series of ANOVAs were carried out. Difference scores were used and Tukey's HSD pairwise comparisons were made after attaining an overall significant F ratio as in the previous analyses. In keeping with the findings of the first pilot field trial study, it was predicted that Type O and Type A would be significantly improved in accuracy on the oral reading and auditory-visual matching-to-sample procedures respectively and Type S would be significantly faster on the visual matching procedure.

It can be seen in Table 8.5 that in fact these predicted results were obtained. Further, each of the subtypes was also significantly improved on these specific measures in comparison to the other subtypes. This means that Type O subjects performed more accurately on the oral reading procedure tasks in comparison to the Untrained Control group as well as in comparison to Type A and Type S subjects (overall $F=12.74$, $p=0.000$). Type A subjects performed more accurately on the auditory-visual matching procedure tasks in comparison to the Untrained Control group and Type O and Type S subjects (overall $F=17.08$, $p=0.000$). Type S

Table 8.5
Means and standard deviations of the difference scores for the Autoskill test procedures for Types O, A, and S and the Untrained Control group with overall significance from ANOVAs indicated as well as the results of the pairwise comparisons.

Autoskill Test Procedures	Type O(O) M (SD)	Type A(A) M (SD)	Type S(S) M (SD)	Untrained Control (UC) M (SD)
Oral Reading				
Errors ***	-22.0 (9.2) O>UC,A,S	-13.3 (8.5) A>UC	-12.5 (9.1)	-5.4 (6.7)
Latency *	-527.4(297.5)	-341.4(282.0)	-348.7(335.0)	-284.6(297.4)
Auditory-Visual Matching				
Errors ***	-6.2 (6.4)	-16.4 (8.0) A>UC,O,S	-2.7 (6.5)	-5.5 (5.2)
Latency***	-360.3(274.3)	-584.9(481.0)	-864.0(712.3) S>UC,O	-248.7(428.8)
Visual-Matching				
Errors	1.6 (5.0)	-2.8 (7.8)	-1.2 (5.8)	-2.1 (5.8)
Latency***	-419.6(250.1)	-444.6(434.6)	-1159.5(735.3) S>UC,O,A	-333.1(760.8)

*** $p \leq 0.001$ * $p \leq 0.05$

subjects were faster in their completion of the visual matching procedure tasks in comparison to the Untrained Control group as well as Type O and Type A subjects (overall F=10.481, p=0.000). With regard to the transfer of training effect, although there was a significant overall F (overall F=2.67, p=0.05) for the latency of oral reading procedures, there were no significant pairwise comparisons. However, in evaluating the trend of the mean difference scores among the four groups, Types O, A, and S each made greater improvement in speed in comparison to the Untrained Control group and Type O made the greatest gains of all the groups.

There was a significant improvement in latency on the auditory-visual matching procedure tasks (overall F=6.15, p=0.001). Type S subjects were significantly faster in comparison to the Untrained Control group and Type O subjects. This finding was surprising since it might be considered that if any group was to make significant gains it would be Type A. An evaluation of the pretest raw scores on this measure in Table 8.6 indicated that Type S was the slowest of all groups at pretest. The improved performance at posttest may be reflecting a transfer of training effect on the visual matching procedure to the auditory-visual matching procedure and in view of the fact that Type S was the group with room for greatest improvement, this may have been a factor.

There was no significant reduction in errors on the visual matching tasks. This finding was in keeping with previous results and may be explained on the basis of the very high level

Table 8.6
Means and standard deviations of the raw scores for the Autoskill test procedures for Types O, A, and S and the Untrained Control group at pretest and posttest.

Autoskill Test Procedures		Type O M (SD)	Type A M (SD)	Type S M (SD)	Untrained Control M (SD)
Oral Reading					
Errors	Pre	35.5 (11.7)	34.6 (14.2)	39.1 (17.8)	38.0 (20.7)
	Post	13.5 (9.0)	21.3 (17.4)	26.7 (18.3)	32.6 (19.8)
Latency	Pre	1691.2(492.3)	1858.7(750.7)	1986.3(1079.3)	1745.3(387.2)
	Post	1163.8(334.2)	1517.3(715.2)	1637.6 (969.2)	1460.7(264.3)
Auditory-Visual Matching					
Errors	Pre	22.7 (7.0)	26.5 (9.3)	25.6 (10.9)	27.1 (11.2)
	Post	16.5 (6.6)	10.0 (5.3)	22.9 (10.5)	21.6 (9.8)
Latency	Pre	1877.2(312.1)	2001.1(523.9)	2347.5 (866.6)	1978.4(563.7)
	Post	1516.9(389.4)	1416.2(561.9)	1483.5 (433.6)	1729.7(480.3)
Visual Matching					
Errors	Pre	4.5 (3.1)	8.5 (8.0)	9.0 (5.6)	9.4 (11.5)
	Post	6.1 (3.7)	5.7 (4.3)	7.9 (5.2)	7.3 (6.6)
Latency	Pre	1819.0(453.8)	1884.1(459.3)	2410.5 (917.6)	1976.5(936.6)
	Post	1399.5(397.3)	1439.5(586.8)	1251.0 (311.1)	1643.5(323.5)

of performance at pretest as indicated in Table 8.6.

The pairwise comparisons also indicated that Type A subjects made significantly fewer errors on the oral reading tasks in comparison to the Untrained Control group as indicated in Table 8.5.

Comparison of the Autoskill Trained subsample and the Alternate Computer Trained Control group.

In the comparison of the Autoskill Trained subsample with the Alternate Computer Trained Control group, the simple difference scores were calculated for each of the reading test variables and t-tests were carried out using SPSSx T-TEST program (SPSSx Inc., 1983). Table 8.7 summarizes the simple difference score means and standard deviations for both groups and the significant results are indicated. Table 8.8 summarizes the pretest and posttest raw score means and standard deviations for both groups.

The Autoskill Trained subsample was significantly improved on the measure of reading word recognition, and a reduction of errors, and increased speed in oral reading of paragraphs at the word recognition grade level and the projected grade level was observed. There was a significant improvement of 6.3 standard scores in word recognition reading skills from a mean of 72.0 to 78.3 for the Autoskill Trained subsample in contrast to the gain of 1.0 standard scores from a mean of 78.3 to 79.4 for the Alternate Computer Trained Control group (t=2.68). The reduction in errors and increased speed in the oral reading of paragraphs was 4.0 errors versus 1.3 errors (t=2.98) and 43.6 seconds versus 15.0 seconds (t=2.75) at the word recognition level and 12.7 errors versus 2.8 errors (t=3.10) and 110.2 seconds versus 40.9 seconds (t=2.67) at the projected grade level. There were no other significant differences.

In evaluating the mean gains of each group on the other

Table 8.7
Mean simple difference scores and standard deviations for the reading tests for the Autoskill trained subsample and the Alternate Computer Trained control group with significant results based on t-tests.

Reading Tests		Autoskill Trained Subsample M (SD)	Alternative Computer Trained Control Group M (SD)
WRAT-R Reading Subtest			
Grade Equivalent		0.8 (0.7)	0.4 (0.9)
Standard Score **		6.3 (6.3)	1.0 (7.3)
G-E Phonetic Knowledge			
Phonic Syllables		6.3 (7.7)	5.3 (9.3)
Phonic Words		12.2 (9.2)	8.5 (7.3)
SPIRE Paragraphs			
Oral	Errors **	-4.0 (3.3)	-1.3 (3.1)
	Latency **	-43.6 (38.5)	-15.0(31.2)
	Retention	0.9 (2.2)	1.5 (1.9)
	Comprehension	1.0 (1.3)	0.5 (1.2)
Silent	Latency	-24.4 (26.8)	-15.3(18.1)
	Retention	1.4 (2.0)	1.4 (2.8)
	Comprehension	1.2 (1.8)	1.0 (1.4)
Projected Grade Level			
Oral	Errors **	-12.7 (13.7)	-2.8 (4.3)
	Latency **	-110.2(101.3)	-40.9(57.9)
	Retention	0.9 (1.9)	1.3 (1.9)
	Comprehension	1.4 (2.1)	1.2 (1.9)
Silent	Latency	-4.9 (46.5)	-3.0(50.1)
	Retention	2.1 (1.7)	1.2 (2.2)
	Comprehension	1.5 (1.7)	0.8 (2.2)

** $p < 0.01$

Table 8.8
Pretest and posttest means and standard deviations for the reading tests for the Autoskill Trained subsample and the Alternate Computer Trained Control group.

Reading Tests	Autoskill Trained Subsample Pre M(SD)	Autoskill Trained Subsample Post M(SD)	Alternative Computer Trained Control Group Pre M(SD)	Alternative Computer Trained Control Group Post M(SD)
WRAT-R Reading Subtest				
Grade Equivalent	2.8 (0.7)	3.5 (1.0)	3.3 (0.8)	3.8 (1.2)
Standard Score	72.2 (10.2)	78.3 (9.5)	78.3 (8.3)	79.4 (10.4)
G-E Phonetic Knowledge				
Phonic Syllables	54.5 (10.5)	60.8 (9.5)	63.8 (10.6)	69.1 (8.4)
Phonic Words	44.7 (20.7)	56.9 (20.2)	60.8 (16.7)	69.3 (14.3)
SPIRE Paragraphs				
Word Recognition Level				
Oral				
Errors	8.2 (5.0)	4.2 (3.2)	4.6 (3.8)	3.3 (1.6)
Latency	123.6 (61.9)	80.0 (32.8)	78.0 (43.7)	63.1 (19.5)
Retention	5.6 (2.4)	6.5 (2.1)	6.2 (2.4)	7.7 (2.1)
Comprehension	7.8 (2.0)	8.9 (1.4)	8.3 (1.6)	8.8 (1.7)
Silent				
Latency	106.5 (47.0)	82.1 (39.9)	72.9 (27.1)	57.6 (17.6)
Retention	5.6 (2.6)	7.0 (2.1)	6.1 (2.5)	7.6 (1.7)
Comprehension	8.0 (2.1)	9.3 (0.9)	8.4 (1.9)	9.4 (1.0)
Projected Grade Level				
Oral				
Errors	30.7 (22.6)	18.0 (12.6)	14.7 (7.1)	11.9 (6.0)
Latency	344.9 (160.9)	234.8 (127.5)	213.8 (87.0)	172.9 (56.1)
Retention	3.9 (2.5)	5.0 (2.4)	4.8 (2.2)	6.3 (2.3)
Comprehension	5.8 (2.9)	7.1 (2.2)	6.7 (2.4)	7.9 (1.7)
Silent				
Latency	152.6 (64.0)	147.6 (58.5)	123.2 (56.4)	120.2 (45.3)
Retention	3.3 (2.8)	5.4 (2.1)	3.7 (2.1)	4.9 (2.5)
Comprehension	5.4 (2.4)	6.9 (1.9)	5.7 (2.3)	6.5 (2.2)

variables, there was a trend of better performance for both groups on many of the other measures, which seemed to be at a generally comparable level of gain for both groups. However, the Autoskill Trained subsample demonstrated greater gains on measures of phonetic knowledge of words (44.7% at pretest and 56.9% at posttest versus 60.8% at pretest and 69.3% at posttest for the Alternate Computer Trained Control group); and speed in reading silent passages at the word recognition level (106.7 seconds at pretest and 82.1 seconds at posttest versus 72.9 seconds at pretest and 57.6 at posttest for the Alternate Computer Trained Control group).

Teacher Evaluations

There were 35 teachers from 26 schools who participated as trainers of the Autoskill Component Reading Subskills Training Program. They were responsible for the training of 55 subjects in the Autoskill Trained group. There were 17 teachers who worked with 1 subject each, 11 who worked with 2 subjects each, and 5 who worked with 3 subjects each. Two teachers shared the responsibility of working with one subject. A preponderance of the teachers had special qualifications for teaching learning disabled students.

After approximately three weeks of experience in using the program the teachers were asked to complete a questionnaire involving an evaluation of several features of the program. Another questionnaire concerning attitudes about computers in general was also completed. Both questionnaires can be found in Appendix 8.1.

