DYSLEXIA AND HYPERLEXIA

NEUROPSYCHOLOGY AND COGNITION

VOLUME 1

The purpose of the Neuropsychology and Cognition series is to bring out volumes that promote understanding in topics relating brain and behavior. It is intended for use by both clinicians and research scientists in the fields of neuropsychology, cognitive psychology, psycholinguistics, speech and hearing, as well as education. Examples of topics to be covered in the series would relate to memory, language acquisition and breakdown, reading, attention, developing and aging brain. By addressing the theoretical, empirical, and applied aspects of brain-behavior relationships, this series will try to present the information in the fields of neuropsychology and cognition in a coherent manner.

P. G. AARON
Indiana State University, Terre Haute, U.S.A

DYSLEXIA AND HYPERLEXIA

Diagnosis and Management of Developmental Reading Disabilities

KLUWER ACADEMIC PUBLISHERS
DORDRECHT / BOSTON / LONDON

Library of Congress Cataloging-in-Publication Data

Aaron, P. G.
Dyslexia and hyperlexia : diagnosis and management of developmental reading disabilities / P.G. Aaron.
p. cm. -- (Neuropsychology and cognition ; 1)
Bibliography: p.
Includes indexes.

ISBN-13: 978-0-7923-3155-1

1. Dyslexia. 2. Reading disability. I. Title. II. Series.
[DNLM: 1. Cognition. 2. Dyslexia. 3. Reading. WM 475 A113]
RJ496.A5A27 1988
616.85'53--dc19
DNLM/DLC
for Library of Congress 88-9098
CIP

ISBN-13: 978-0-7923-3155-1 e-ISBN-13: 978-94-009-1065-2
DOI: 10.1007/978-94-009-1065-2

Published by Kluwer Academic Publishers,
P.O. Box 17, 3300 AA Dordrecht, The Netherlands.

Kluwer Academic Publishers incorporates
the publishing programmes of
D. Reidel, Martinus Nijhoff, Dr W. Junk and MTP Press.

Sold and distributed in the U.S.A. and Canada
by Kluwer Academic Publishers,
101 Philip Drive, Norwell, MA 02061, U.S.A.

In all other countries, sold and distributed
by Kluwer Academic Publishers Group,
P.O. Box 322, 3300 AH Dordrecht, The Netherlands.

Printed on acid-free paper

To
Albert J. Harris

TABLE OF CONTENTS

PREFACE

Even though I had been studying reading problems in children for a number of years as a means of understanding cognitive processes, I became deeply committed to the study of developmental dyslexia after my encounter with S. H., a dyslexic college student. Until then, dyslexia to me remained an interesting phenomenon but somewhat removed from the mainstream of my research interests. The facts that, in spite of his superior IQ, S. H. could read no better than a child in the fifth grade and misspelled even common words such as *was* and *here*, however, took me by surprise and made me appreciate the intriguing and challenging nature of developmental dyslexia. This led to a series of studies of college students with reading disability, a group that is relatively unexplored. The general plan of these investigations was to study a small number of disabled readers at any given time, rather intensively. Even though this approach limits the generalizability of the research findings, it lays bare some of the most interesting facts about dyslexia which are obscured in large-scale statistical studies. These studies have now extended well over a decade and are still continuing. As soon as these studies were started, it became obvious that not all reading-disabled college students are alike and that disabled readers could be classified into three broad categories: those with poor decoding skill, those with poor comprehension ability, and those with a combination of these two deficits. In my opinion, the term *dyslexia* is applicable only to the first of the three categories of poor readers.

I was also struck by the fact that none of the dyslexic students I had studied showed any sign of language difficulty during normal conversation. This was contrary to some of the published reports which claim that dyslexic children have language difficulties. Unless the dyslexic college student told me beforehand, I could have guessed from neither his speech nor his gestures that he had dyslexia. It appeared to me, therefore, that deficits of the semantic aspects of language production and reception did not constitute the core of the dyslexia problem, at least in the students I had seen. As data accumulated, it also became obvious that poor reading is just one aspect of the dyslexia problem and that dyslexia is a syndrome with many symptoms such as poor spelling and incorrect writing. Any viable hypothesis of developmental dyslexia should, therefore, be able to account for all these symptoms. Once tentative hypotheses were proposed and tests developed, it was possible to cross-check their validity by testing reading-disabled children who were referred to the Porter School Psychology Clinic. The views expressed in this book are, therefore, drawn from these two groups of poor readers, namely, college students and school children.

As for S. H., he is happily married and is employed as a teacher of industrial technology in a nearby highschool. He had been successful, not because he was able to overcome his reading problems, but because he was able to successfully cope with the academic demands. The University provided him with a "reader," a privilege normally extended to blind students. Above all, S. H. succeeded because of his motivation and intelligence.

In the late sixties, well-documented reports appeared in journals concerning very young children who could read aloud astonishingly well but could not comprehend what they had read. These children were referred to as hyperlexic. The existence of hyperlexic children demonstrated that decoding and comprehension are two independent components of reading and that they are dissociable. This leads to the conclusion that dyslexia and hyperlexia represent two distinct forms of reading disorders that arise from the malfunctioning of two different components of reading. The phenomenon of hyperlexia makes tenable the proposition that dyslexic readers can have decoding deficits in the presence of adequate comprehension. Furthermore, it also provides a tentative explanation of the contradictions seen in research reports by suggesting that such differences of opinion are partly due to the practice of misclassifying a large number of poor readers with comprehension deficits as dyslexics.

This book examines reading disabilities of different kinds within the dyslexia—hyperlexia framework. Within this perspective, disabled readers, on the basis of the etiology of their deficits, are classified into three broad categories: those with decoding deficit, those with comprehension deficit, and those with varying degrees of a combination of these two deficits.

In Chapter 1, the history of the study of reading disabilities is presented in the hope that such a knowledge will be helpful in alleviating the misunderstandings regarding dyslexia that exist among investigators with diverse backgrounds.

An important feature of this book is its effort to explain reading disabilities in terms of the processes that underlie normal reading. A description of the reading process, along with some of the related issues in reading, is presented in Chapter 2. Following this, in Chapter 3, developmental dyslexia and hyperlexia are examined with reference to these processes. In Chapter 4, the nature of the two major forms of reading disorders, viz., dyslexia and hyperlexia, are delineated. Because phonological deficit appears to be the common etiological factor of dyslexia, a definition of dyslexia that is based on phonological deficit is proposed. Poor phonological skill and deficient comprehension skill are manifested in two different kinds of reading disorders. Developmental dyslexia and hyperlexia, therefore, represent two different syndromes, and the nature of these syndromes is described in Chapter 5.

This book is written with reading teachers, reading specialists, and school psychologists in mind. Because educators are concerned with the practical aspects of children's reading problems, the last two chapters are devoted to the diagnosis and treatment of reading disabilities. Diagnosis of reading disabilities has traditionally been made on the basis of IQ scores and discrepancy formulas derived from the IQ scores. For several reasons, this approach has proved to be unsatisfactory. In Chapter 6, a differential diagnostic procedure, which does not rely on IQ scores but uses measures that are ecologically close to the reading process, is described.

In the final chapter, suggestions for treatment and management of different types of reading disabilities are provided. Brief descriptions of different remedial approaches, along with the sources where detailed descriptions of these techniques can be obtained, are presented in this chapter. Professors in graduate courses can direct their students to these sources should detailed information be required.

The book attempts to bring research and practice together. It also draws conclusions from data obtained from disciplines such as cognitive psychology, education, neuropsychology, and computer studies and thus presents an integrated view of reading.

ACKNOWLEDGEMENTS

Some of the views presented in this book are based on the conclusions derived from studies conducted by me, often in collaboration with graduate students and school teachers. I wish to express my gratitude to the following administrators and teachers who administered tests and collected data: Greg Ulm, Director, University School, Indiana State University; Shirley Waterman, University School, Indiana State University; Robin Shippee, George Rogers Clark Jr. High School, Vincennes, Indiana; Kathy Blome, Central Elementary School, Bicknell, Indiana; Teresa Stateler, Christie Simpson, and Carol Samuelson, Central Elementary School, Clinton, Indiana. Mere written language is inadequate to express my gratitude to Carole Gustafson, who read the manuscript, corrected the errors of syntax and spelling (yes, everybody commits such mistakes), and made this book readable. I am much indebted to her for the meticulous care with which she carried out the editorial work.

Jane Healy gave me valuable advice in planning the book during the initial stages and later read the sections on hyperlexia and made suggestions for improving them. I am grateful to her.

Finally, I must express my gratitude to the numerous students with reading problems who were the source of the data of some of the studies reported in this book. I owe much to those college students with developmental dyslexia who often discussed their reading problems freely, candidly, and with admirable insight.

OUTLINE OF CHAPTER 1
['READING DISABILITIES: THE PUZZLE AND THE HISTORY']

1. Introducing the Puzzle
2. Developmental Dyslexia: History of Research
   2.1. Classical Studies: The Medical Men and the Problem of Etiology
   2.2. The Educators:
      2.2.1. The Problem of Terminology
      2.2.2. The Problem of Methodology
   2.3. Neuropsychology:
      2.3.1. Beginnings of a Compromise
      2.3.2. Orton the Pioneer
      2.3.3. Recent Developments
         2.3.3.1. Cerebral Hemisphere Processes and the "Imbalance Hypothesis"
         2.3.3.2. Acquired or Traumatic Reading Disorders
         2.3.3.3. Comparison of Acquired and Developmental Reading Disorders
3. The Current Scene: An Orchestrated Effort
   3.1. The Biological Approach
   3.2. The Neurological Approach
   3.3. The Neuropsychological-Cognitive Approach
   3.4. The Educational Approach
4. Hyperlexia: History of Research
   4.1. Awareness of the Presence of Extraordinary Decoding Skills in Some Young Children
   4.2. Recognition That Some Children Can Decode Words Much Better Than They Can Comprehend
   4.3. Emergence of the Concept of Hyperlexia
5. General Conclusions

CHAPTER 1

READING DISABILITIES: THE PUZZLE AND THE HISTORY

1. INTRODUCING THE PUZZLE

Why is it some individuals of average or even superior intelligence fail to learn to read well for no apparent reason? And why is it some children with extraordinary decoding skill fail to comprehend what they have read? Children of the first type have been recognized and studied from the beginning of the present century and have been described by terms such as *congenital word blindness*, *dyslexia*, and *specific reading disability*. In this book, the terms *developmental dyslexia* and *specific reading disability* (SRD) are used interchangeably to refer to this form of reading disability.