Several questions were concerned with the technical features of the program. There was 100% agreement that the format and procedures in the software were consistent, logical, and easy to use. This included such aspects as: Log-in and sign-off procedures, student registration, identification of students, following menu options, viewing results, screen displays, size of stimuli, ease of viewing, display of positive and negative responses, and graph structure. In addition, 96% reported that the software required only minimal computer expertise, was well documented, had an excellent graphing system of results for both testing and training, and excellent feedback for the student which was motivating. The organization and sequencing of the lessons were also highly commended.

A consistent negative criticism was the sound quality. Although all of the stimuli were recognizable, a majority of the teachers recommended that the clarity be improved. All of the stimuli for the auditory-visual matching procedure have since been rerecorded and appears to be improved.

Another concern for some of the teachers, particularly those in the Ottawa Roman Catholic Separate School board was the time commitment required. There were scheduling conflicts in arranging the half hour, three times per week to meet with their student. This was much less of an issue in the other two boards primarily because careful scheduling arrangements had been worked out with the teacher and the student. This issue appeared to be an administrative one. In a final analysis, only 2 of the 29 teachers surveyed or 6.9% indicated that the program was too demanding of teacher time. Overall the initial teacher evaluation of the Autoskill Component Reading Subskills Training Program was most positive.

A second evaluation form was completed in May, following approximately eight months of using the program. The final teacher evaluation form can be found in Appendix 8.2. Once again the overall response was very favourable. The majority of the teachers reported a positive appreciation of the program and 75.8% indicated that they would continue to use the program after the project was completed, another 13.7% indicated they probably would use it, and 6.8% indicated they would not or probably would not use it. Those in this latter group objected primarily to the time demands.

In response to the item about how many of the teachers would feel comfortable in training other teachers to use the program and providing answers to questions these new trainees may have in using the program, 86.2% answered "yes", 3.4% answered "maybe", and 10.3% answered "no". Despite the fact that such a large percentage of the teachers felt they were experienced to the point they could teach others to use the program, 44.8% indicated they would need back-up expertise, 6.9% indicated they possibly would need the back up, and 37.9% indicated they would not need further help.

Several teachers suggested that the program was not only appropriate for reading disabled children, but could be helpful in a variety of other problem areas. These included hearing impairment, short attention span, retrieval difficulties, language delayed, visual and/or auditory processing problems, primary grade students learning how to read, reluctant readers who needed stimulation and motivation, and slow learners.

There were also some recommendations for improvements to the program. Several teachers indicated that they would like to have the option of adding more content so that they could incorporate their own word lists and paragraphs. Some wished to include vocabulary from other subject areas such as geography, science and history. Others wished to include content conerning local events and interests as well as current events. Teachers using a Language Experience approach to reading suggested that new words being introduced to a student's vocabulary could be added. The teachers were not made aware that the program already had the option for new content files to be added by any user of the program. This was done to allow for maximum flexibility and adaptability of the program. However, this feature was not made available to the teachers during the course of the study since it was considered important to provide a uniform set of stimuli in the field trial investigation. It is encouraging, however, that this feature seems to be in demand and was spontaneously and independently suggested by the teachers.

There was a recommendation to include comprehension questions following the paragraphs. This was considered to be a very valuable suggestion and this feature has since been added to the program. Questions requiring factual information derived from the passages as well as inferential questions now follow each paragraph.

With regard to the question concerning whether or not there was compatibility of the Autoskill Component Reading Subskills Training Program with a Language Experience approach to reading, 55.2% responded "yes", 10.3% responded "maybe", 17.2% responded "no", and 6.9% responded "not sure". The inclusion of the new words that are being introduced to a student's vocabulary, or that are already a part of the student's vocabulary in a special content file was discussed previously as one means of a teacher using the Language Experience approach to make effective use of the Autoskill program. It was also suggested that the phrases, sentences, and paragraphs in the oral reading procedure could be used as "motivators" for story writing. In addition the children could write their own paragraphs to be included in the content file. Many teachers also stated that the skills developed through the use of the Autoskill program are important basics to any approach to teaching reading including a more "global" approach such as Language Experience. Further, there is no one way to teach reading and the students who fail to acquire reading skills through the Language Experience approach could benefit from a more structured skill-oriented program.

Those teachers who responded "no" to this question included reasons such as the approach used in the Autoskill program was too disassociated from the experience of the student and that there was not enough stress on comprehension and usage of the materials presented.

In response to the question about whether the Autoskill program was an effective use of computer technology, 27.6% did not answer this item and 72.4% responded "yes". Several comments included points already addressed in the first questionnaire. Other comments emphasized the benefit of the immediacy of response to correct and incorrect answers, the immediate summary of results following every trial, the use of graphs to chart progress over time, and the presentation of stimulus items at a very fast rate.

Some teachers commented negatively about the use of drill and repetition and that the effect can be boring with extended use. A greater number of teachers commented positively about this type of practice. Those who responded favourably emphasized challenging the student to "beat his own performance". The use of the graphs to show the progress was found to be very motivating as there could be a reduction of errors or a reduction in speed from one trial to the next. The use of hard copies of the graphs, printed out when particular success was achieved or when one level was completed enhanced the effectiveness of the graph. Some teachers had the students make up a book of their progress, bring home graphs "to put up on the refrigerator", or made bulletin board displays. Involving the student in the entire process in understanding the program was also considered important in maintaining motivation. Some teachers gave the students the responsibility of operating the computer and selecting their own files and programs.

Student Evaluations

Unfortunately, standard questionnaires were not administered to the students participating in the Autoskill training procedures. However, several of the students were interviewed by the researchers and the research assistants, and further, several teachers commented on their student's response to the program in the teacher evaluation forms. Although the comments were not attained according to a rigorous scientific method, they provide some insights about the response of several of the students.

The majority of the students seemed to like the program and several were very enthusiastic. When asked why, most answered similarly -- "because it helps me". There appeared to be a strong relationship between positive reactions to the program and progress. Those who thought they were doing well seemed to be more enthusiastic. It was also evident that those students who understood the nature of the training and the specific aims were more positive. Some subjects explained quite clearly why they were classified as a Type O, A, or S and why they were being trained on a specific procedure.

The graphing of results also impressed many of the students and they could explain for example how they started out with 30% errors and steadily progressed to 0% errors or how their latency scores were reduced. They were encouraged by seeing the "graph lines go down" and they liked having printouts of graphs that showed their success. They also liked having the hard copies to bring home to their parents or to keep in a book.

There were a variety of responses to the question: "How do you know the program is helping you?" One student described how he used to be in the low reading group in his class, but now was in the 'best' group. A Grade 5 student, after working on Grade 7 level words went to the Grade 7 teacher in his school and asked if he could try to read a Grade 7 level textbook. To his delight, and the surprise of the teacher, he read some passages very well. Another subject described how he used to skip words he couldn't read, but after working on the program tried to sound out all the words. Several students indicated that they felt better about their reading and were more self confident: "I used to be a dummy." "I'm more sure of myself." "I feel better now."

There were some students who felt they had progressed but still needed more improvement to catch up to the others. One student summarized it this way: "A step is a step but I'm getting there!"

Several students commented that it was "neat" working on a computer and enjoyed the experience of selecting their files and selecting various menu options.

There were a few who found the programs "boring". For the most part they were students who were not progressing through the levels very quickly or who were not attaining the accuracy or latency criteria and had to be moved along to the next level. There were also some students who not only found the program boring, but also school boring in general, including those who were frequently away sick or truant.

Case Studies

Two case studies are reported to illustrate the progress of two individual subjects.

Case 1

Table 8.9 summarizes the results for the first case. RS was a 12-year-old boy who was in Grade 6, but based on age expectation, the projected grade level was Grade 7. At the time of screening the WISC-R Verbal IQ was 90, Performance IQ was 100, and Full Score IQ was 93 indicating overall intellectual abilities within the average range. At pretest, reading word recognition skills were at the late Grade 3 level as measured by the WRAT-R indicating a projected grade delay of slightly over 3 years. Following the assessment on the Autoskill Component Reading Subskills Test Program, RS was classified as Type O reading disability subtype. As such he was placed on the oral reading progrm and received 58 hours of training over the course of one academic year. Figures 8.1 and 8.2 illustrate the pretest error and latency scores, respectively, for each of the subtests administered for each of the three procedures. Figures 8.3 and 8.4 illustrate the postest error and latency scores, respectively. It can be seen that there was considerable improvement in the error profile for the training procedure. Error rates were reduced on all of the subtests for the oral reading procedure. There was also some reduction in error rates for the auditory-visual matching procedure tasks, notably on those subtests where there was greater difficulty at pretest, specifically cv or vc syllables, cvc syllables and words, ccvc syllables and words, and cvcc syllables

Table 8.9
Case RS: Summary of reading test results.

NAME: RS TYPE O	58 HOURS OF TRAINING
GRADE: 6 PROJECTED GRADE: 7	AGE: 12 SEX: M

WESCHLER INTELLIGENCE SCALE FOR CHILDREN-REVISED
VIQ: 90 PIQ: 100 FSIQ: 93

	PRETEST	POSTTEST
WIDE RANGE ACHIEVEMENT TEST-REVISED		
(word recognition)		
Standard Score	78	91
Percentile	7	27
Grade Equivalent	3E	6B

STUDENT PROBLEM INDIVIDUAL READING	Pretest Oral		Pretest Silent		Posttest Oral		Posttest Silent	
EVALUATION GRADE LEVEL grade	3	7	3	7	3	7	3	7
(paragraph reading)								
Fluency (words per minute)	98	106	117	138	85	112	219	136
Comprehension (%age)	100	60	100	60	100	90	100	90
Retention (%age)	70	60	70	50	70	90	70	90

GALLISTEL-ELLIS TEST OF CODING SKILLS	PRETEST	POSTTEST
(phonetic knowledge)		
Sounds (%age) Total	68	82
1. Single Consonants	85	100
2. Vowels - Short Sounds	67	83
3. Common Consonant Combinations	77	92
4. Vowels - Long Sounds	83	100
5. Soft c,g,s; tch,dge	80	80
6. Common Vowel Combinations	55	64
7. Combinations of Vowel with R	60	80
Words (%age) Total	69	69
Single Syllables		
1. Closed Syll. - Single Cons. (cvc 'can')	100	96
2. Closed Syll. - Cons. Comb. (ccvcc 'chest'	80	90
3. Silent E & Open Syll. (cvcc 'tame' & cv 'me')	87	60
4. Soft c,g,s,; tch,dge ('cent' 'rage' 'catch')	87	73
5. Vowel Team Syllables (cvvc 'toil')	80	88
6. Vowel R. Syllables	73	80
More than One Syllable		
7. Words with Easy Endings s,ed,ing,er,est,y	60	56
8. cle Syll. & Common Suffixes 'candle' 'nation'	60	72
9. Multisyllable Words	12	16
Phonetically Irregular Words	90	95

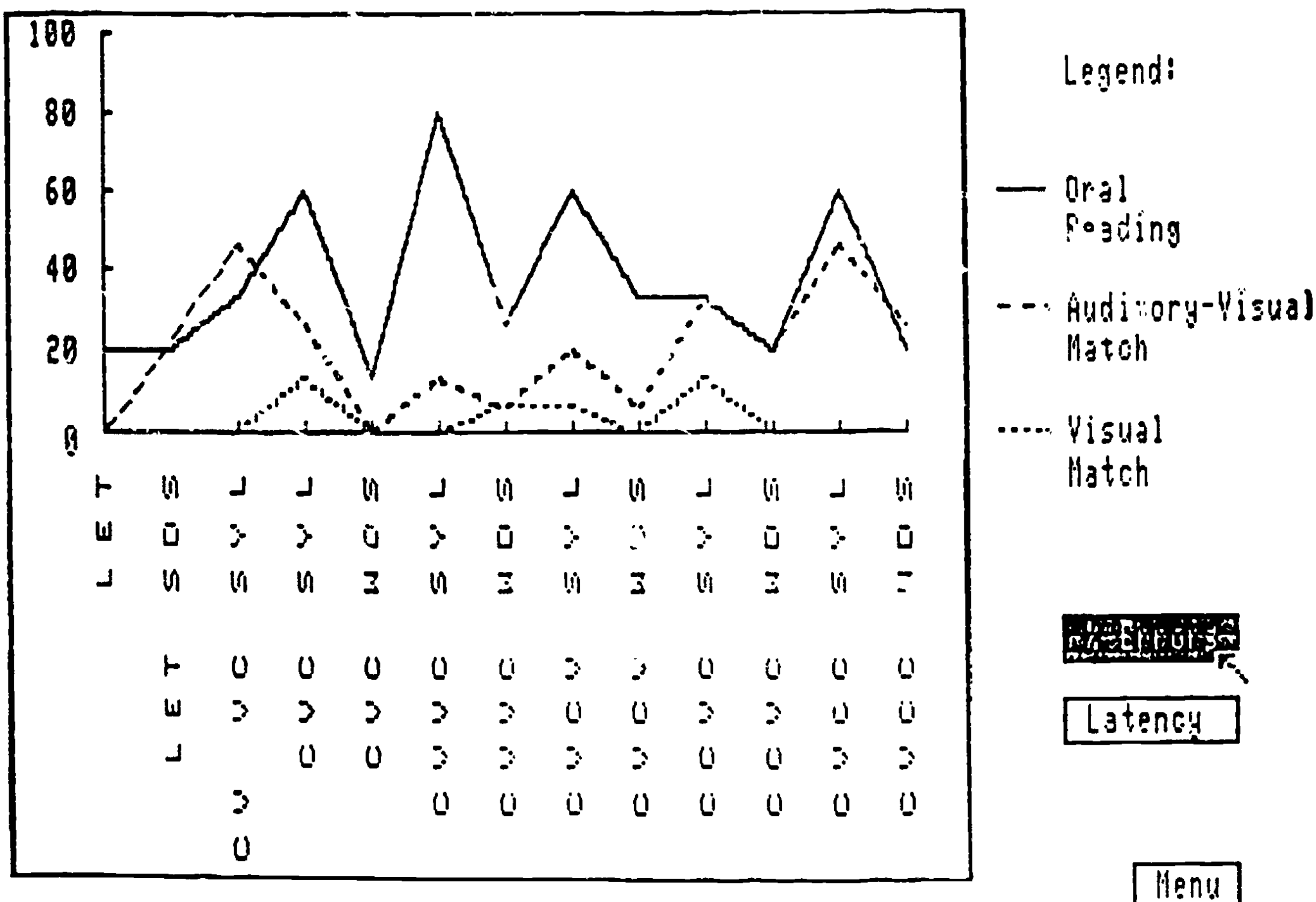


Figure 8.1
Autoskill Component Reading Subskills Test Program error profile for case RS at pretest.

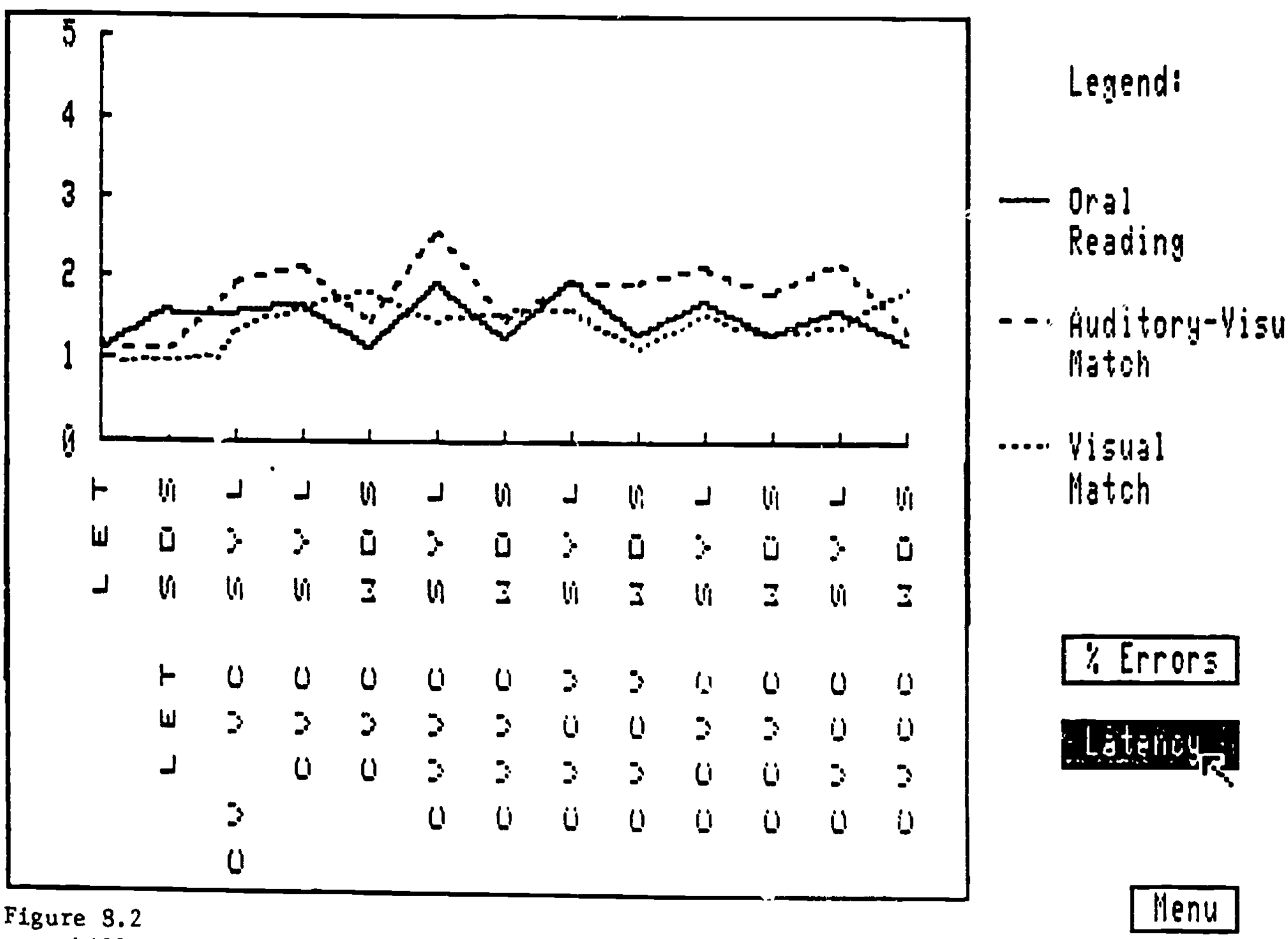


Figure 8.2
Autoskill Component Reading Subskills Test Program latency profile for case KS at pretest.

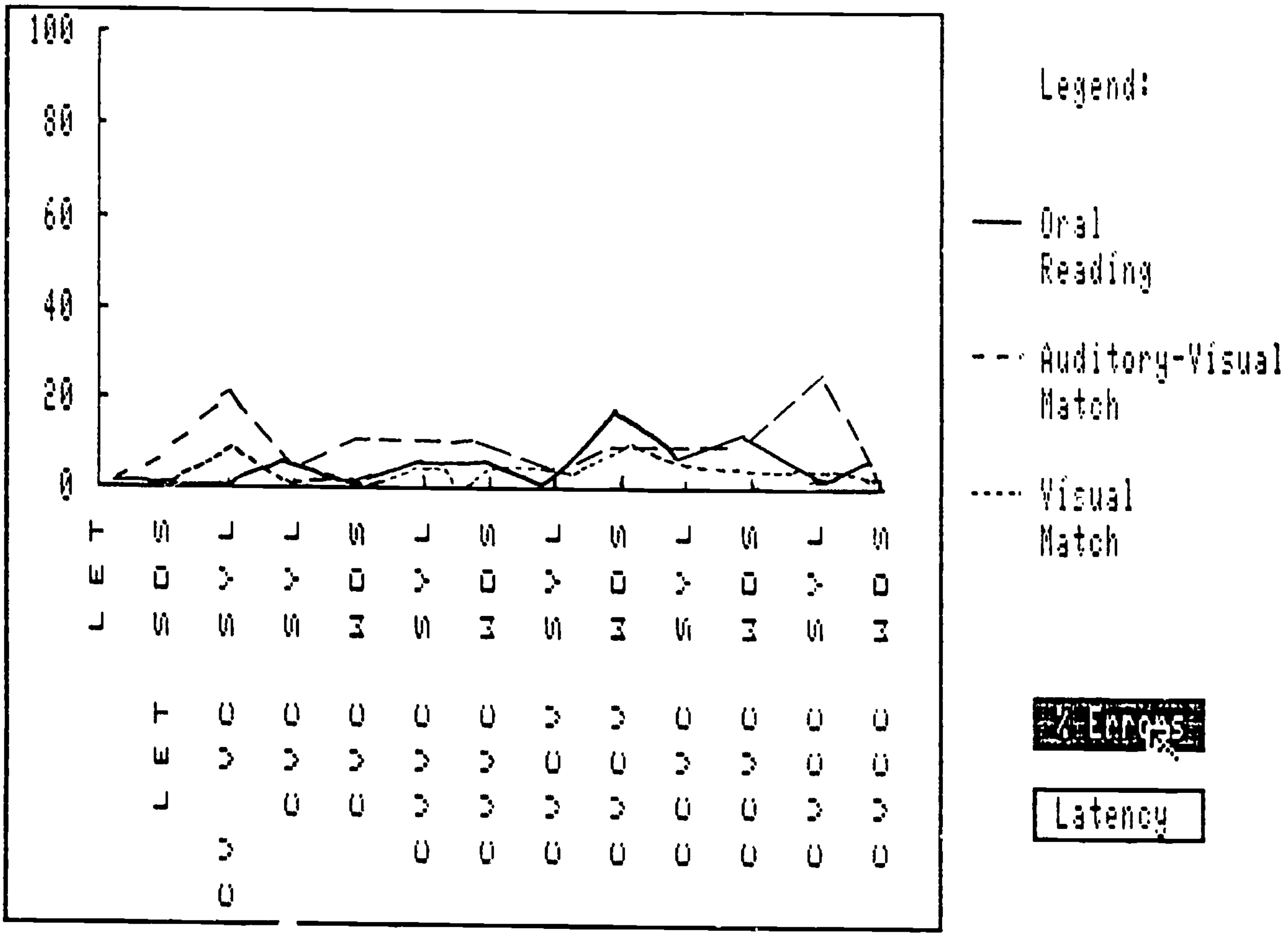


Figure 8.3
Autoskill Component Reading Subskills Test Program error profile for case RS at posttest.

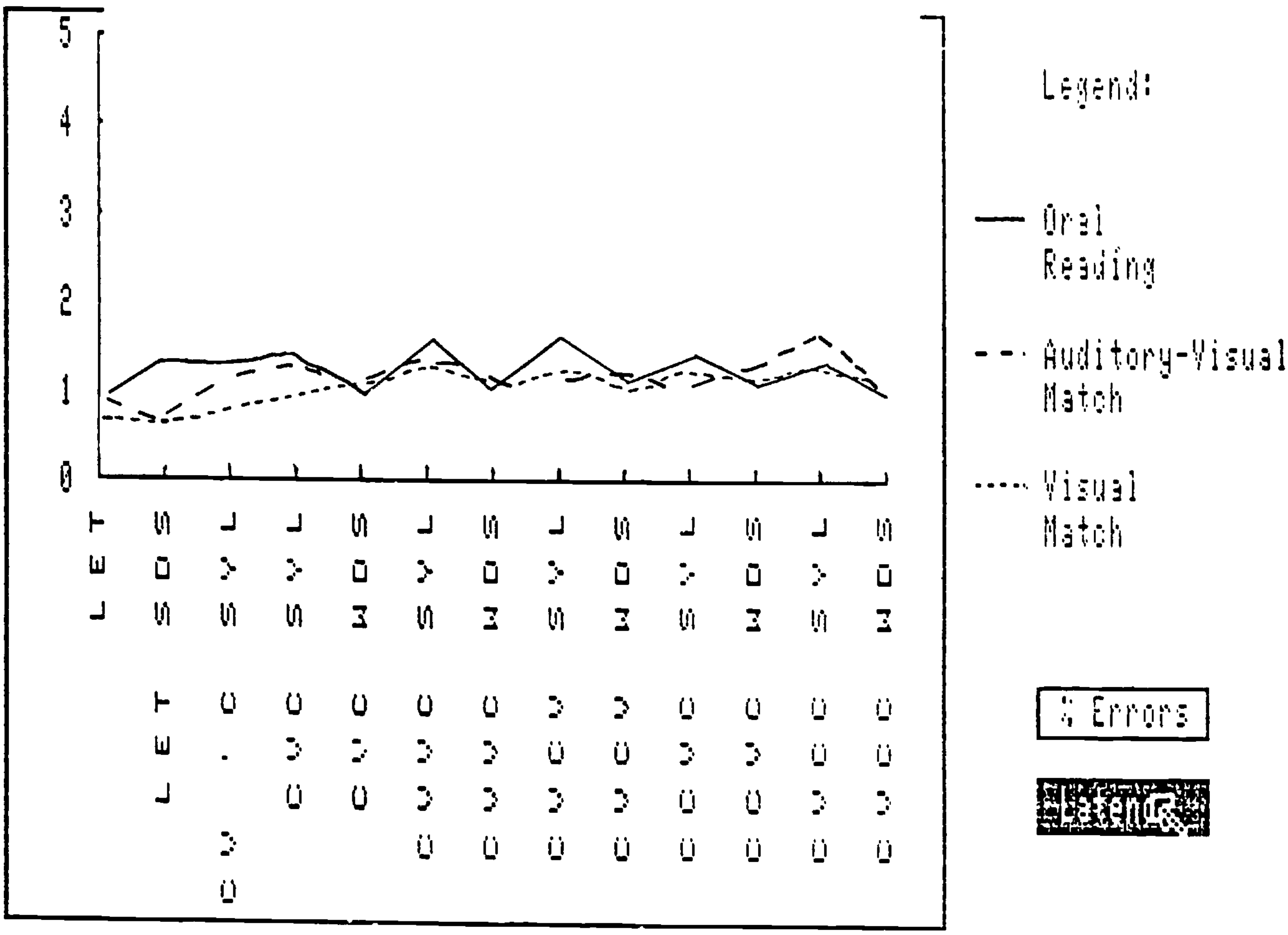


Figure 8.4
Autoskill Component Reading Subskills Test Program latency profile for case RS at posttest.