The study of children who have comprehension deficits in spite of superior oral reading skill has a relatively short history. These children have come to be known as "hyperlexic" since 1967 when Silberberg and Silberberg first used this term to describe them. It appears that dyslexia and hyperlexia are caused by the breakdown of separate but complementary components of the reading process and, therefore, are of both theoretical and practical significance.

2. DEVELOPMENTAL DYSLEXIA: HISTORY OF RESEARCH

In recent years, the term *dyslexia* has been loosely employed to include all forms of reading disabilities, and some educators have come to question if developmental dyslexia should be assigned a status that is different from other forms of reading disorders. For instance, Rutter (1978) states that the term *dyslexia* "does not refer to any well-defined group of disorders. Rather it constitutes a hypothesis regarding the supposed existence of a nuclear group or groups of disorders of reading" (p. 27). Taylor *et al.* (1979), who studied 80 disabled readers, claim that although about half of their subjects could be classified as dyslexic, there is no real difference between the "dyslexic" poor readers and the remaining nondyslexic disabled readers. They, therefore, conclude that "the tendency for some investigators to identify dyslexia on the basis of characteristics presumed to be specific to it would appear unjustified" (p. 98). Bloom *et al.* (1980) compared 32 children with borderline intelligence with 32 reading disabled children with normal intelligence. After analyzing the performance of the two groups on many reading subskills, they conclude that poor readers with borderline IQs do not differ from children with normal IQs and primary reading problems. Nevertheless, numerous articles and books have been written about developmental dyslexia, and organizations devoted entirely to its study have been founded. This state of contradiction and confusion appears to be due to two factors. The first is caused by the differences in the etiologies sought by different groups of investigators. Medically inclined investigators describe developmental dyslexia in neurological terms, whereas educators tend to describe it in pedagogical terms. The second reason for disagreement among experts regarding the nature of developmental dyslexia is the misinterpretation of terms such as *congenital word blindness* and *dyslexia.* An improper use of the term *dyslexia* has led to an overextension of the concept to include all shades of reading disabilities. This problem can be minimized by limiting the application of the term *developmental dyslexia* to those cases for whom the label was originally intended. For this reason, an analysis of classic cases of developmental dyslexia as provided by pioneers in this field is included in the following section.

2.1. *Classical Studies: The Medical Men and the Problem of Etiology*

A brief survey of educational journals published between the years 1890 and 1895 reveals that reading disability in children was not perceived as a major problem by educators of that time. The few reading-related articles found in educational journals, such as *Journal of Education* (New England), *Education* (London), *Ohio Educational Monthly,* and *Indiana School Journal,* were concerned primarily with methodological issues such as whether it is more effective to use the whole sentence than the single word as the basic unit of instruction. The handful of research articles that appeared about this time were concerned primarily with eye movements and rates of reading (Quantz, 1887; Abell, 1894; Cattell, 1895). Even when it was recognized that some children were slow in reading, their tardiness was attributed to extrinsic factors such as methods and materials used in the teaching of reading and the amount of time devoted to it in the classroom. The only reference to any form of reading disability appeared as a small news brief in the 1887 issue of *American Journal of Psychology* (Vol. 1, No. 1, p. 548) concerning Berlin's description of acquired reading disability in a neurological patient.

A quarter of a century later, however, the situation was vastly different. According to Harris and Sipay (1985), the first report in the United States of an attempt to diagnose and treat individual reading problems was published in 1916 by Uhl. This was followed by a spate of books and articles published by educators and psychologists. In 1917, Bronner described several cases of reading disabilities which, interestingly, resemble the two categories of reading disorders that constitute the focus of this book, namely developmental dyslexia and hyperlexia. Terms such as *developmental alexia* and *congenital word blindness* began to be used by some educators to describe reading disability in children (e.g., Schmitt, 1918; Wallin, 1920; Fildes, 1922; Dearborn, 1925; Lord, 1925). Fernald and Keller (1921) studied a number of children whom they described as nonreaders. In 1922, three monographs addressing the issue of reading disability from an educational perspective were published (Gates, 1922; C. T. Gray, 1922; W. S. Gray, 1922). Thus, a dramatic change in the interests of educators toward reading disability appears to have taken place within a quarter of a century.

Is there a major event that could be associated with this upsurge in the study of reading disabilities? Although it is too simplistic an idea to consider a single event as providing all the impetus necessary for this inevitable interest, the use of terms *congenital word blindness* and *congenital dyslexia* by some educators suggests that articles written by physicians such as Morgan (1896) and Hinshelwood (1900) might have had a catalyzing influence on the thinking of educators. It has been suggested (Pelosi, 1977) that the turning point for reading disability may well have been the publication of *A Case of Congenital Word-Blindness* by Morgan in 1896.

During the latter part of the nineteenth century, reports of isolated instances of sudden but circumscribed loss of reading ability as a result of neurological impairment in literate adults began to appear in medical journals. The term *acquired dyslexia* has been used to distinguish this form of reading disability from developmental dyslexia, a failure to learn to read. The most complete accounts of loss of such reading ability, along with post-mortem findings, were provided in 1891 and

1892 by Dejerine, a French neurologist (Geschwind, 1974). These reports aroused a great deal of interest because the issue of localization of functions in the brain was a much debated topic at that time and Dejerine's findings appeared to indicate that the ability to read was located in a particular region of the brain. Dejerine not only demonstrated that reading ability could be lost discretely with other mental abilities well preserved, but also provided a plausible neuro-anatomical explanation for such a circumscribed loss. His first report (1891) described a 63-year-old literate man who suddenly lost his ability to read and write. The patient's vision remained unaffected and he was able to name objects correctly. His oral language also contained no noticeable defects. His reading disability, however, was total and he could write almost nothing except his own name. The patient died about eight months after the onset of the disability and post-mortem examination revealed a large lesion which originated in an area of the left cerebral cortex called the angular gyrus. Dejerine concluded that both the visual cortex and the angular gyrus of the dominant hemisphere played an important role in the processes of reading and writing.

Dejerine's second case of reading disability (1892) presented an even more dramatic set of symptoms. The patient was a very intelligent 68-year-old man who awakened one morning and was startled to find that he could no longer read a single word. He could see objects well, and his speech was totally unaffected. In fact, there was no hint whatsoever that he was ill. Even though he was able to write, he could not read what he had written. He could not read even isolated letters; nevertheless, he could name individual numbers and successfully carry out mental calculations. The reading disability extended to include musical notations, even though he had been a skilled musician. Dejerine also noted that the patient had a blind spot in his right peripheral vision. Upon the death of the patient four years later, an autopsy revealed that parts of the left visual cortex had sustained an earlier damage which could have accounted for the blind spot; in addition, the splenium of the corpus callosum through which fibers from the visual cortex reach the angular gyrus was also damaged (see Figure 1.1.).

Dejerine concluded that at the time of the onset of the disability, the angular gyrus, which he thought stored the visual representations of words, was unaffected and this was why the patient could write spontaneously. Since his right visual cortex was intact, he could see objects, relate the representations to the language area of the left

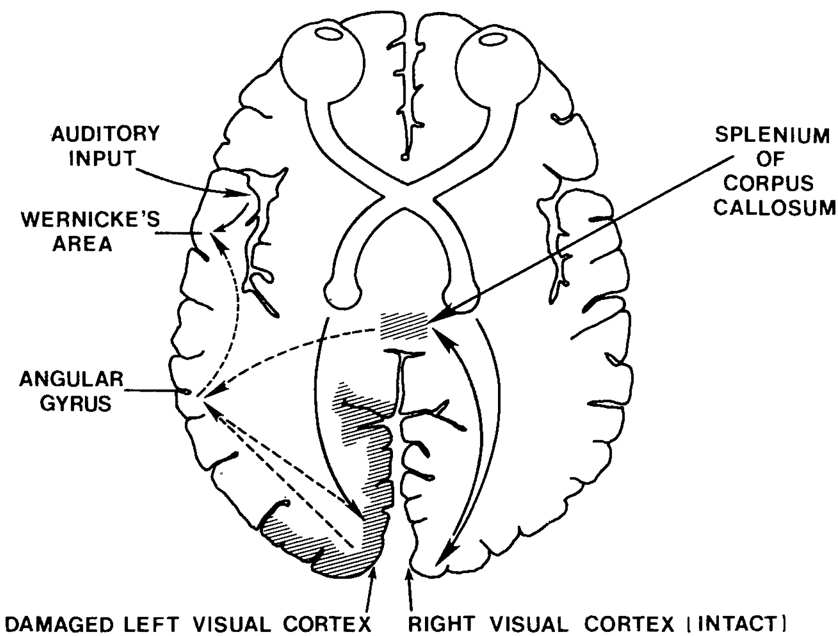


Fig. 1.1. Anatomy of an acquired reading disorder as proposed by Dejerine. (Because the left visual cortex is damaged, it cannot process visual information. The right visual cortex cannot transmit visual information to the language areas in the left cerebral hemisphere because the corpus callosum is damaged. Speech and listening comprehension are not affected because the language centers of the left hemisphere are intact. This form of acquired reading disability closely resembles developmental dyslexia.)

hemisphere, and name the objects. The visual representations of printed words, however, could not be named in a similar fashion because the fibers connecting the right visual cortex and the angular gyrus were disrupted. Numbers could be named, probably because, in addition to the visual input, they have kinesthetic representations since during the initial stages of learning, knowledge of number is acquired by using fingers. Thus, a disconnection of the angular gyrus from the right visual cortex coupled with a damaged left visual cortex was responsible for producing the perplexing syndrome seen in Dejerine's second patient.