and words. This is likely reflecting a transfer of training effect since there was no direct training on the auditory-visual matching procedure. There was essentially little change in the profile for the visual matching procedure in error rate, however, error rates were low at pretest. There was some reduction in latency rates for the oral reading and auditory-visual matching procedures and little change for the visual matching procedure. Therefore, in terms of the component reading subskills, the predominant benefit of the training on the oral reading procedure was a considerable reduction in error rate on the oral reading tasks with minimal improvement in speed. In addition, error rates and latency on the auditory-visual matching procedures were also improved.

In evaluating the benefit of training in terms of general reading tasks, as indicated in Table 8.9, reading word recognition skills (WRAT-R) improved from a late Grade 3 level at pretest to a beginning Grade 6 level at posttest. The corresponding percentile scores were 7 and 27, and the standard scores were 78 and 91 at pretest and posttest, respectively. This gain represents a considerable improvement. Paragraph reading performance (SPIRE) showed little change at the word recognition level (Grade 3) possibly reflecting a ceiling effect. However, there were gains in retention and comprehension at the projected grade level (Grade 7) for both oral and silent reading. Phonetic knowledge (G-E) was improved overall by 14% (68% at pretest and 82% at posttest) for single letter and letter combination subtests, with no change overall in phonetic knowledge of words (69% at pretest and at posttest). Therefore, the predominant gains included a considerable improvement in reading word recognition skills, moderate improvement in phonetic knowledge of sounds and moderate improvement in paragraph reading comprehension at the projected grade level. Although very good progress has been made, it would be recommended that RS be maintained on the oral reading program. He was still 2 years behind projected grade level and one year behind his placement in Grade 7. Phonetic knowledge of words continued to be weak in some areas, most notably multisyllabic words. Additional training may be beneficial in helping RS to improve in all the weak areas and "catch up" completely to his grade placement level. If he made the same rate of gain over the next academic year while on the Autoskill program as he did over the past year, his reading skills would be at an expected level for his entry into the Grade 8 class.

Case 2

MB was a 10-year-old girl in a learning disability class. Based on age expectation, the projected grade level was Grade 5. Results of the WISC-R at screening included a Verbal IQ of 84, a Performance IQ of 102, and a Full Scale IQ of 91. The significant difference between Verbal IQ and Performance IQ is a frequent pattern in reading disabled children (Trites and Fiedorowicz, 1976). Reading word recognition skills at pretest (WRAT-R) were at the late Grade 3 level representing a 2-year projected grade delay. A classification of Type A was made following teting on the Atoskill Component Reading Subskills Test Program. Over the course of one academic year, she received 57 hours of Training. The auditory-visual matching procedure was completed after 26 hours of training and at that time, following a re-evaluation on the Autoskill Component Reading Subskills Test Program, she received training on the oral reading procedure. MB was one of the few Type A subjects who proceeded quickly through the auditory-visual matching procedures as part of the first phase of training for Type A and advanced to the second phase of training. Figures 8.5 to 8.8 illustrate the pretest scores and the profile for error and latency on each of the three procedures following training on the auditory-visual matching procedure. Figures 8.9 and 8.10 illustrate the final posttest profile. It can be seen that following training on the auditory-visual matching procedure, considerable improvement was attained on the training tasks. Error rates were reduced for the auditory-visual matching procedure and latency rates were also reduced. Further, error rates and latency rates for the visual-matching and oral reading procedures were also reduced. At final posttest, error rates and latency rates on all procedures were considerably reduced compared to baseline at pretest.

Table 8.10 summarizes the pretest and posttest results on the general tasks of reading. It can be seen that reading word recognition skills (WRAT-R) were at a late Grade 3 level at pretest and a beginning Grade 5 at posttest. The corresponding percentile scores were 18 and 39, and the standard scores were 86 and 96 at pretest and posttest, respectively. This reflects moderate progress in reading word recognition skills. Rate of paragraph reading (SPIRE) showed a very good gain in speed of reading for both oral and silent reading of paragraphs at both the

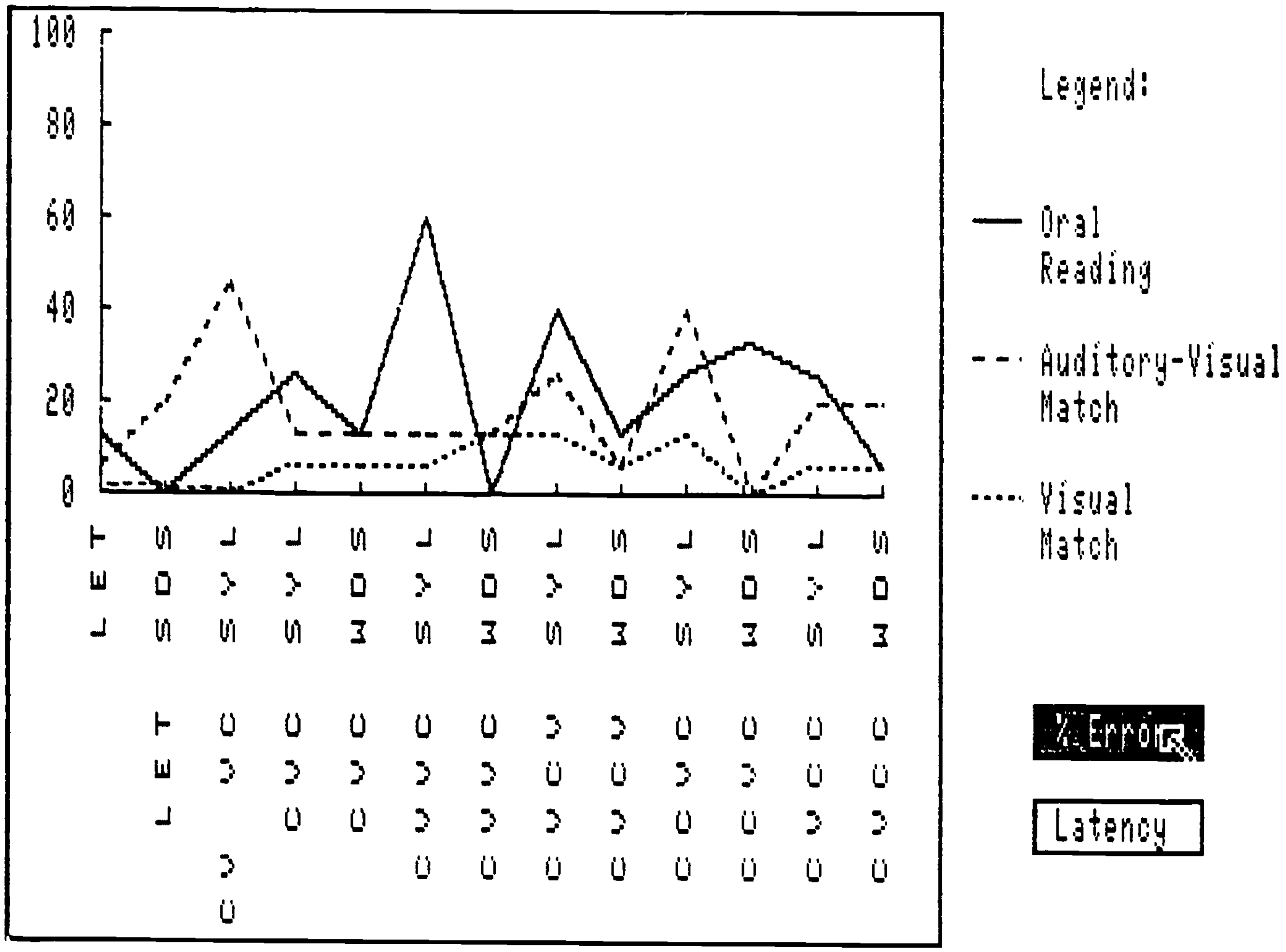


Figure 8.5
Autoskill Component Reading Subskills Test Program error profile for case MB at pretest.

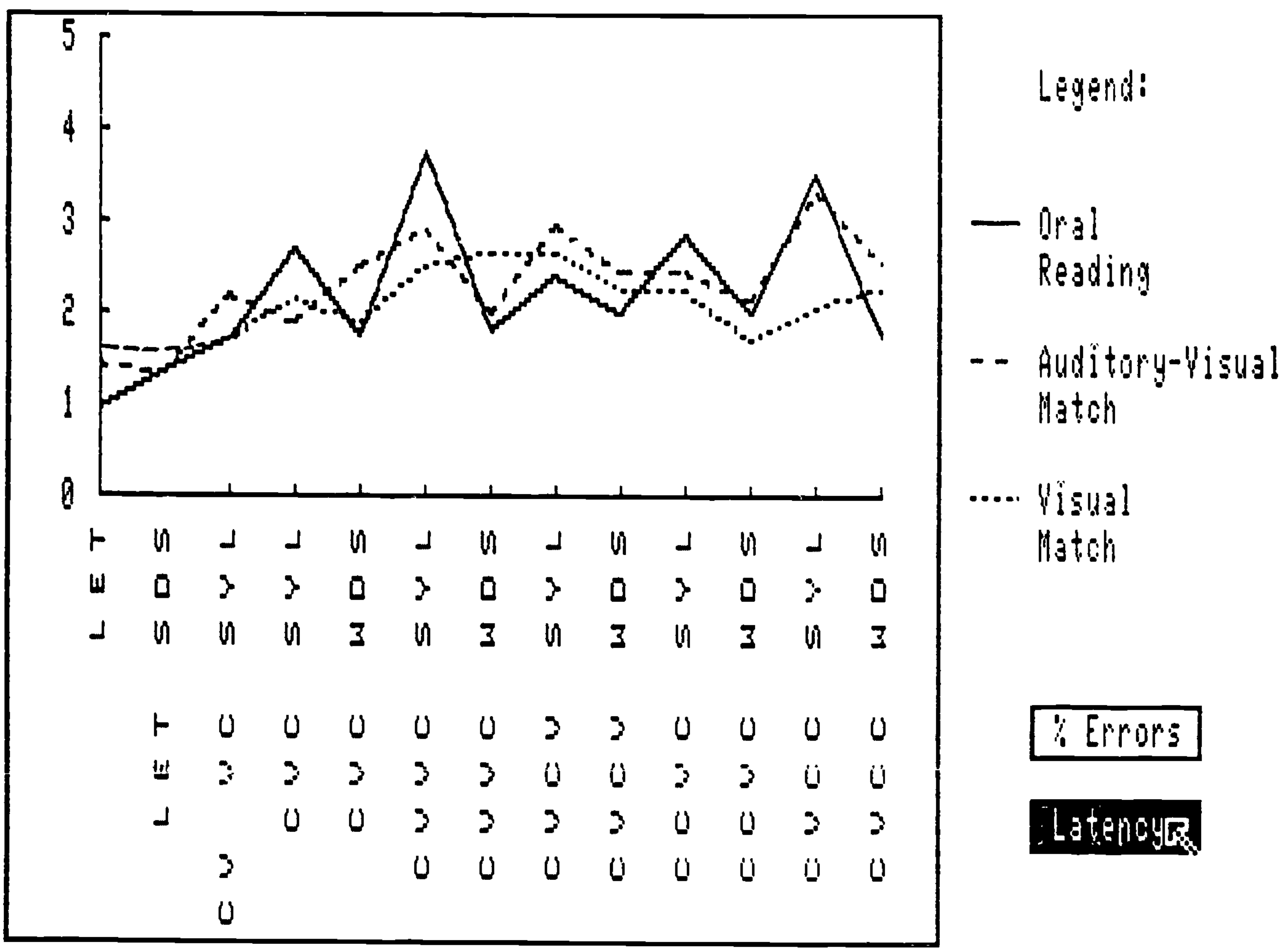


Figure 8.6
Autoskill Component Reading Subskills Test Program latency profile for case MB at pretest.