In 1895, James Hinshelwood, an ophthalmologist from Glasgow, reported the case of a 58-year-old teacher of French and German who suddenly lost his ability to read printed and written materials in all the languages he knew. This description is almost identical to the one provided by Dejerine three years earlier. Hinshelwood wrote that the patient "spoke as fluently as ever ... his mental powers were as vigorous as ever, nor was there any defect of memory apart from the loss of memory for the visual symbols of language" (1895, p. 1565). Hinshelwood called this condition *word blindness* and noted the fact that the patient had no difficulty whatsoever with numbers. Even though Hinshelwood did not provide anatomical evidence, he made a very important observation regarding the effect of training on the reading skill of the patient. Nearly seven months after the initial diagnosis, Hinshelwood advised the patient to relearn to read using a child's primer and practicing daily. After six months of such training, the patient could read, albeit slowly and laboriously; his spelling, however, did not show a corresponding improvement.

The following year (1896) Pringle Morgan, another English physician, published a report of a healthy 14-year-old boy in whom he observed a set of symptoms similar to the ones described by Hinshelwood in adult patients. The boy had failed to learn how to read in spite of a number of years of schooling, and Morgan called this condition *congenital word blindness,* the first known report of developmental dyslexia in English language. Morgan, who was familiar with Hinshelwood's paper, was quick to observe the similarities between the traumatic and congenital forms of word blindness. Even though his report of this case is very brief, he took care to describe the most salient features. The boy, according to Morgan, was bright and intelligent; he could read and write all the letters of the alphabet, even though he had great difficulty in reading even common monosyllabic words. His spelling was poor and in writing he committed errors by substituting word suffixes (*winding — winder*) and by transposing letters. At times he could not write his own name correctly (*Percy — Precy*). His oral language was good, and the teacher who taught him for some years thought that he would be the smartest lad in the school if the instruction were entirely oral. He experienced no difficulty in reading multidigit numbers such as *785852017* and correctly solved problems such as $(a + x)(a - x) = a^2 - x^2$. Since the health history revealed no illness or injury, Morgan considered the etiology of the reading disability to be congenital and attributed it to defective development of the left angular gyrus.

Hinshelwood (1900) himself soon published detailed accounts of two more cases of congenital word blindness. He not only used the term *congenital word blindness* but also coined the term *congenital dyslexia*. However, he drew no operational distinction between the two. The first case (Hinshelwood, 1900) was that of an intelligent boy who could orally spell simple words correctly but could not read even common words such as *the*, *of*, and *in*. The boy had good auditory memory and Hinshelwood cites the following illustrative anecdote: "When I first saw the boy and his father at the Glasgow Eye Infirmary I asked them to call on me at my house and I wrote down the address on an envelope. A few days thereafter the father could not find the envelope, but the boy at once repeated the address correctly, having remembered it from hearing me state it once" (p. 1506). Hinshelwood's second case was the 10-year-old son of a physician. He too was a bright boy and did not have any difficulty with arithmetic or spoken language.

Hinshelwood went on to theorize that reading skill is acquired in two stages, the first stage involving "the storing up of the visual memory of individual letters of the alphabet" and the second stage consisting of the "gradual acquirement and storage of the visual memories of words" (p. 1507). At the second stage, words cease to be simple congeries of letters but are regarded as ideograms or symbols which suggest a particular idea. When the child reaches this stage, he recognizes a word just as he recognizes a familiar face and can read by sight. Since damage to the angular gyrus was implicated in the loss of reading ability in adults, Hinshelwood argued that this part of the brain is the center for visual memory for words and attributed congenital word blindness to faulty development of the same region in the dominant cerebral hemisphere. Hinshelwood stressed the point that no neurological damage was implied. It should be noted that Hinshelwood was careful to make a distinction between neurological impairment and abnormal development of the putative center for visual word form. Nevertheless, the terms *congenital word blindness* and *congenital dyslexia* have continued to carry a stigma primarily because of their guilt by association with *acquired word blindness*. Thus a tendency to link developmental dyslexia with brain disorder and damage has become deeply entrenched in the minds of reading specialists. In his 1907 article Hinshelwood wrote "the condition is not due to cerebral disease, nor is there any history of difficulties at birth. We are therefore inevitably led to the conclusion that the defect is due to faulty development of this special area" (p. 1231). He closed his first article with a pragmatic and optimistic note: "The recognition of the true character of the difficulty will lead the parents and teachers of these children to deal with them in the proper way, not by harsh and severe treatment, but by attempting to overcome the difficulty by patient and persistent training" (1900, p. 1508).

These initial reports were followed by several similar descriptions of other cases published in British medical journals. In the United States, two reports of developmental reading disability were published in 1906 in the *Journal of the American Medical Association* and the *American Journal of Medical Science* by Clairborne and Jackson, respectively. Clairborne described two boys aged 9 and 10 and devoted much attention to a discussion of educational implications. He even ventured to comment on his own special disability in mathematics: "Mathematics has always been a bugbear to me from childhood," he wrote; "every other department of learning which I have essayed has been fairly easy to me, but in the presence of figures I become as shy and shamefaced as the last boy whom I have described was in the presence of written words" (p. 1815). He went on to speculate that there might be a condition of congenital figure blindness analogous to word blindness.

By 1905, a sufficient number of cases had accumulated to enable Thomas to provide a summary based on nearly 100 instances of the condition that were recorded in case books at "special schools" in England. Thomas foreshadowed many of the current descriptions of developmental dyslexia. He noted that congenital word blindness was more frequent than had been suspected. It frequently assumed a family type and, in many instances, more than one member of the family was affected; it occurred three times more frequently in boys than in girls; and the condition was frequently associated with a good visual memory, intelligence, and an ability for arithmetic calculations. Thomas's suggestions for treatment are similarly illuminating. He recommended that the disabled child be taught on a one-to-one basis and that initial teaching of the alphabet be accomplished through touch by encouraging the child to handle large letters carved in wood. Subsequently, the visual—sound association of the letters could be developed. Thomas was optimistic about the prognosis, citing the case of an excellent surgeon who "practically did no reading, but acquired all his knowledge by the ear at 'grinds' and lectures" (p. 384).

The interests of these early medical practitioners did not remain a scientific curiosity but went beyond neurological confines to include educational practices. As a result of these early reports, physicians became aware of reading difficulties in children, and observations on several such cases were published (see, for example, Stephenson, 1907; Fisher, 1910). Many of these men were as much concerned with remedial methods as they were with diagnosis. For example, in his 1917 monograph, Hinshelwood devoted an entire chapter to the educational treatment of congenital word blindness, drawing from his own efforts to teach children with congenital word blindness. He recommended that the child should be taught on a one-to-one basis using the "the old fashioned" phonics system with a simultaneous appeal to the auditory, speech, and visual centers. He was reluctant to recommend any single technique but took issue with the "look—say" approach.

This is not to say that there was, at this period, a consensus about the method of remedial teaching. For instance, contrary to Hinshelwood's view, Fisher, in his 1910 paper, recommended the use of the "look and say" method to teach these children to read. This controversy also marked the beginnings of disagreement about the methods to be used in remedial reading, an issue which has persisted till today. It may seem strange that this great debate about methods of teaching reading was started by physicians.

2.2. *The Educators*

2.2.1. *The Problem of Terminology*

In view of the nearly one hundred years of history and research relating to developmental dyslexia, one might expect it to be a well-recognized and accepted syndrome. Even though some educators used neurologically oriented terms to refer to specific reading disability (see, for example, Dearborn, 1925; Lord 1925), these terms slowly fell into disuse. Eventually, as Harris and Sipay (1980) point out, two opposing tendencies came into existence regarding the etiology of reading disability. Physicians postulated a basic constitutional condition; educational psychologists, on the other hand, tended to be impressed by the wide range of psychological, emotional, sociological, linguistic, and educational handicaps that could be seen in poor readers and favored a pluralistic theory of causation. However, these two perspectives, neurological and educational, need not be considered mutually exclusive since they have different orientations and deal with etiology at different levels. The conflict that exists between the neurological and educational theories of reading disabilities happens to be an artifact of professional thinking.

Nevertheless, the attitude of many educators toward the concept of developmental dyslexia is one of skepticism and indifference. One reason for this state of affairs is a misunderstanding of the terms used, for example, the term *word blindness*. Even though Hinshelwood took pains to explain that it does not refer to any blindness per se, many professionals, including the neurologist Orton, misinterpreted this term. Some educators, while describing specific reading disabilities, chose not to use terms such as *word blindness*. For instance, Fernald and Keller (1921) reported four cases "of normal mentality who have failed to learn to read after three or more years in the public schools" (p. 357) but avoided terms such as *word blindness*, *specific reading disability*, and *congenital dyslexia*. Bronner (1917) described seven cases of reading disability, six of whom had average or above average intelligence, and noted that these children had great difficulty in mastering reading but, nevertheless, spoke well and had no difficulty in the use of language as a medium of self-expression. She also did not use terms such as *word blindness* or *dyslexia* to describe these children. Although, these investigators described children much like the ones Morgan and Hinshelwood had described earlier, either they tended to be critical of the neurological concepts used to explain reading disabilities (e.g., Burt, 1921) or they simply rejected the neurological terms. Gates (1929), for instance, after studying more than 400 poor readers, concluded that he "has not yet encountered a case of disability which seemed to be best described as word-blindness" (p. 273). He then went on to give detailed case histories of eight children who had average or above average IQs with no associated auditory or visual memory deficits. He used terms such as *deficiency in word analysis* and *deficiency in phonetic analysis* to describe these children. Information regarding four of these children is shown in Table 1.1. along with Gates' diagnostic descriptions. All four children had average or above average IQs and at least three might have been viewed as cases of developmental dyslexia, but Gates avoided the use of the term.

The converse situation, wherein the term *dyslexia* is loosely applied to all kinds of poor readers, can also be seen in the educational writings of the early twenties. In calling attention to the purity of the reading

TABLE 1.1.
Four cases of poor readers described by Gates

Case no.	Chronological age	Reading age	IQ	Descriptive diagnosis
1.	9.7	6.7	101	Deficiency in perceiving words
2.	8.5	6.4	116	Deficiency in word analysis
3.	7.9	6.6	113	Deficiency in phonetic analysis
4.	11.5	7.0	120	Deficiency in experience

disorder, Hinshelwood had stressed the point that the term *congenital word blindness* should not be applied to children with defective general intelligence, but this distinction was often ignored. For instance, Fildes (1921) conducted a "psychological inquiry into the nature of the condition known as congenital word-blindness" and studied 26 children of whom 25 had IQs that ranged from 55 to 88. Only one child with an IQ of 111 could be considered as a case of congenital word blindness by Hinshelwood's standards. Fildes, nevertheless, concluded that "word blind individuals reveal special difficulties in dealing with material other than words" (p. 304).