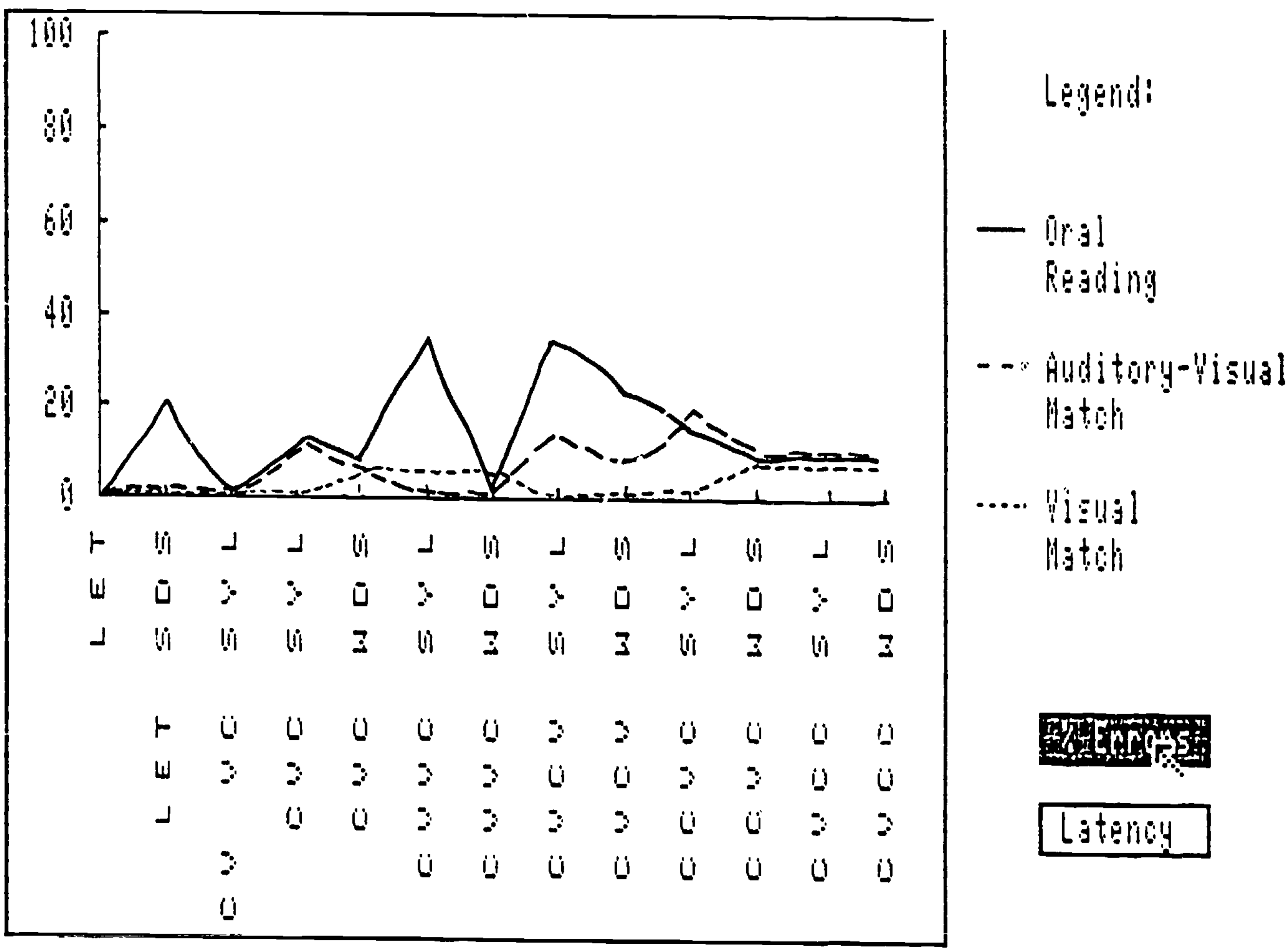


Figure 8.7
Autoskill Component Reading Subskills Test Program error profile for case MB at completion of training on the auditory-visual matching procedure.

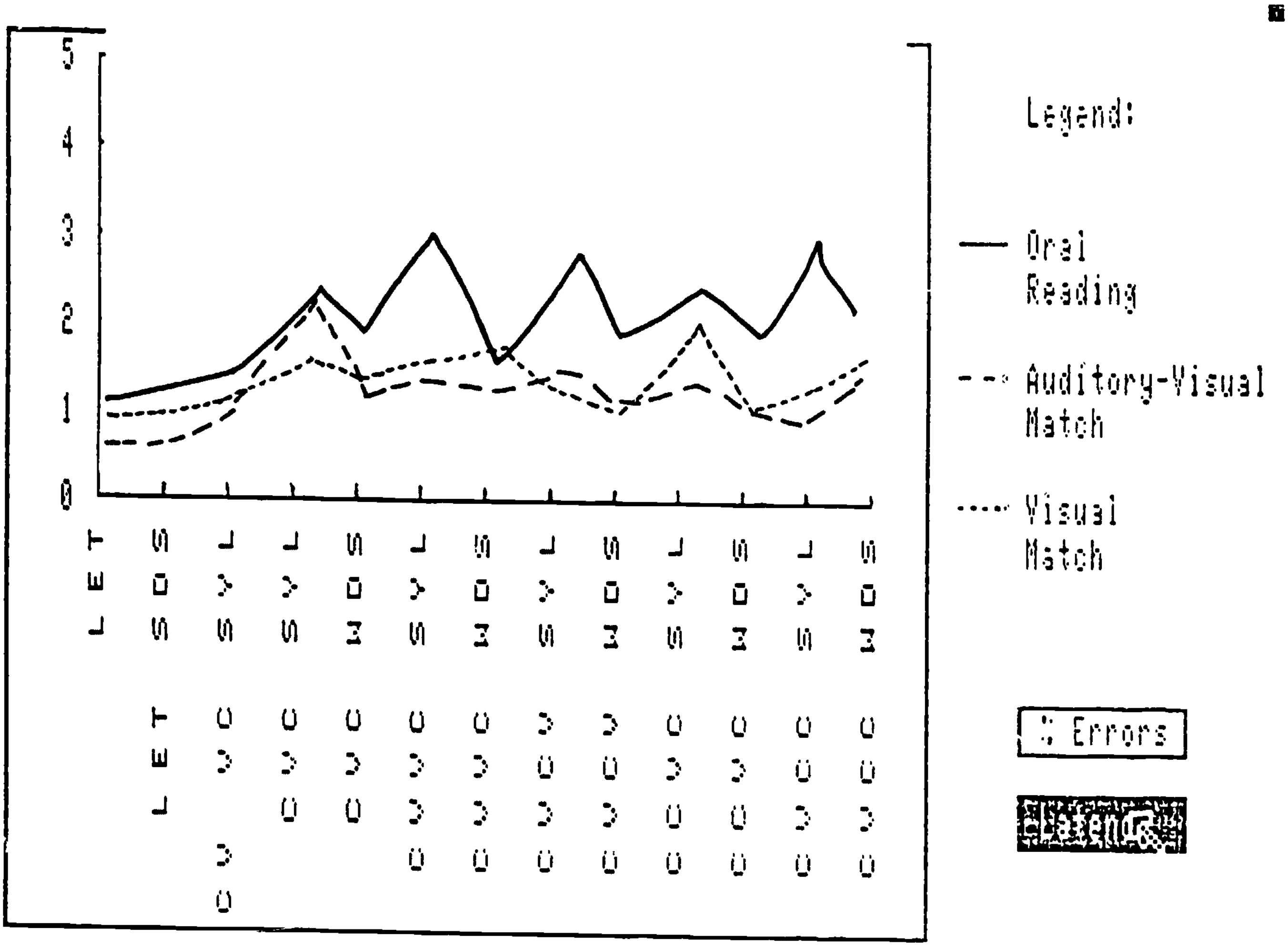


Figure 8.8
Autoskill Component Reading Subskills Test Program latency profile for case MB at completion of training on the auditory-visual matching procedure.

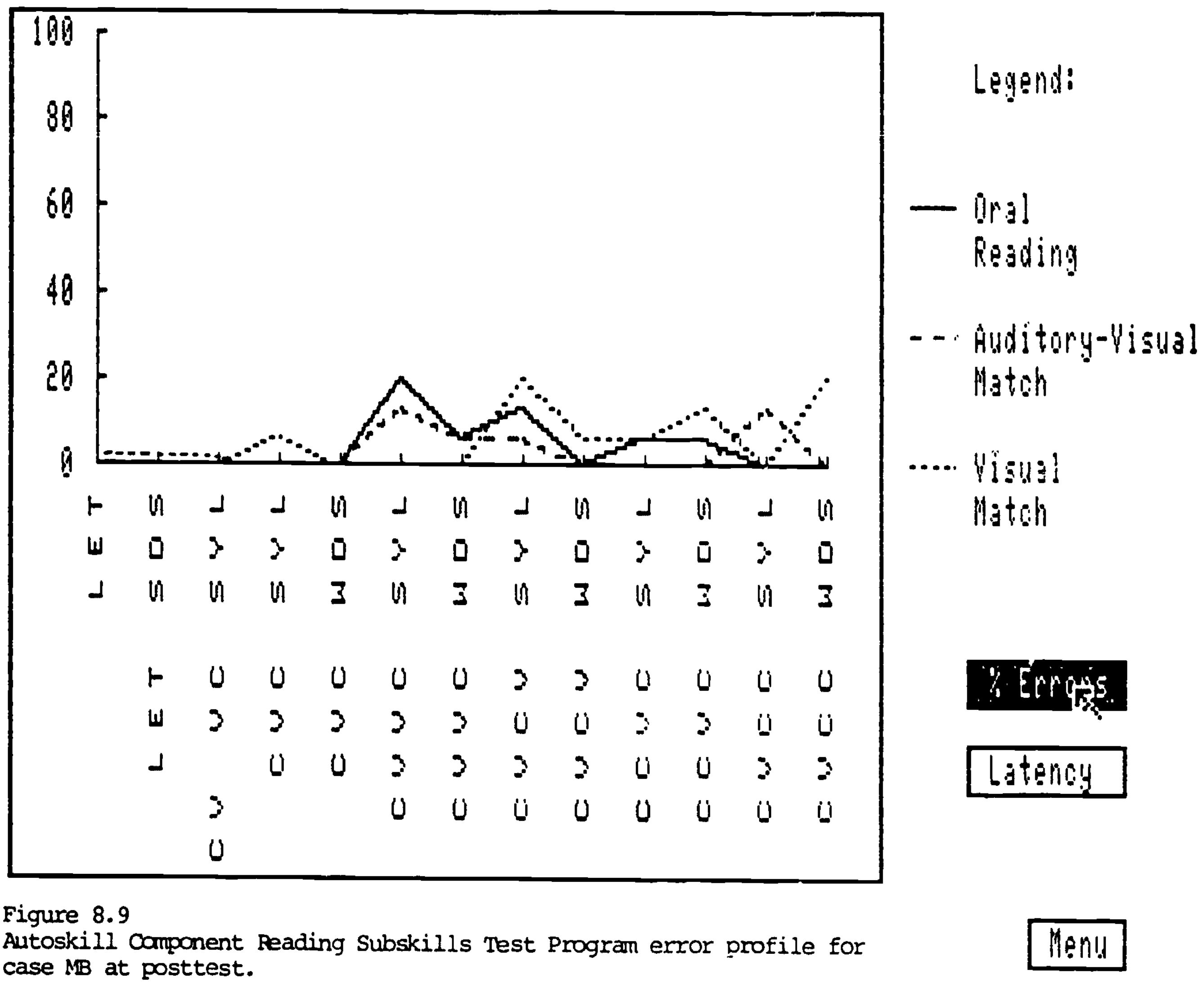


Figure 8.9
Autoskill Component Reading Subskills Test Program error profile for case MB at posttest.