Clearly, confusion about application of labels used in decribing reading disabilities has been a major contributing factor to the misunderstandings that exist in the field. Unfortunately, laxity in clearly delineating specific reading disability is not a merely historical phenomenon but continues to persist even today. The field of learning disabilities, wherein children are identified primarily in terms of reading achievement, is a glaring example. After examining a number of research studies, Stanovich (1986a) writes that a substantial number of children whom schools label learning disabled would be equally good candidates for the EMR or borderline retardation categories. Moreover, he points out that empirical support for the concept of specific reading disability is weak because of lack of restraint in applying the reading disability label and the common practice of choosing research subjects on the basis of school labeling rather than by strict psychometric criteria.

Perhaps for these reasons, reading specialists have continued to use labels other than *developmental dyslexia* to describe specific reading disability. For example, one of the most influential books on reading disability (Harris and Sipay, 1980) classifies poor readers into three categories: disabled reader, slow learner, and underachiever in reading. *Disabled readers* are defined by the authors as individuals "whose general level of reading ability is significantly below expectancy for their age and intelligence and also is disparate with their cultural, linguistic, and educational experience" (p. 144); the *slow learner* is one who may read below age level but functions close to his intellectual potential; and the *underachiever* is one who may read at grade level but is functioning below his potential. It is obvious, from the above definitions, that many of the *disabled readers* of Harris and Sipay may be good candidates for the term *dyslexia.*

2.2.2. *The Problem of Methodology*

The concept of developmental dyslexia also became alienated from mainstream educational research because dyslexia was originally studied by methods in which clinical observation, intuition, and experience played major roles. In contrast, even during the early part of the present century, reading research, as carried out by educationists, tended to be quantitative and objective (see Huey, 1908). Reading tests and other standardized instruments were also developed and used in assessment procedures. Among the most frequently investigated topics were the difference between oral and silent reading, the relationship between eye movement and reading, and the effects of teaching reading through different methods. As early as 1917, Gray was able to assemble 48 such investigations and provide brief summaries of many of them. In light of such a comparatively advanced state of research and measurement, the reports provided by physicians regarding specific reading disability were considered to be of poor scientific quality. Bronner's criticism (1917) of such investigative procedures illustrates this feeling:

> Reviewing the work thus far done, it may be said that the English school first used the term congenital word-blindness and has offered most of the published cases. On the whole, from a psychological standpoint, these cases have been very inadequately studied and poorly analyzed; no psychological tests have been used, and no standard for gauging general intelligence has been employed. Tasks placed in the Binet scale at the four-year level of intelligence are cited as evidence of good mentality in the case of an eleven-year-boy. All together, the material is most unsatisfactory. (p. 87)

Definitional and methodological controversies aside, it is clear that some children who are of normal and superior intelligence fail to become skilled readers in spite of all efforts. Recognition and treatment of this type of reading difficulty is of obvious importance.

2.3. *Neuropsychology*

2.3.1. *Beginnings of a Compromise*

Defining the term *neuropsychology* and describing precisely who is a neuropsychologist and who is not is a difficult task. Some neuropsychologists explain learning and behavior in terms of brain processes and make use of anatomical and physiological information, whereas other neuropsychologists explain learning and behavior purely in psychological terms. In general, neuropsychologists draw information freely from all sources — anatomical, neurological, psychological, and behavioral — and construct theories on the basis of such information. This eclectic approach provides a unique opportunity for neuropsychology to integrate findings from diverse fields and resolve some of the conflicts found among the various disciplines regarding reading disabilities. In a broad sense, physicians such as Morgan and Hinshelwood can be considered as neuropsychologists since they used psychological concepts (such as visual memory for words) to explain the failure to learn to read.

2.3.2. *Orton, the Pioneer*

The earliest neuropsychological explanation of specific reading disability was advanced in the mid twenties. The author of this new theory was Samuel Orton, a neuropsychiatrist with extensive firsthand experience in dealing with children who had educational problems. Even though Orton used the term *word blindness* in his early writings (1925), he later objected to the term, since there was no "blindness" in the ordinary sense of the term nor, indeed, was there even blindness for words. In this context, it has to be noted that Hinshelwood (1917) himself was aware of the inadequacy of the term *word blindness* and used it to mean "a condition in which with normal vision and, therefore, seeing the letters and words distinctly, an individual is no longer able to interpret written or printed language" (p. 2). Orton's reason for objecting to the term "word blindness" was that many of these reading disabled children could copy words correctly even though they could not read the words they had copied. Ironically, the very term Orton chose to replace it — *strephosymbolia* (literally, twisted symbols) — was later subjected to similar misinterpretation by those who took mirror reversed writing and reading to be the most salient feature of developmental dyslexia. Orton, however, coined the term to highlight a deficit in the *sequential processing of visual language* and a striking tendency in children with reading disability to distort the order of letters recalled while reading and spelling. He made special mention of the fact that "reversals are not an outstanding feature" of specific reading disability (1937, p. 93) and frequently used the phrase "specific reading disability" in place of strephosymbolia. Even though in recent times the label *strephosymbolia* has fallen into disfavor, an overall inability of the dyslexic reader to process any information presented in a sequential manner is considered by some psychologists to be a viable explanation of developmental dyslexia.

Orton's criticism of Hinshelwood's terminology was accompanied by his rejection of Hinshelwood's notion of a putative visual memory center for words and its hypothesized failure to develop properly in reading disabled children. Orton (1937) raised three objections in this regard. First, he noted that such failure of development was rare and unconfirmed by autopsy examinations. Second, influenced by the writings of Marie the French neurologist, Orton claimed that in children, when one cerebral hemisphere was damaged, the other could assume its language functions since these children grew up to be apparently normal, as far as speech was concerned. Consequently, Hinshelwood's hypothesis would require both cerebral hemispheres to be defective, an exceedingly rare possibility. Finally, Orton noted that reading is too complex a process to be mediated by a single anatomical component such as the angular gyrus.

To replace Hinshelwood's angular gyrus hypothesis, Orton proposed his own. In his clinical experience, Orton had observed a high incidence of left-handedness among dyslexic children and members of their families. He also noticed that children with dyslexia could read mirror reversed words at least as well as conventional print. On the basis of the neuropsychological information available to him at that time, Orton considered the control mechanisms for speech, reading, and writing to be concentrated in one hemisphere of the brain and thought that this specialization had an intimate relationship to the development of unilateral manual skills. He further believed that normal reading is strictly a unilateral operation in the sense that in a majority of people, engrams necessary to recognize words are located in the left hemisphere. Under such a condition, any registration of word images that reaches the right hemisphere is suppressed or "elided." If, however, engrams persist in the nondominant right hemisphere, they cause confusion in word recognition and recall, since these engrams have an orientation opposite to the ones in the dominant hemisphere. The existence of two sets of representations, the engram and its mirror image, causes reversals of letters and words in reading as well as writing. Orton suggested that incomplete dominance manifested in the form of mixed handedness, eyedness, and so forth is indicative of such a diffuse cerebral condition.

A literal version of Orton's hypothesis is not accepted by many authorities today since there is no reason to believe that engrams that are present in the opposite cerebral hemispheres are mirror images. Moreover, numerous studies have failed to establish a significant link between "mixed dominance" and reading disability. Nevertheless, many of Orton's insightful observations in connection with specific reading disability are worth mentioning. First of all, like Hinshelwood some years before, Orton (1937) emphasized the purity of the symptoms of the reading deficit. He noted that many children show no deficit other than reading, spelling, and written language and that the most searching examinations revealed no deviations in the functions of the brain. In this connection, he mentioned that the auditory development of these children was usually quite normal as was their ability to understand words and acquire speech. Furthermore, he observed that the spoken language of the reading disabled children could be normal or even superior. Their visual—motor coordination could be excellent. The strephosymbolics were found to be no less bright than normal readers and, in fact, some of them ranked high in intelligence. Orton emphasized the distinction between children with specific reading disability and children with an overall intellectual deficit:

> A word of caution must be offered here, however, and that is poor reading comprehension forms an integral part of the general picture presented by children with dull normal intelligence and those of the defective group, so that failure in learning to read with understanding must not be considered a specific disability unless it is distinctly out of harmony with the child's skill in other fields — notably the ability to learn by hearing and to master arithmetical concepts. (p. 73)

Orton also occasionally referred to developmental reading disability as *developmental alexia* and noted that affected children have "adequate mastery of spoken language" (p. 98). Those with difficulty in oral language, he considered, to be cases of developmental motor aphasia. Further, he pointed out that children who have specific reading disability form a graded series including all degrees of severity of the handicap. They are often poor spellers and, as a group, are also poor in the skills of written language and commit errors of grammar, punctuation, and so forth. Orton also made the following very important observation regarding the reading speed of these children. Milder cases gradually learn to read but as they progress in school, both the volume and intricacy of the reading demands surpass their ability, and their slow rate of reading impedes academic progress. Consequently, cases who fail in secondary schools and even in college because of their inability to read with sufficient speed are not uncommon.

Orton noted that in tests of silent reading, students with specific reading disability could reach the norms for their age. During oral reading, however, these poor readers showed a tendency to guess many printed words; sometimes, a highly imaginative child would concoct a whole story which had no relation to the words on the page. Misreading or the omission of small words was also common. Orton also believed that a hereditary factor is involved in specific reading disability and that it is seen about three and one-half times more in boys than girls. He was, however, quick to point out that it is a sex-influenced factor, not a sex-linked one. He did not specify any reason for considering specific reading as limited to one sex but probably drew his conclusion from his observation that dyslexia occurred in girls more frequently than a *X*-linked trait normally would. Since he also recognized the role played by environmental factors, Orton preferred the term *developmental* to *congenital.*

From an operational point of view, Orton thought that the major factor underlying all these deficits was a difficulty in "repicturing or rebuilding in the order of presentation, sequences of letters, of sounds, or of units of movement" (p. 145). This deficit results in the tendency for reversals, even though such errors occur in an unsystematic and random fashion. With reference to other subject matter areas, Orton mentioned that sequential deficits could also cause trouble in arithmetic because of a failure to preserve correctly the order of numbers or their spatial location.

A considerable portion of Orton's book was devoted to the diagnosis and treatment of specific reading disability. He did not offer a blanket prescription, but recommended capitalizing on the poor readers' auditory competence by teaching them the phonetic equivalents of printed letters and combining them with the kinesthetic approach. In general, he favored a phonetic approach and stressed the development of word attack, blending, and written spelling skills. Contrary to the generally held notion, careful reading of Orton's writings shows that he did not limit reading disability to mirror image writings and reversals. An excerpt from Orton's original writing illustrates this point (see Box 1.1.).

BOX 1.1.
An excerpt from Orton's writing

The hallmark of the specific reading disability or strephosymbolia is a failure in recognition of a printed word even after it has been encountered many times. Because of this and because the great majority of the children whom we studied had already been unsuccessfully exposed to the sight- or flash-card method of teaching reading, we believed it unnecessary to experiment extensively with this procedure and indeed as our observations were extended we came to feel not only that repeated flash exposure of the whole word was not effective but that it might in certain children even increase the tendency to confusion and failures of recognition. Since the majority of the cases of reading disability have shown a normal development of spoken language and could readily understand, when spoken to them, the same words which they could not read, our approach has been an attempt to capitalize their auditory competence by teaching them the phonetic equivalents of the printed letters and process of blending sequences of such equivalents so that they might produce for themselves the spoken form of the word from its graphic counterpart. (Orton, 1937, pp. 158—159)

The influence of Orton's views on the field of developmental dyslexia is aptly summarized by Benton (1980): "Orton's theoretical formulation decisively influenced the direction of subsequent research on dyslexia. Over the past 50 years no topic in the field has been so thoroughly investigated as has the question of whether specific reading disability is systematically related to incomplete or anomalous hemispheric dominance" (p. 17). The tremendous influence Orton had on the study of developmental dyslexia is exemplified by the establishment of the Orton Dyslexia Society, an organization which holds international and regional meetings and provides a forum for physicians, psychologists, and educators to meet and share their knowledge in this rapidly developing field of research.

2.3.3. *Recent Developments*

2.3.3.1. *Cerebral hemisphere processes and the "Imbalance hypothesis."* Since Orton's time, experimental procedures such as dichotic listening and tachistoscopic presentation of visual stimuli have made it possible to study, with reasonable accuracy, the relative roles played by the two cerebral hemispheres in the processing of information. As noted earlier, a literal version of Orton's hypothesis is not accepted by many contemporary researchers, but an operational version of the hypothesis in a modified form holds much promise for our understanding of developmental dyslexia. This version is based on the observation that the two hemispheres differ in the strategies they utilize with the left cerebral hemisphere processing information sequentially and the right hemisphere processing information in a simultaneous fashion. Thus, the two hemispheres differ from each other in their strategies. Normal reading involves a judicial blend of the two strategies since skilled reading depends on the rapid processing of familiar printed words as wholes as well as a phonological analysis and transformation of infrequent and unfamiliar words (Pennington *et al.*, 1987b; Van Orden, 1987). These two sets of skills are believed to correspond to the simultaneous and sequential strategies. An excessive dependence on one strategy and the under-utilization of the other strategy are likely to impede the reading process. According to this modified hypothesis, dyslexic subjects appear to be overdependent on the simultaneous strategy while they under-utilize the sequential strategy. This *imbalance hypothesis* has received experimental support from studies that have used cognitive approaches (Kershner, 1977; Aaron, 1978) as well as from investigations that have used neuropsychological approaches. Witelson (1977) also has shown that the dyslexic child has a diffuse cerebral organization and acts as though he has "two right hemispheres and none left" (p. 309). Recently, Kirby and Robinson (1987) studied 105 reading disabled children by administering a battery of tests which assessed simultaneous and successive information processing skills and reading achievement. Application of the statistical procedure of principal component analysis to the data yielded simultaneous and successive processing factors in the information processing domain, comprehension, and word analysis. They interpreted these findings as indicating that the reading disabled children employed simultaneous processing in reading tasks that normally require successive processing. These findings suggest that Orton's proposal that a basic deficit in the sequential ordering of information was an underlying problem seen in children with specific reading disability is essentially correct.

An interesting feature of the "imbalance hypothesis" is that its validity can be investigated in neurological terms by studying the characteristics of the right and left cerebral hemispheres or in behavioral terms by studying the learner's ability to process information that is presented sequentially or simultaneously. A number of studies have used these two approaches. Even though at present no firm conclusions can be drawn from these studies, a review of this research by Bryden (1982) suggests that there is a relationship between diffuse cortical representation and deficits in reading or language related skills.

In a series of three articles Geschwind and Galaburda (1985a; 1985b; 1985c) have presented a set of hypotheses about the biological mechanisms that lead to the lateralization of cerebral functions and the consequences of atypical lateralization. They have proposed that cerebral dominance which results from the lateralization of such functions is based on neurochemical factors such as sex hormones present in the maternal uterine environment and on fetal tissue sensitivity. Neuro-anatomical studies show that, in animals as well as in man, the left cerebral hemisphere develops later than the right hemisphere, a fact that leaves the left hemisphere immature for a longer period than the right hemisphere. Geschwind and Galaburda argue that because testosterone has a retarding effect on neural tissue, it will have a greater retarding effect on the development of the left than of the right hemisphere resulting in the formation of fewer synapses in the left than the right hemisphere. This is consistent with findings of animal experiments which show that a lesion placed in one cortical region results in the establishment of an increased number of neuronal connections by the corresponding contralateral cortical region with other cortical regions of both hemispheres. The underdevelopment of the left cerebral hemisphere, therefore, can be expected to result in a compensatory over-development of the contralateral right hemisphere which can lead to an atypical form of cerebral dominance. Such a retardation of the left hemisphere will, therefore, show, on the average, diminished left hemisphere skills and associated augmented superior right hemisphere skills. Because males are likely to have above-average amounts of fetal testosterone, atypical cerebral lateralization is likely to be seen in more males than females. Testosterone also affects structures involved in the development of immunity. The Geschwind—Galaburda hypothesis can, therefore, account for facts such as higher incidence of reading disability in males than in females, a higher than chance association between left-handedness, immune system disorders such as allergies and reading disability, and superior visuo-spatial abilities frequently reported in dyslexic subjects. Psychological data that support this hypothesis are presented in Chapter 3.

2.3.3.2. *Acquired or traumatic reading disorders.* A new methodology which could best be described as "cognitive neuropsychology" is an influential development of the seventies. This method utilizes a detailed neurolinguistic case study approach and investigates in great detail the reading performance of adult patients who have sustained brain damage. The impetus for this type of research was provided by Marshall and Newcombe (1966, 1973) who identified two different forms of reading failure and labeled them as *deep dyslexia* and *surface dyslexia.* The term *alexia* previously used to refer to such neurological problems was abandoned because a total loss of reading ability is almost never observed. In contrast to earlier neurological studies which were interested in brain localization and possible etiologies, the cognitive neuropsychological approach focuses on the linguistic features of reading. The qualifying terms *deep* and *surface* reflect the influence of modern psycholinguistics on this kind of research.

Those who study reading disorders from the cognitive neuropsychological orientation tend to use lists of isolated words which the patients are required to read. The use of isolated words eliminates context effects. Since this type of neuropsychological investigation has had much impact on reading research and because efforts have been made to study developmental reading disability from the cognitive neuropsychological perspective, the major findings of this research are briefly reviewed.

Deep dyslexia is characterized by the following features that become apparent when the patient tries to read isolated words: presence of semantic paralexic errors (*act — play, close — shut, tall — long*); visual errors (*stock — struck, saucer — sausage, crocus — crocodile*); derivational errors (*wise — wisdom, truth — true, strange — stranger*); a hierarchy of word-reading difficulty with more nouns correctly read than adjectives which are, in turn, read better than verbs; function word reading more erratic than that of content words; and an almost total inability to read aloud pronounceable nonwords such as *nol* and *wux* (Marshall and Newcombe, 1980). In contrast, patients who are classified as *surface dyslexics* are thought not to be able to recognize words on the basis of their meaning, tending rather to sound them out by applying literal spelling-to-sound rules. Comprehension appears to depend upon the oral response. Thus, the word *sale* is read as *Sally* and the patient, when asked what it means, says it is the name of a woman. As data from more surface dyslexic patients have accumulated, however, it has become apparent that a great deal of variation is observable among the performance of these subjects (Patterson *et al.*, 1985) and additional subtypes have been postulated to accommodate these variations.

One of the major goals of the investigators who have analyzed reading breakdown from a cognitive neuropsychological perspective is to develop a theory and a model of the normal reading process. For example, errors committed by the two kinds of dyslexic patients suggest that the deep dyslexic is poor in grapheme—phoneme conversion skills (decoding) but is able to comprehend the written word much better than pronounce it whereas the surface dyslexic is able to convert print into sound but is unable to comprehend the written word correctly. It would appear, therefore, that phonological conversion of print and the comprehension of the printed word are two separate skills which may be affected independently.

Some "surface dyslexics," in spite of their poor comprehension, can pronounce correctly some *exception words* that do not conform to the conventional spelling-to-pronunciation rules. (Examples of exception words are *have* and *pint* which are not pronounced like the regular words *gave* and *pave* or *mint* and *tint*.) Furthermore, they can pronounce highly familiar words faster than relatively unfamiliar words. The ability to pronounce exception words that cannot be pronounced correctly by applying decoding rules suggests that some process, in addition to the simple spelling-to-sound correspondence, facilitates reading. Thus, a third skill or process that enables the conversion of the word as a single unit into its phonological equivalent without resorting to spelling-to-sound analysis also appears to be involved in reading. The study of these three routes to word recognition has raised interesting questions about their differential roles in both skilled and disordered reading. As will be shown later, they may offer a significant clue to the puzzling differences seen in the reading abilities of dyslexic and hyperlexic children.