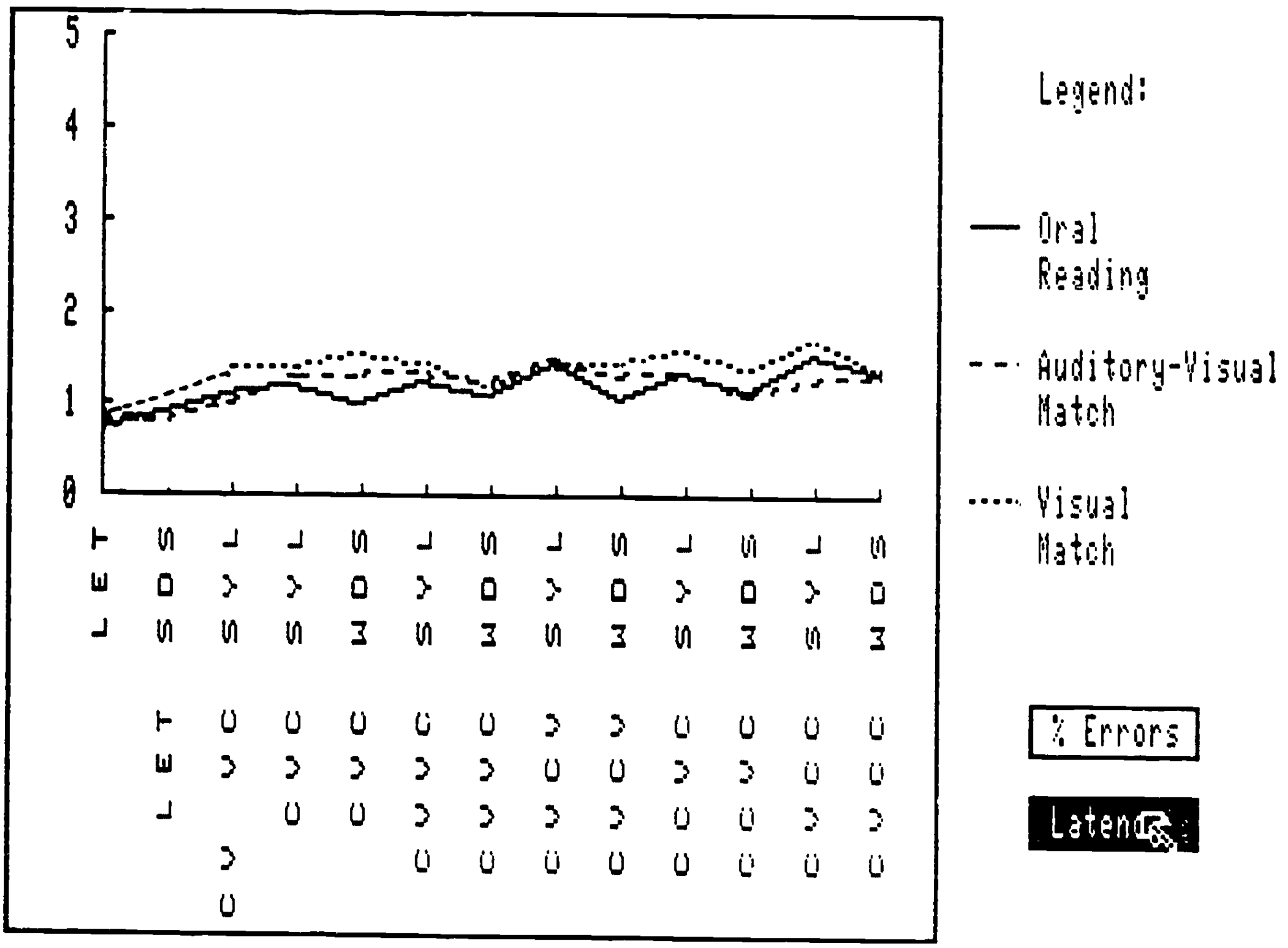


Figure 8.10
Autoskill Component Reading Subskills Test Program latency profile for case MB at posttest.

Table 8.10
Case MB: Summary of reading test results.

NAME: MB TYPE A — 57 HOURS OF TRAINING
GRADE: LD CLASS — PROJECTED GRADE: 5 — AGE: 10 — SEX: F

WESCHLER INTELLIGENCE SCALE FOR CHILDREN-REVISED
VIQ: 84 — PIQ: 102 — FSIQ: 91

	PRETEST	POSTTEST
WIDE RANGE ACHIEVEMENT TEST-REVISED		
(word recognition)		
Standard Score	86	96
Percentile	18	39
Grade Equivalent	3E	5B

STUDENT PROBLEM INDIVIDUAL READING EVALUATION GRADE LEVEL	Pretest Oral		Pretest Silent		Posttest Oral		Posttest Silent	
grade	3	5	3	5	3	5	3	5
(paragraph reading)								
Fluency (words per minute)	61	50	73	40	103	93	113	104
Comprehension (%age)	100	60	100	50	100	60	100	90
Retention (%age)	80	40	30	10	70	40	70	80

GALLISTEL-ELLIS TEST OF CODING SKILLS	PRETEST	POSTTEST
(phonetic knowledge)		
Sounds (%age) Total	64	74
1. Single Consonants	100	100
2. Vowels - Short Sounds	83	100
3. Common Consonant Combinations	69	69
4. Vowels - Long Sounds	83	100
5. Soft c,g,s; tch,dge	20	40
6. Common Vowel Combinations	48	64
7. Combinations of Vowel with R	47	60
Words (%age) Total	58	75
Single Syllables		
1. Closed Syll. - Single Cons. (cvc 'can')	84	96
2. Closed Syll. - Cons. Comb. (ccvcc 'chest'	85	95
3. Silent E & Open Syll. (cvcc 'tame' & cv 'me')	60	87
4. Soft c,g,s,; tch,dge ('cent' 'rage' 'catch')	40	80
5. Vowel Team Syllables (cvvc 'toil')	84	84
6. Vowel R. Syllables	80	100
More than One Syllable		
7. Words with Easy Endings s,ed,ing,er,est,y	60	72
8. cle Syll. & Common Suffixes 'candle' 'nation'	40	68
9. Multisyllable Words	0	12
Phonetically Irregular Words	90	85

word recognition level and the projected grade level. Silent reading retention scores were considerably improved at the word recognition level and the projected grade level. Phonetic knowledge (G-E) also showed considerable improvement with an overall gain of 10% (from 64% at pretest to 74% at posttest) for sounds and an overall gain of 17% (58% at pretest to 75% at posttest) for words.

In general, MB demonstrated good progress in a number of skills related to reading. In terms of future management, it would be recommended that MB complete the oral reading program since she was only part way through by the end of the academic year. Latency rates were still too slow in comparison to age expectation and further training may be of benefit. In addition, in view of the generally poor verbal skills, it would be recommended that MB receive language enrichment programs to enhance general language development.

CHAPTER 9

Discussion

The acquisition of reading skills is a complex process and many students have considerable difficulty in learning how to read. The teaching of reading is also a complex issue particularly since there is no existing comprehensive developmental theory of reading. Different methods of teaching reading have been advocated over the years and the majority of students learn how to read regardless of the method. However, some students have difficulty with any approach and the answer to the question of how to teach them is essentially unknown. Part of the reason for the lack of definitive answers for the reading disabled may be secondary to a lack of understanding of the dysfunction *per se*, as well as a failure to examine the dysfunction within the context of theoretical models of reading. In this study a reading program that incorporated both of these issues was evaluated.

Subgroup Concept

The concept of subgroups of reading disabilities developed out of an attempt to obtain a better understanding of the reading disability dysfunction. The diagnosis of reading disability is typically based on exclusionary criteria in which reading failure is evident despite average intelligence, adequate hearing and vision, an absence of gross brain dysfunction and adequate educational and sociocultural opportunity. This categorization, however, does not result in a homogenous group. Rather, the application of more specific classification criteria results in subgroups. It has been postulated that if methods of teaching reading are developed in accordance with the subgroup, then this specificity of matching training strategies with subtypes of reading disabilities may produce a better outcome. This supposition appeared to be logical and viable and the results of the first pilot field trial offered support for such an approach. The findings of the present study also provided strong evidence to support this approach.

The Autoskill Trained group consisted of reading disabled subjects classified according to Type O, Type A, and Type S who were provided with training procedures specifically developed in accordance with their respective reading difficulty subtype. The Autoskill Trained group made significant gains on reading measures of word recognition, phonetic knowledge, and paragraph reading after approximately 56 hours of training. Reading word recognition skills were improved by a gain of 1.2 grade levels and a corresponding standard score gain of 7.8 representing half a standard deviation. This improvement in reading word recognition is a positive outcome of the study. Reading disabled students typically do not achieve one grade level in reading over the course of one academic year. Further, each of the subtypes made a comparable grade level gain: Type O average gain was 1.4, Type A average gain was 1.0, and Type S average gain was 1.1. The corresponding standard score gains were 9.0, 7.5 and 6.6 respectively, each representing approximately half a standard deviation improvement. This is contrasted with the average grade level gain of 0.3 and standard score gain of 0.7 for the group of reading disabled students who did not receive the Autoskill training but were provided the standard language arts program by their schools. The gain in word recognition was also significant for the matched Autoskill Trained subsample and the Alternate Computer Trained Control reading disabled subjects who received language arts computer programs related to reading skills for 30 hours of training. The standard score gain for the former group was 6.3 and for the latter 1.0. The fact that the Autoskill Trained group made such impressive progress in reading word recognition may be interpreted as a positive benefit of their participation in the training.

Phonetic knowledge of letters and syllables was improved by 8.6% for the total group, a modest gain but nonetheless significant in contrast to the gain of 3.4% for the Untrained Control group.

The ultimate goal of any remedial training program for reading disabled children is to improve general reading skills including word recognition, but particularly reading of connected text. The Autoskill Trained group was not only significantly improved in reading paragraphs at a level corresponding to their word recognition skills, but also at their projected grade levels, i.e., the level at which they should be able to read based on their chronological age expectation. This was evident on measures involving passages read aloud and silently, as well as cloze passages. In the comparisons of the total Autoskill Trained group with the

Untrained Control group, only 3 of the 20 variables measuring some aspect of paragraph reading failed to reach statistical significance in favour of the Autoskill Trained group. In the analyses in which more stringent levels of protection against Type 1 errors were applied, and in which the degrees of freedom were increased by the inclusion of the subtype comparisons, approximately half of the paragraph variables were significant. One interesting finding was that each of the Type O, A, and S groups significantly improved in comprehension of paragraphs at the projected grade level, read aloud. Even in the matched control comparisons which involved only 30 hours of training, accuracy and speed were significantly improved at the word recognition and projected grade levels for the Autoskill Trained subsample. The improvement in various aspects of paragraph reading is another positive outcome of the study.

Task-analytic and Process-oriented Models

In addition to applying the subgroup concept in the development of training strategies for the reading disabled, there are two predominant theoretical aspects that have been incorporated in the Autoskill Component Reading Subskills Testing and Training Program. One involves an integration of the task-analytic and process-oriented models. The testing and training procedures involved component reading skills as opposed to other psychological processes which were derived from a task analysis of reading word recognition skills. Since the skills defined by the testing procedure are the same skills that are trained, this method is conducive to measuring the direct effects of training.