2.3.3.3. *Comparison of acquired and developmental reading disorders.* In order to be considered viable, any theory of reading must be able to explain satisfactorily not only the important features of acquired reading disorders but also those of developmental reading disorders. It is, therefore, interesting to see what impact cognitive neuropsychological studies of adult-acquired deep and surface dyslexias have had on developmental reading disabilities. While it is to be recognized that a strict comparison of the two conditions — acquired and developmental — is not possible since one is concerned with loss of a once well-developed skill and the other with a skill not fully developed, such a comparison could be useful in confirming or challenging the hypothesis that reading can be accomplished only with the syncretic action of independent subsystems.

The first systematic attempt to relate acquired dyslexia to developmental dyslexia was made by Holmes (1973) who compared two cases of acquired dyslexia with four cases of developmental dyslexia. Later, she discussed her findings with reference to the "regression hypothesis" which postulates that brain damage makes the patient regress to an earlier stage of cognitive development (1978). Even though Holmes did not speculate about which of the two forms of acquired dyslexia — deep or surface — better matches the developmental type, she did note that "the majority of the errors from all six subjects are 'literal,' that is, they reflect a partial failure of grapheme—phoneme correspondence rules" (1978, p. 91). She also observed that both cerebral injury and some unexplained developmental defect cause the subjects to be unable to "hold in mind" and process the sequence of graphemic items over which linguistic mapping rules operate. Noting that previous efforts to compare developmental reading disability with the pathological loss of reading ability have provoked a strong reaction, Holmes cautiously concluded that "brain lesions take apart what the child is trying to put together" (1978, p. 95).

Jorm (1979) proposed that developmental dyslexia resembled deep dyslexia in the sense that in both cases a disability in the phonological conversion of print is the underlying cause of the problem. Ellis (1979), however, argued that developmental dyslexics hardly ever commit semantic errors (e.g., father — dad) in reading isolated words, a cardinal symptom of deep dyslexia and, therefore, a comparison with acquired surface dyslexia is more appropriate. After reviewing some of these conflicting findings, Snowling (1983) repeated the warning that comparisons between acquired and developmental disorders of reading cannot be very accurate because factors such as the reading level of children and their tendency to deploy more than a single strategy while reading cannot be adequately controlled.

These somewhat pessimistic observations have not deterred researchers from casting developmental dyslexia within the framework of acquired reading disorders. For example, Coltheart *et al.* (1983) have described a case of developmental dyslexia which they consider an instance of developmental surface dyslexia, and, more recently, Temple (1985) has reported five additional cases of "developmental surface dyslexia."

A developmental analog of deep dyslexia has not been reported although Temple and Marshall (1983) have described a case of developmental phonological dyslexia. Developmental phonological dyslexics have a great deal of difficulty converting graphemes into the corresponding phonemes (i.e., decoding). They present all the symptoms of the acquired deep dyslexic patient with the exception of the semantic reading errors. Many dyslexic college students reported in this book present symptoms that are similar to the case described by Temple and Marshall as developmental phonological dyslexia. In fact, it will not be surprising if a majority of developmental dyslexics turn out to be instances of phonological dyslexia since, as will be seen later, the most salient symptom of their reading difficulty is phonological conversion deficit.

The question of whether there are similarities between developmental and acquired forms of reading disabilities is not entirely an academic one. If reading is mediated by independent subsystems, as studies of acquired disorders would indicate, it can be expected that an incomplete development of any one of these systems will also affect normal acquisition of reading skill. This is likely to result in subtypes of developmental reading disabilities which, in turn, would call for different remedial approaches. At any rate, these new studies of neurological patients have provided researchers of developmental dyslexia with fresh data, new tests, and refined models of reading.

This brief review of neuropsychological views of reading disability indicates that this field is a meeting ground of neurological, psychological, linguistic, and educational theories and practices. As such, it may be expected not only to integrate information available in these divergent fields but also to help bring about a compromise among the dissenting views.

3. THE CURRENT SCENE: AN ORCHESTRATED EFFORT

The study of developmental dyslexia continues to be an active field of research that attracts specialists with backgrounds as varied as neurology, artificial intelligence, experimental psychology, and reading instruction. We will briefly discuss the current developments with reference to four specialized approaches.

3.1. *The Biological Approach*

Those who study reading disability from a biological perspective are interested in the genetic aspects of the disability as well as the possibility of some neurohormonal involvement. Recently, Geschwind and Behan (1982) reported a higher than chance association between left-handedness, incidence of allergies, and learning disabilities. The hypothesis proposed by Geschwind and Galaburda (1985a) that links reading disability with left-handedness, immune disorders (allergies), the male sex, and superior visual—spatial abilities was mentioned earlier in this chapter. According to this hypothesis, an excessive amount of testosterone during the embryonic and fetal periods retards the maturation of the left hemisphere which results in compensatory development of the right hemisphere leading to a high incidence of left-handedness and superior visual—spatial abilities. The increased level of testosterone may also delay the maturation of the thymus gland which is responsible for the normal development of the immune system. In accord with a neurohormonal explanation of the etiology of developmental dyslexia, a number of studies have shown that specific reading disability is highly heritable (Decker and Vandenberg, 1985; DeFries, 1985). Future research in this area is likely to focus on the unraveling of the exact nature of the genetic transmission of the disorder.

The Geschwind—Galaburda hypothesis is an attractive one since it can accommodate features commonly associated with dyslexia such as left-handedness, predominance of the male sex, superior visual—spatial skills, and high degree of heritability. Geschwind (1985) has made special efforts to point out that the way the brain of the dyslexic is programmed might endow it with special talents in art, certain areas of engineering, and music. This "difference model" of dyslexia (as opposed to the "deficit" model) could very well guide many future research efforts.

3.2. *The Neurological Approach*

Anatomical examination of a few dyslexic brains has shown signs of anomalous development (Galaburda, 1985). Results of studies that have used various imaging techniques such as CAT scan show that the right hemisphere of dyslexic readers is comparatively more developed than the left hemisphere (Hier *et al.*, 1978). Duffy and McAnulty (1985) used the brain electrical activity mapping technique (BEAM) to study 30 children with reading difficulties. They found that the group of poor readers with global language disorder, as compared to poor readers with sequencing or naming disorders, showed pervasive deviant brain activity over a wide area of the cortex. In a recent study Voeller and Armus (1986) compared 17 dyslexic children with two matched groups of 26 children half of whom had left-hemisphere dysfunction and half of whom had right-hemisphere dysfunction. These 26 children were identified with the aid of CAT scan and clinical neurological examination. The 17 dyslexic children did not show any signs of neurological dysfunction but had a genetic history of reading disorder in addition to being poor readers. These investigators found that the dyslexic children resembled those with left-hemisphere dysfunction; children with right-hemisphere dysfunction differed from the other two groups. This study indicates that developmental dyslexia can exist in the absence of detectable brain dysfunctions or deficits and suggests that developmental dyslexia may be caused by a tendency to use a neuropsychological strategy that is different from the one used by normal readers. The implications of this "difference model" of developmental dyslexia are contrasted with the "deficit model" and explored further in Chapter 5.

3.3. *The Neuropsychological-Cognitive Approach*

Since no clear-cut separation is possible between the experimental procedures adopted by cognitive psychologists and those of neuropsychologists, these two groups will be dealt with as a single unit. The most important advance made in the area of neuropsychology within the past quarter century is the knowledge that the two cerebral hemispheres are specialized in their cognitive styles. The left hemisphere, in a majority of people, processes information temporally in a sequential fashion, whereas the right hemisphere tends to process information in a simultaneous, spatial fashion. Along with these findings comes the recognition that the right hemisphere has its own competence. Zaidel (1985) has summarized the abilities of the right hemisphere in the following terms. The right hemisphere has relatively large auditory vocabulary but smaller visual vocabulary; it does not use phonological analysis and has no grapheme—phoneme conversion skill (i.e., decoding). Consequently, it tends to access meaning directly from print, is poor in handling bound morphemes (suffixes), and has very limited short-term memory capacity. This portrait of the right hemisphere reads like a description of the dyslexic child's capabilities. There is an increasing tendency to view cerebral-hemisphere functions in terms of differences in strategies rather than in structure (Goldberg and Costa, 1981; Sundet, 1986) even though, for practical purposes, structure and function may be inseparable. The possibility that the dyslexic individual may read with his right hemisphere or, to be more accurate, use a "right-hemisphere strategy" for reading is, therefore, an attractive one. As noted earlier, Witelson (1977) has obtained evidence in support of this hypothesis. An alternate, but not an altogether different hypothesis, to be considered is that, in the dyslexic, the anterior frontal area of the left hemisphere is not functioning efficiently in processing sequentially presented information, and the posterior temporal region compensates for these deficiencies by directly accessing meaning of the written word. This situation may be analogous to the one seen in some Japanese neurological patients who, depending upon whether the lesion is in the anterior or the posterior region of the brain, fail to read one or the other form of script of the Japanese language (Paradis *et al.*, 1985).

Many cognitive psychologists have disregarded neurological conceptualizations and have approached the problem of phonological recoding in the dyslexic from an entirely psychological perspective. Liberman and her associates (1980a, b) have provided evidence for a phonological deficit in children with specific reading disabilities. If phonological conversion of print is the underlying problem in dyslexia, then learning to read nonalphabetic ideographic script (such as Chinese) should be easier for the dyslexic child than the learning of alphabetic script such as English. A study of Rozin *et al.* (1971) showed this to be the case.

Another research area that has received considerable attention is the relationship between reading ability, short-term memory capacity, and the speed with which words are retrieved from the memory store. Investigators study deficits in this area by assessing the reader's ability to repeat a series of digits or to name pictures rapidly (Denckla and Rudel, 1976a; Rudel, 1985). The poor performance of many dyslexic children in these tasks may be related to some deficit in the working memory. A problem that remains to be resolved is that not all dyslexic children and adolescents perform poorly in tests of short-term memory; a few poor readers perform normally in these tests (Aaron *et al.*, 1980; Torgesen and Houck, 1980). Future research may tell us whether poor memory is a cause of reading problem or if it occurs only as a cofactor of reading disability. It is quite possible that performance on short-term memory tests is confounded with variables such as mnemonic devices used by the subjects, sex, intelligence, and reading experience.

The recently developed method of intensively studying single patients with acquired reading disorders has provided important insights into the reading process. These in-depth studies reveal information that is usually obscured in statistical procedures which analyze data collected from large populations. Even though this approach has not been widely used by those who study developmental dyslexia, it has provided a framework for the study of developmental reading failure (Coltheart *et al.*, 1983; Temple and Marshall, 1983).

3.4. *The Educational Approach*

How best to teach the reading disabled child has been an important goal of the reading specialist. Although many educators recommend a phonics approach (Naidoo, 1981), it is unlikely that a single method of remedial teaching will emerge as the most successful one. This is because factors such as the severity of the reading problem and the age of the dyslexic individual interact with the instructional method. Pioneering efforts to match the nature of the reading disability with selected remedial methods appear to be promising (Aaron *et al.*, 1982; Fiedorowicz, 1986). A program developed by Beck and Roth (1984a, b) to provide practice in identifying and discriminating subword letter patterns is reported to have led to substantial increase in student's accuracy and speed of word recognition as well as comprehension. A major change that is taking place is to make diagnosis in terms of the disabled reader's performance on the essential components of reading and then to target the remedial instruction to the weak component (Brown and Campione, 1986). This pragmatic educational approach is based on a judicious blend of the knowledge obtained from research, diagnostic procedures, and remedial efforts. These remedial approaches are more fully explored in Chapter 7.

Finally, studies of long-term prognosis of individuals with developmental dyslexia have recently been undertaken. Finucci *et al.* (1985) conducted a survey of 468 men who attended an independent school for boys with developmental dyslexia and found that more than 40 percent of these dyslexics had graduated from college. This and other anecdotal reports provide room for optimism. Of particular interest is the type of curriculum and instructional program that leads to success or failure of the dyslexic individual. Such information will be of much practical value to teachers and administrators since the number of special schools for dyslexic children is on the increase.

4. HYPERLEXIA: HISTORY OF RESEARCH

The history of accretion of our knowledge about hyperlexia can be conveniently examined in terms of three stages which can be somewhat arbitrarily separated from each other: (a) the awareness stage, (b) the recognition stage, and (c) the conceptualization stage.

4.1. *Awareness of the Presence of Extraordinary Decoding Skills in Some Young Children*

Sporadic reports of children who could decode written words with amazing facility but could not comprehend what they had read have appeared in educational literature since the early part of the present century. Bronner (1917) described 46 children with various kinds of disabilities one of whom fits the description of hyperlexia. The child was a 13-year-old boy who had a mental age of 7.4 years. He was unable to reply to any common-sense questions and could not reproduce with any semblance of correctness a passage read to him; there was no doubt that the boy was feeble-minded. However, he showed quite a facility for reading. To Bronner's great surprise, he was able to render fluently a third-grade passage. He wrote well and his spelling was also fair. He, however, had no ability in the handling of numbers; he could count slowly only by ones. Bronner noted that special ability for some type of performance is frequently found in members of the subnormal group. She reasoned that in the ability to deal with the concrete, the normal and the defective are much more nearly equal in ability than in powers of reasoning, judgment, or ability to deal with abstractions.

Other investigators also have noted an unusual ability to read aloud words and sentences in some mentally retarded or emotionally disturbed children. Often, such skills were described within the framework of the phenomenon of "idiot savants" or "autism" (Parker, 1917; Phillips, 1930; Scheerer *et al.*, 1945). These investigators, however, did not undertake detailed analyses of the reading processes of these children.

Reports of the existence of some children who could read aloud fluently but not understand what they had read together with the knowledge that there are children with normal intelligence who cannot decode printed language led to an awareness of the existence of two types of poor readers. A passage from Monroe's 1932 book illustrates this awareness:

> Even between closely related abilities, such as reading and intelligence, there is a range of disparity in which we found such variations as the bright child who cannot read although he can comprehend material read to him, and the defective child who reads fluently although he is unable to deal intelligently with the material read. (p. 1)

4.2. *Recognition That Some Children Can Decode Words Much Better Than They Can Comprehend*

The recognition that the discrepancy between decoding and comprehension seen in some children is of psychological and educational significance can be traced to a report by Silberberg and Silberberg (1967) in which they used the term *hyperlexia* to describe word-decoding ability that is out of proportion to comprehension ability. On the basis of their observation of 20 children who "recognized words on a higher level than their ability to integrate them" (p. 41), Silberberg and Silberberg concluded that hyperlexia suggests a continuum of word-recognition skills which may exist separate and apart from general verbal functioning. The 20 children referred to by these authors ranged in intellectual functioning from the mentally defective to the bright normal. In a subsequent article, Silberberg and Silberberg (1968) provided descriptions of six cases whom they appear to consider as hyperlexics. Three of the six children had below-average IQs while the remaining three had IQs of 107, 112, and 113. Further, these investigators proposed a continuum of reading ability based on the relationship between word recognition (decoding) and general verbal functioning with hyperlexic children occupying one end of the continuum and dyslexic children the other. In yet another article, Silberberg and Silberberg (1971) provided psychometric data for 28 children whom they considered to be hyperlexic. The school placement of these children ranged from preschool to grade 4.5, and their IQs ranged from "nontestable" to 126. Even though the authors noted that hyperlexic children could read aloud very well but could not comprehend what they had read, they did not include defective comprehension as a symptom of the hyperlexia syndrome but proposed that children be classified as hyperlexics if "their measured reading [decoding] level was above their expected word recognition [decoding] level by the following amounts: 1.5 in grades 1 and 2; 2.0 in grades 3 and up" (1971, p. 236). Based on the reported IQs, it is reasonable to assume that some of these 28 children must have had average or even superior comprehension abilities. In fact, the authors themselves noted that "hyperlexics have *occasionally* been retarded children; sometimes, however, they have been children with normal and bright normal conceptualization ability" (1971, p. 238; emphasis added). Their conceptualization of hyperlexia was based on the reasoning that decoding is a unique trait independent of intellectual functioning and is distributed in a statistically normal way. Silberberg and Silberberg, however, noted that eight of the 28 children manifested behavior consistent with the diagnosis of cerebral dysfunction and four children displayed signs of schizophrenia and autism.

It appears, then, that the term *hyperlexia*, as originally coined, was not meant to denote a form of reading disability but was intended to remind teachers and school psychologists that they should be careful not always to expect a level of reading achievement that is equivalent to the reader's decoding ability.

Defining hyperlexia on the basis of the discrepancy between the expected and actual decoding skill alone, however, would result in a criterion that is over-inclusive and, consequently, could lead to the labeling of some normal or even superior readers as hyperlexic. This, in fact, has happened. Niensted (1968) tested 45 children with a graded list of words and identified 26 children as exhibiting the hyperlexia syndrome. She then proceeded to improve their comprehension through in-service training of teachers. When lessons on comprehension were added to the regular classroom program, she claimed that of the ten "hyperlexic" children who were retested, only one remained hyperlexic.

If the label *hyperlexia* can be attached to some normal readers simply because they are good decoders, the concept of hyperlexia cannot be considered as serving any useful educational purpose. A case study, reported by Pennington *et al.* (1987a) illustrates this point. These investigators tested a preschool boy of superior intelligence who read very early and at a level well beyond what his age would predict. At the age of 4 years and 2 months, his WPPSI full-scale IQ was 144, and at the age of 2 years and 11 months, he read correctly 24 of the 30 words from a list of nonwords. Furthermore, at the same age, he had a Peabody Picture Vocabulary that was equivalent to 4 years and 5 months, and his sentence comprehension, both written and oral, was at the 6-year level. Clearly, the term *hyperlexia*, as it is used today, is not applicable to this boy. For most contemporary researchers, the term *hyperlexia* seems to have the implication of a pathological condition, even though it was not clearly stated so in the early writings. Subsequent to the publications of Silberberg and Silberberg, other writers began to use the term in the context of reading disability. The turning point could be traced to a series of articles published in Volume 5, number 3 of the *Journal of Special Education* (1971) as a symposium. Contributors to this symposium (deHirsch, Rawson, Campbell, Tien, McNeil and Cooney) used terms such as *isolated proficiency, poor in learning, their disadvantages, problem, poorly developed intelligence, and learning problem*, when they referred to hyperlexia and hyperlexic children. Hyperlexia, therefore, came to be viewed as an educational liability rather than an asset.

4.3. *Emergence of the Concept of Hyperlexia*

Most of the research articles that have appeared since 1971 have treated hyperlexia as a form of reading disability. Huttenlocher and Huttenlocher (1973) traced the developmental history of three hyperlexic children and tested their comprehension by asking them to carry out certain instructions given in both written and spoken forms. The three children were found to be poor in performing these tasks whether they listened to the instructions or read the instructions. These investigators focused their research efforts on the basic language defects of these hyperlexic children. In a study published in 1975, Rosenberger *et al.* described four preschool hyperlexic children and noted that the syntactic ability of these children was poorly developed. Cobrinik (1974) described six hyperlexic children who showed behavior typical of autism. The mean WISC full-scale IQ of these children was 55.6. Their mean language development, as determined by the Illinois Test of Psycholinguistic Ability, was at 5.5 years even though the children's mean chronological age was 13.3 years.

Richman and Kitchell (1981) examined ten hyperlexic children for their general and specific cognitive functioning. Even though poor language skill was not part of the subject-selection criterion, all ten children turned out to be impaired in language. In a later study, Cobrinik (1982) used clearly prescribed criteria such as well-developed rote reading skill, profound developmental arrest of general intellectual ability, and backward language skills for subject selection. As these studies show, by the early part of the present decade, impaired language ability became well recognized as a criterion of hyperlexia.

In their study of the three hyperlexic children, Huttenlocher and Huttenlocher (1973) noted that these children learned to read between the ages of 3 and 5 years without parental help. At the age of 4 years and 10 months, one of these children read a third-grade reading paragraph fluently. This happened against a backdrop of poor comprehension of the spoken language. A second child began to read everything in sight including newspapers by the age of three years. He could pronounce the words extremely well even though his speech was largely limited to echolalia. These observations as well as descriptions of hyperlexic children by other investigators (Richman and Kitchell, 1981; Cobrinik, 1982) add yet another dimension to the syndrome of hyperlexia, namely, a precocious but almost spontaneous acquisition of the decoding skill which, once acquired, takes the form of a compulsive-obsessive ritual that is carried on to the exclusion of all other childhood activities including play.