In this study it was found that there was a significant improvement in accuracy for Type O and Type A subjects and latency for Type S subjects on their respective training procedure tasks. These results were predicted and consistent with the results of the first field study. Further, in this study it was found that each subtype was significantly improved in relation to the other subtypes as well as the Untrained Control group on these respective variables. It had been predicted that with approximately 56 hours of training, versus 21 hours in the first study, the extended training period would also result in significant improvement in latency for Type O and Type A on their respective training procedure tasks. However, this was not the case. Although there was overall significance for improved latency on oral reading and on auditory-visual matching-to-sample, Type O and Type A subjects did not perform statistically significantly better than the other groups in their respective training procedures. In evaluating the average score gains, the latency scores for Type O on the oral reading procedure were improved in relation to the other groups, especially the Untrained Control group. Latency scores for Type A on the auditory-visual matching procedure also improved in relation to Type O and the Untrained Control group. Type S, however, was significantly improved in relation to Type O and the Untrained Control group.

The differential results of greater accuracy on the stimuli and procedure on which Type O and Type A subjects were trained, and faster rate of response on the stimuli and procedures on which Type S subjects were trained, seems to support those in the literature who have proposed that training involving automatic responding in reading involves two factors in training: accuracy and latency. The error percentage score for the oral reading and auditory-visual matching procedure was greater than for the visual matching procedure for all of the subtypes (average score of 35.5% for the oral reading procedure for Type O subjects, 26.5% for the auditory-visual matching procedure for Type A subjects and 9.0% for the visual matching procedure for Type S subjects). Therefore, the potential for improvement in accuracy was greater for the oral reading and auditory-visual matching procedure than the visual matching procedure. This could have resulted in the benefit of training being reflected initially in more accurate performance for Type O and Type A subjects. Similarly since the potential for more accurate performance on the visual matching procedure was restricted, the main effect of training using this procedure was to improve rate of responses for the Type S subjects.

There was an assumption that the increased training period would extend the benefit of training for Type O and Type A beyond significantly improved accuracy to significantly improved latency as well. It would seem that although there are indications of some progress, the effect is not substantial. Perhaps an even longer training period is necessary to reduce both accuracy and latency sufficiently to effect maximum benefit. Alternatively, it may be necessary to alter the procedural criterion regarding latency. The criterion that has been used in the training to date has included three consecutive 50 trial runs within a range of 100 msec. at the same time maintaining the accuracy criterion of 96% correct. This was considered to be sufficient to reflect an individual asymptote in acquiring speed while maintaining accuracy. Perhaps an additional expectation should include attaining the criterion at a level in keeping with norm values of age equivalent peers who are "average" readers. Since the norms for each grade level from one to eight on "average" readers have been obtained on all three procedures, this alternative is feasible. Certainly it should be given some consideration in future applications of the training procedure and in future studies.

It was also assumed that the increased training period would extend the benefit of training for Type S to other component reading subskill areas. It would seem that this may have been the case, at least in some areas. Type S was not only significantly improved in latency on the procedure of training, visual matching, but also on the auditory-visual matching procedure. Type S was significantly improved on this task in comparison to Type O and the Untrained Control group. This likely represents a transfer of training effect. Interestingly however, the transfer was restricted to the latency scores since the gain score in accuracy was minimal (2.7%). Nevertheless in evaluating the specific subtype gains on the general reading tasks it would seem that Type S made significant gains in comparison to the other two subtypes as well as the Untrained

Control group on some of the paragraph variables. This may be reflecting a greater transfer of training effect for the subtype that has reduced accuracy (attained prior to training) and reduced latency (attained as a consequence of training). If this is the case, it emphasizes the need to reduce latency by a significant degree for Type O and Type A subjects.

Automaticity Model

Inherent in the training procedure is the model of automaticity in which it is essential that a skill be developed to a level of rapid automatic responding so that fluent reading and comprehension of text can be attained. In the Autoskill program component reading subskills are practised to a specified level of accuracy and speed. The results indicated that reading word recognition and paragraph reading were significantly improved following the training and thereby lend support to the model. In the first field study, there was significant improvement of reading word recognition skills. There was a trend of improvement in paragraph reading, however, the results were not conclusive. It was considered that the training period was not sufficient to improve the component reading subskills to a level where there would be a transfer of training to paragraph reading and comprehension. The training period to achieve these initial results was 21.5 hours. In the present study, a subsample of the Autoskill Trained group was evaluated after 30 hours of training. The results indicated a significant improvement in reading word recognition skills but importantly, there was a significant improvement in accuracy and speed in reading paragraphs at the word recognition level and the projected grade level. These results substantiated the trend found in the pilot study. But the retention and comprehension scores were not significantly improved with this amount of training. However, following 56 hours of training, significant results were obtained on measures of retention and comprehension on passages read aloud and silently, as well as cloze passages both at the word recognition level and the projected grade level. In the context of the automaticity model, it would seem that the training of component reading subskills to a rapid level does have a beneficial effect in improving reading word recognition as well as connected text. The definition of and criteria for automaticity is a difficult issue and certainly has been one of controversy in the literature (LaBerge, 1973; Logan, 1980; Posner and Snyder, 1975). Based on the present findings it would appear that attaining an appropriate automaticity level demands considerable time in training. Further, the establishment of an appropriate latency level is complicated and, as described earlier, systematically varying the latency criterion may be important in future investigations. The procedural change with regard to the latency criterion may have a beneficial training effect.

Summary, Conclusions and Recommendations for Further Research

The purpose of this study was to investigate the effectiveness of training reading disabled subjects on the Autoskill Component Reading Subskills Testing and Training Program. The rationale for the training procedures was based on current theoretical issues including the concept of subtypes of reading disabilities, the automaticity model of information processing, and an integration of the task-analytic and process-oriented models. Reading disabled subjects were first tested on the program to determine their subtype classification: Type O, Type A, or Type S and then provided training according to their specific classification. The first field study yielded encouraging results and the primary aim of the present study was to replicate and extend the findings. It was also anticipated that modifications in the methodological design of the present study compared to the first would serve to demonstrate extended benefits of training. The major changes consisted of a larger sample size, a longer training period, and the inclusion of two different control groups. In addition, the majority of the subjects were trained by teachers. The results of this study were very positive and the following conclusions were made.

1. The major conclusion is that systematic training of deficient component reading skills according to subtype classifications does improve reading skills in general, including reading word recognition, phonetic knowledge and paragraph reading fluency and comprehension.. These results not only replicate the findings of the first study, but in addition represent more extensive benefits of training in that the transfer of training effects include paragraph reading and comprehension.

2. The initial benefit of training Type O on the oral reading procedure and Type A on the auditory-visual matching-to-sample

procedure seems to be the improvement of accuracy of performance on their respective training procedure tasks. The attainment of significant improvement in latency for these two subtypes appears to be a more difficult process. It may be that extending the training period for an even longer time, and/or changing the procedural criterion for latency, is necessary to achieve significant gains in latency. Alternatively, the dysfunction of these two subtypes may be such that they are more resistant to major improvements in latency.

The initial benefit of training Type S subjects on the visual matching-to-sample procedure seems to be the improvement of latency in their performance on the training procedure tasks. There also appears to be a transfer of training effect to other component reading subskill areas, specifically latency of auditory-visual matching-to-sample. Based on the differential results of Type O and Type A in contrast to Type S, one hypothesis to explore in future studies is that it may be necessary to train accuracy and latency on the predominant deficient component reading subskill area maximally before there is a transfer of training effect to other component reading subskill areas. It is interesting that despite the incomplete direct benefits of training Type O and Type A in both accuracy and latency, there still is a transfer to general tasks of reading. The reason for this is unclear, but perhaps maximum training in latency may yield even stronger beneficial transfer effects to general tasks of reading.

3. On the basis of the current results, no conclusions can be

made regarding the advantage of one specific type of reading subskill training procedure over another. Although Type S did demonstrate significant improvements on some of the general reading tasks, and Type O in others, there was no consistent specific pattern. All subtypes made gains in reading word recognition and comprehension of paragraphs at the projected grade level. Further investigation of the advantage of one procedure over the other is necessary. At this point the results support the application of the subgroup concept to training strategies. In addition, there is also support for the approach of training to the deficit or the main weakness. It would, however, be necessary to carry out studies using alternative training strategies, such as training to the strengths, before definitive conclusions could be drawn.

4. The duration of the training period may be an important factor deriving maximum benefit from the program. There appears to be a greater transfer of training effect to general reading tests, with a longer period of training. At this point, this observation is tentative and based on the findings that with 21 hours of training the overall effectiveness was observed in word recognition and phonetic knowledge. In the 30-hour training comparison, accuracy and latency in paragraphs was improved. In the 56-hour training comparison, comprehension of paragraphs was improved. The specific number of hours is no doubt just a rough gauge but the duration of training may be related to the automaticity model. One postulation is that there is a process of improvement that occurs in levels such that as a greater

proficiency in the component reading subskill areas is attained, which is acquired over time, there is a transfer of training effect initially to word recognition and phonetic knowledge and then with increased proficiency over time there is an effect on paragraph reading. The present results are consistent with this interpretation, but future research is necessary to replicate this observation.

5. The Untrained Control group made relatively poor progress on all of the general tasks of reading in comparison to the Autoskill Trained group. This supports the effectiveness of the Autoskill procedures in the management of reading disabled subjects. The Untrained Controls made such poor progress (52% made no improvement in reading word recognition) despite the fact that they received whatever management and help is typically offered to such students by the schools. It is evident that their management was ineffectual.

6. The results of the comparison of the subsample of Autoskill Trained subjects and the Alternate Computer Trained Control subjects indicate that the benefits of the Autoskill training are not due to the use of a computer *per se*, but the benefit is secondary to the specific training procedures used in the Autoskill program.

7. The overall results for the Autoskill Trained group are positive. These results are based on group means and statistical analyses. In evaluating the progress of each individual student, the majority did very well, however, some of the students made poor progress. On the basis of reading word recognition alone,

6% of the sample made no gain, and 18% made minimal progress. This is in contrast to 36% who gained up to one grade level, an additional 21% who gained up to two grade levels, and a further 16% who gained up to four grade levels. There is a need to investigate the characteristics of those subjects who made poor progress in contrast to those who made good and excellent progress. This work is in progress and if clear individual characteristics can be determined, it would be helpful in screening criteria for candidates suitable for the training.

8. The long-term effects of the benefit of training using the Autoskill procedures need to be investigated. In the previous field trial it was shown, on a very small sample, that the benefits of training were maintained for at least four months. It would be of value to determine the status of the subjects in this more extensive study one year following the completion of training.

9. The teacher evaluations of the Autoskill program and the students' reactions were for the most part quite positive. Further, the teachers appeared to be effective users of the program, however, this was with intensive training and supervision. Based on teacher reports it is most evident that other teachers who wish to use the program should receive specialized in-service training. Although there is extensive documentation associated with the program, all of the teachers specified that the workshop provided for them at the beginning of the study was essential. In addition, all indicated that the year long supervision with an experienced user was the most

valuable. Further, the teachers' impression that the Autoskill program has application for other populations needs to be investigated.

In summary, there is more research needed to fully evaluate the Autoskill Component Reading Subskills Testing and Training Program. However, the results of this study substantiate previous findings and indicate its effectiveness in training the reading disabled.

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Appendix 7.1
Subject classification according to school board and school.

Ottawa Roman Catholic Separate School Board
Ottawa, Ontario
Contact person - Mrs. Mary Warnock

		Type O	Type A	Type S	Untrained Control
1.	St. Daniel	3M	2M 1F	1M	1M
2.	St. Elizabeth	1M	1M	2F	1M
3.	St. George	2M	1M		1F
4.	St. Joseph			1M	
5.	St. Luke		1F		1F
6.	St. Michael		2M		2M 1F
7.	St. Raymond		1M		
8.	St. Victor		2M 1F	1M	

Renfrew County Board of Education
Pembroke, Ontario
Contact person - Mrs. Ruth Woodcock

		Type O	Type A	Type S	Untrained Control
1.	Alexander Reid (Arnprior)		1M	1M	1M
2.	Cobden (Cobden)			1M	
3.	Cockcroft (Deep River)	1M	1M	1M	1F
4.	Highview (Pembroke)	1M		2M 1F	1F
5.	Keys (Deep River)		1M		
6.	McNabb (Arnprior)	2M	1M	1M	
7.	Morison (Deep River)			1M	
8.	PSPS (Pembroke)	3M			
9.	Queen Elizabeth (Renfrew)		1M	1F	1M
10.	Walter Zadow (Arnprior)	1M 1F	1M	1M	1M

Appendix 7.1 "b"
Subject classification according to school board and school.

Renfrew County Roman Catholic Separate School Board
Pembroke, Ontario
Contact person - Mr. Brian Heaney

		Type O	Type A	Type S	Untrained Control
1.	Cathedral		2M	3M	
2.	Holy Name	1F	1F	1M	1M 1F
3.	Our Lady of Fatima	1M		2M	
4.	Our Lady of Lourdes	1M		2M	1M
5.	Our Lady of Sorrows	1M 1F	1M		
6.	Pope John XXIII	2F	1F		
7.	St. Joseph (Arnprior)	1M 1F		1F	
8.	St. Thomas The Apostle	2M		1F	1M

Appendix 7.1 "c"
Subject classification according to school board and school.

Carleton Board of Education
Ottawa, Ontario
Contact person - Dr. David Ireland

		Alternate Trained	Computer Control
1.	Jockvale Elementary (Nepean)	3M	2F
2.	Richmond (Richmond)	6M	3F

Stormont, Glengarry and Dundas County Board of Education
Cornwall, Ontario
Contact person - Mr. David Hill

		Alternate	Computer
1.	Laggan (Dalkeith)	3M	2F
2.	Viscount Alexander (Cornwall)	2M	3F

Appendix 7.2
Qualitative Analysis of Silent and Oral Reading (QASOR).

RATIONALE: QASOR is proposed as one means for helping teachers determine the relative balance among the three information sources - semantic, syntactic, and grapho-phonemic - as used by an individual reader as he/she attempts to make sense out of printed text material. It is proposed as a means of guiding teachers' observations, formulating tentative hypotheses regarding reading strengths and needs, and suggesting further diagnostic teaching in order to confirm or revise those tentative decisions.

DESCRIPTION: One narrative or expository passage is selected, depending on the experience and/or reading needs of the reader. For example, at or below the Grade 3 level, narrative material is perhaps more appropriate; at Grade 5 or above, expository material may better reflect the reader's needs. The passage must be "whole", that is, thematically or artistically complete, and should reflect genuine print material of a sustained nature, perhaps 500 to 1500 words in length, depending on the reader's age and level.

The final paragraphs, except for the very last, should be mutilated by cloze deletions: random 5th word at Grades 5 and above; random 8th or 10th word for Grades 4 and below. Although the material can be re-typed to include blanks of standard length, it may be more practical to simply black out the deleted words with a black flow pen. Delete a total of 20 to 50 words, depending on the level.

USE: The QASOR should be used in a relaxed manner; as nearly as possible the session should be one of teacher, rather than tester. In order to accomplish this, the following guidelines are suggested:

1. Explain to the reader that "we" are going to be reading a story (or article) called, "....". While he/she is enjoying the story (or understanding the article), you will also be trying to observe how well he/she is "getting his/her reading together", that is, "sounding good and making sense".

2. Ask the reader to look at the title, first paragraph, any pictures or other visuals, subheads, and talk to you. Encourage the reader by asking some "What else?" or "Does the last paragraph help you to predict anything?" types of questions.

3. Ask the reader to read the entire text silently to see "how well (he/she was) able to predict". Time the silent reading from the beginning to the start of the cloze passage. Make sure that the reader knows that when he/she comes to the cloze deletions, he/she will complete the meaning by writing or telling you "one word that seems to make sense".

4. When the reader has completed the silent reading and the cloze passage, ask him/her to read aloud to you several paragraphs from the first part of the text. He/She can select the oral reading portion, if there is a preference, and you can select additional paragraphs, if you feel it necessary. Be sure to tape-record the oral reading, for purposes of timing and analysis later on.

5. Before you end the session, spend a few minutes complimenting the reader on strengths you've noticed, model some behaviour or explain to clarify an area of possible need, and ask for reaction to the meaning of the text as well as performance and feelings. If appropriate, discuss your view of "getting your reading together", and "sounding good and making sense".

Appendix 7.3
Initial Teacher Evaluation Forms.

COMPUTER ASSISTED READING TRAINING PROGRAM

NAME: -------------------

DATE: -------------------

1. Having recently completed instruction in the Autoskills Program and started training programs with your students, would you please briefly evaluate the following list of program features with regards to clarity and ease of learning/using?

	clarity/ease minimum				maximum
Log in procedure	1	2	3	4	5
Learning about the program:					
Overview	1	2	3	4	5
Program Operation	1	2	3	4	5
Student Registration procedure	1	2	3	4	5
Identification of students (from the student register)	1	2	3	4	5
Main memu options:					
Train	1	2	3	4	5
Choice of program	1	2	3	4	5
Choice of subtest	1	2	3	4	5
Viewing results:					
Order of presentation (i.e. graph, detail)	1	2	3	4	5
Return to 2nd, 3rd, etc. block of TRAIN	1	2	3	4	5
Log off/exit procedure	1	2	3	4	5

2. Please evaluate the following features with regards to effectiveness and positive impact:

	effectiveness/impact minimum				maximum
Screen format (display set-up)	1	2	3	4	5
Size of letters	1	2	3	4	5
Ease of viewing	1	2	3	4	5
Sound quality	1	2	3	4	5
Colour scheme	1	2	3	4	5
Number of trials/training blocks (i.e. 50)	1	2	3	4	5
Display of positive reinforcement	1	2	3	4	5
Display of negative reinforcement	1	2	3	4	5
Graph structure	1	2	3	4	5

3. Do you find the Autoskills program, in general, easy to work with in terms of program flow? ---- Comments: ------------
----

4. Do you find the sub-programs appealing to the students with whom you are working? -----

Auditory-visual ( )
Visual-match ( )
Oral-reading ( )

Comments: --

5. How much program specific training did you receive in number of hours (include school board in-service presentation)? ---
Was this amount of time adequate? --------------------------

6. Does the program have uses beyond those suggested by the developer? ---- Explain: ------------------------------------

7. Did the software require an excessive amount of introduction, supervision, or explanation? ------------------------------

8. Could the program be used by a person with minimal computer expertise? YES --- NO ---

9. Does the program have enough internal documentation to permit ease of use? YES --- NO ---

10. Are appropriate techniques used (e.g. cursors, underlining, inverse video, etc.) to indicate when a response is required and where the response should go? --------------------------

11. Are formats and protocols for communication to the user consistent and logical? ------------------------------------

12. Time limits are imposed on performance. Does this appear to motivate students or make them anxious? --------------------

13. Scoring is used. Does this appear to motivate students or make them anxious? --

14. Is the student, at any time, confused by the organization or sequence of the lesson? ------------------------------------

15. Does the student attend to the salient aspects of the learning material? ------- Is the student, at any time, distracted by irrelevant information? ---------------------

16. Are there times when the student appears impatient with the presentation (e.g. illustrations that take too long to form, information that takes too long to access, or repetitive sequences, etc.)? ---------------------------------------

17. Are there any questions, problems, or tasks that seem to reoccur too often (i.e. that are not randomly generated)? ---

18. Does the student appear to understand why his/her responses are correct or incorrect? -----------------------------------

19. Does the feedback appear to be motivating or discouraging to the student? ---

20. Are there any times when the student appears to need feedback but does not receive it? ----------------------------------

21. Are there feedback messages that the student finds tedious or that reoccur too often? ------------------------------------

Appendix 7.3 "b"
Initial Teacher Evaluation Forms

AUTOSKILL READING PROGRAM

TEACHER QUESTIONNAIRE

NAME: SCHOOL:

BOARD: DATE:

How many years of teaching experience do you have?

1. 1 - 5
2. 5 - 10
3. 10 - 20
4. 20 +

Do you have a specialty teaching area? Please specify ----------------

----

Are you presently teaching in this specialized field? -----------------

How does the computer training program fit into your teaching schedule?

1. fairly easily incorporated into regular schedule
2. requires significant extra time and planning to adapt to regular schedule
3. causes some difficulty in terms of adapting to time available

Comment--

Do you have <u>any</u> prior experience with computers?

1. none
2. some
3. a lot

Have you taken computer courses of any kind? Please specify ---------

---.

Do you have a computer at home? Yes No

Do you personally use your home computer? Yes No

Have you used the school computer? Yes No

Do you see a computer program as an effective aid in teaching reading skills?

1. in general, yes
2. for specific reading disabilities only
3. for specific types of children only
4. in general, no

Please rate the following areas of reading skills or program characteristics in terms of your opinion of their value in training reading skills through a computer program:

	(minimal value) 1	2	(medium) 3	4	(maximum) 5
1. increased quantity of drill and practice					
2. heightened interest in student					
3. rapid, objective feedback					
4. ease of individualizing training program					
5. student participation					
6. others? ____________					

What prerequisites do you feel a teacher should have before using a computer as a teaching tool?

1. extensive computer training
2. some computer training
3. program-specific training

How difficult do you think it will be for you to become skillful in using a computer program as a teaching aid?

1. not at all difficult
2. a little
3. a lot

Why? ____

Do you have any ideas or opinions at this time on the need (if any) for a special approach to teaching with a computer?

Please feel free to add your comments or questions in any area of this questionnaire and thank you for your cooperation in supplying us with this information.

Appendix 8.1
Final Teacher Evaluation Forms.

TEACHER EVALUATION OF
AUTOSKILL READING PROGRAM

Will you continue to use the Autoskill program after this project is completed? --

With what type of student? ------------------------------------

Will you need any back-up expertise next year? -----------------

With the experience you have now had with the Autoskill program, would you feel comfortable training other teachers and providing answers to questions they may have as they use the program? -----

How else could this program be used in the curriculum? ----------
----

Can you think of any ways the program could be improved? --------
----

This is a skill development approach. Is it compatible with a language experience approach? ----- Please explain: -----------
----

This software will be available throughout Ontario in 1986 at no extra charge to the schools. If it were not, would you recommend to your principal that your school purchase it? ----------------

How much would you estimate it should cost? -----------------

Has this program been an effective use of computer technology? Please explain: --

What do you think about the order of training of the subprograms? (e.g. doing words Grade 1-8 before phrases 1-8, etc.) -----------
----

Is there an order you think would be better? ----------------

Which procedure do you prefer?

Oral Reading ----

Auditory-visual Matching ----

Visual Matching ----

No Preference ----

Why? ---

Appendix 8.1
Final Teacher Evaluation Forms.

PUPIL REPORT

AUTOSKILL READING PROJECT

Note to teacher: Please review any records available to you that would be helpful in completing this questionnaire.

Pupil's Name: --------------------

Birthdate: --------------------- Age: -----------

Pupil's Grade: ---------- Grade(s) repeated: -----------

Special help? -------- What type? ------- When started? ---------

French Immersion? Yes ------ No -------

Any languages other than English spoken at home? Yes ---- No -----

Any siblings with learning difficulties?

Yes ----- No ----- Not known ------

Any history of hearing, vision, or other significant physical problems?

No ---- Yes (describe) ---

Any history of behaviour or social problems?

No ---- Yes (describe) ---

Any history of speech therapy?

No ---- Yes ---- When? --------------------

Date you began working with this student on the computer? ------------

Frequency of sessions ----- times per week for ----- minutes each.

When the student began the program what was his/her:

Reading comprehension level? -------------------------------------

Spelling level? ---

What placement and level of work will this student be ready for in September of 1986? -----------------------

How much gain would you say this student has made in reading skills during the course of this project? ------------------------------------

Specifically, what effects has this program had on this student's:

Reading skills? --

Ability to handle course work in other subjects?------------------

----

Communication abilities? ---

Attitude towards school? ---

Self concept? --

Other? ---

Was this student receiving special help in reading:

Prior to this program? ----------

Along with this program? --------

What type? --

Will this need to be continued in the future? -------- ------------

----

Should this student continue this program next year? ----------------

----

Considering the time you have spent with this student on this program, has the time been well spent? ------ Please explain: ----------------

----

Is this program "cost effective"? ------------------------------------

Could you think of any other program that would have been more useful with this student? ---

If so, please describe: --

Globally, please rate the usefulness of this program with this student:

Not Helpful	Somewhat Helpful	Helpful	Greatly Helpful	Exceptionally Helpful
-------	-------	-------	-------	-------