By 1982, sufficient information about hyperlexic children had accumulated which enabled Healy (1982) to raise the question: "Is there an identifiable syndrome of hyperlexia?" (p. 323) and to answer it in the affirmative. Based on the research material published until that time as well as her own studies of hyperlexic children, Healy concluded that hyperlexia is a specific and identifiable syndrome made up of three symptoms: (a) spontaneous reading of words before age 5, (b) impaired comprehension of both listening and reading tasks, and (c) word recognition (decoding) skill above expectations based on other cognitive or linguistic abilities.

In addition to conceptualizing the syndrome of hyperlexia, Healy *et al.* (1982) investigated the psychoeducational and psycholinguistic characteristics such as listening and reading comprehension, nonword reading ability, and syntactic ability of twelve hyperlexic children. This investigation set a precedence for subsequent studies of hyperlexia that investigated the phenomenon in-depth primarily from a psycholinguistic perspective. In their study of eight hyperlexic children, Goldberg and Rothermel (1984) carried this trend further. These researchers examined the effects of psycholinguistic dimensions such as word frequency, imagery, meaningfulness, and grammatic class on hyperlexic children's reading behavior and concluded that hyperlexic children have an organized though limited lexicon and that they are able to access the lexicon via both the visual-orthographic and phonological pathways. They also found that word imagery had a significant effect on the reading of hyperlexic children and that these children were able to comprehend single words and simple sentences but not paragraphs. Goldberg and Rothermel also noted that hyperlexic children utilized spelling-to-sound transformation rules when reading aloud the written language.

Even though not many reports on hyperlexia have appeared since the publication of the Goldberg–Rothermel study, the few articles that have been published have addressed important aspects of hyperlexia such as the visual–spatial abilities of hyperlexic children (Fontenelle and Alarcon, 1982); developmental changes (Aram *et al.*, 1984; Siegel, 1984); word-class (i.e., regular vs. exception words) effect (Aram *et al.*, 1984); the nature of the comprehension deficit (Snowling and Frith, 1986), and the relationship between hyperlexia and autism (Whitehouse and Harris, 1984). Important research published recently has been gathered and reviewed by Aram and Healy (1987) who not only have reasserted the syndromic nature of hyperlexia but also have raised relevant questions regarding the extent of the discrepancy between word decoding and comprehension skill and age of onset of early reading that could be considered as a marker for hyperlexia. They have also suggested areas for future research: the process by which hyperlexic children begin to read initially, individual differences among hyperlexics, possible changes in hyperlexia symptoms that occur over time, the neurological dysfunction that underlies hyperlexia, and possible ways of treating the deficits of hyperlexic children.

5. GENERAL CONCLUSIONS

The brief history of hyperlexia illustrates how concerted efforts of educators, neuropsychologists, psycholinguists, and physicians can bring about clarity to a complex form of learning disability such as hyperlexia. It is, of course, true that each investigator tends to explore a certain aspect of a problem depending upon his/her interest and expertise. This multi-pronged attack of a problem can be an asset rather than a liability provided there is intercommunication among the various groups of investigators. Unfortunately, such a cross-talk did not exist during the early history of the study of developmental dyslexia. Regardless of the divergent views held by investigators from the different speciality areas, the fact remains that there are some children who cannot decode the written word well but can comprehend it better, and there are others who can decode the written language well but cannot comprehend it. There is yet another group of children who can neither decode the written word well nor comprehend it. How to differentiate these groups of disabled readers from each other and what method of teaching would work best with each one of these groups are important issues that are discussed in the following chapters.

OUTLINE OF CHAPTER 2
['THE READING PROCESS']

1. Introduction
2. The Visual Encoding Stage
   - 2.1. The Icon
   - 2.2. Short-Term Visual Memory
3. The Word-Recognition Stage
   - 3.1. Working-Memory
   - 3.2. Models of Lexicon
     - 3.2.1. The Feature Model of Lexicon
     - 3.2.2. The Search Model of Lexicon
     - 3.2.3. The Subset Model of Lexicon
   - 3.3. Issues in Word Recognition
     - 3.3.1. What is the Basic Unit in Word Recognition — The Letter or The Word Itself?
     - 3.3.2. Must the Written Word Be Converted into Phonological Code to Be Recognized?
     - 3.3.3. The Role of Phonology in Reading
       - 3.3.3.1. Phonology: Evidence from Experimental Psychology
       - 3.3.3.2. Phonology: Evidence from Neuropsychology
       - 3.3.3.3. Phonology: Evidence from Developmental Psychology
       - 3.3.3.4. Phonology: Evidence from Studies of Specific Reading Disability
     - 3.3.4. Conclusions
4. Reading Comprehension Beyond the Word Level
   - 4.1. Sentence-Level Comprehension
   - 4.2. Text-Level Comprehension
   - 4.3. Metacognition
     - 4.3.1. Verbal Reports
     - 4.3.2. On-line Processing Measures
     - 4.3.3. Confidence Estimates
5. Components of Reading: Decoding and Comprehension
   - 5.1. Studies of Componential Analysis
   - 5.2. Reading Comprehension and Listening Comprehension
     - 5.2.1. Experimental Studies
     - 5.2.2. Review Studies
     - 5.2.3. Implications

CHAPTER 2

THE READING PROCESS

1. INTRODUCTION

A sound knowledge of the psychological processes which underlie normal reading can be expected to facilitate an understanding of the causes of reading disability. This expectation is consistent with the fact that diagnosis and management of reading disabilities discussed in this book are explained within the framework of cognitive psychology and neuropsychology. Unfortunately, the information we have about the normal reading process is incomplete. There are several reasons for this. First, reading is an extremely complex mental operation. As Huey (1908) observed many years ago, to completely analyze what we do when we read would be almost the acme of all psychologists' achievements. Second, psychologists very often study reading behavior as a means of understanding the fundamental cognitive processes and not because they are interested in reading per se. Finally, reading is not a unitary phenomenon; rather, there are several varieties of reading behavior and different kinds of readers: Careful reading is different from skimming and scanning; reading a novel is different from reading a textbook; and beginning readers are different from skilled readers. Depending upon the material being read and the purpose of reading, different subprocesses are likely to be brought into play. This diversity in reading behavior frequently results in research findings that are in apparent contradiction. In spite of this lack of total agreement among research findings, a broad picture of the cognitive processes that underlie reading has emerged over the years. For example, a fair amount of information regarding the nature of components that make up the reading process is available today. We also have a general idea about the ways in which beginning readers differ from skilled readers, and more is known about reading disabilities today than was known a decade ago.

This chapter does not present an exhaustive account of the reading process but provides a comprehensive analysis of the components involved in the reading behavior to see if different kinds of reading disabilities could be traced to the malfunctioning of any one of these components. The widely-held view today is that reading is an interactive process involving the operations of several cognitive skills. Even though these processes operate more or less synchronously, for the sake of convenience, reading behavior will be described in three stages. Five operations take place in these three stages: visual encoding, word recognition,[1] sentence comprehension, text-level comprehension, and metacognition. Visual encoding which is accomplished in the first stage is considered precategorical since neither recognition of the word nor understanding of its meaning is realized at this stage. During the next stage, the word is recognized on the basis of its pronunciation, meaning, or a combination of both. This stage, therefore, is referred to as the word-recognition stage. In the third stage, the meaning of the text is constructed by integrating words into sentences and sentences into cohesive passages. Certain aspects of metacognition, as they relate to reading, are also discussed in this section. A complete and accurate understanding of the text is possible only if the reader is aware of his own progress in reading and undertakes corrective measures when necessary. Such knowledge of one's own performance and the ability to initiate corrective procedures are components of metacognition. It is important to remember that the sequential analysis of the reading process as presented in this chapter is to facilitate understanding; reading itself is a highly interactive process and many operations are carried out simultaneously.

Dysfunction of any one of these operations can affect reading differentially. Consequently, there can be more than one kind of reading disability. The purpose of this chapter is to provide an adequate description of each one of these operations so that the etiology of developmental dyslexia and hyperlexia can be examined in terms of potential dysfunction of any of these operations.

2. THE VISUAL ENCODING STAGE

2.1. *The Icon*

The term *icon* refers to the visual information kept in a temporary store for a very brief period. The visual sensory processing of the written word, including the iconic storage that eventually leads to its

[1] All notes are to be found at the end of the relevant chapters; for this note see p. 89.

recognition, constitutes the first step in the reading process. In cognitive psychology, the process of capturing the meaning or the pronunciation of the word is referred to as *lexical access*. The term *lexicon* refers to a putative mental dictionary which contains all the information the reader has about the words he knows. The mental lexicon can, therefore, be viewed as part of the long-term memory store. Consequently, in reading, *lexical access* refers to the process of relating the printed word to its representation in the mental lexicon.

During the reading process, movement of the eyes is not smooth and continuous but consists of a series of fixations interspersed with short, jerky movements called *saccades*. The average duration of fixation is thought to be about 250 milliseconds even though factors such as word length, familiarity, and word frequency can affect the duration. The number of words fixated also can vary but, in general, one word is processed during a single fixation; function words such as *the*, *of*, and *to* are not always fixated. Studies by Just and Carpenter (1980) show that the reader tries to recognize each word as it is being viewed and that the eye remains fixated on a word as long as it is being processed. This indicates that eye movement during reading is not an automatized act but is governed by higher-level cognitive decisions. The visual sensation created during fixation stays in a temporary store, the icon, for a short duration; the eyes move again, fixate and process the next visual unit. Experiments by Sperling (1960) show that visual information remains in iconic store for only about 250 milliseconds after which it decays. In order to be preserved, information in the icon must be processed further before input from the subsequent eye fixation comes in and wipes out the first icon. Experimenters have taken advantage of this feature of the visual process by superimposing a second visual stimulus on the first icon in order to experimentally obliterate the first input. This experimental process is referred to as *masking*. A processing mechanism that is sluggish in relaying visual input to the next stage rapidly could be an impediment and, therefore, become a potential source of reading difficulty.

Even though the iconic store has a very brief life, it has a relatively large storage capacity of about twelve letters. In a classic study, Sperling (1960) investigated the nature of the icon by presenting, for a fraction of a second, twelve letters arranged in a matrix of four columns and three rows and asking subjects to report the letters in one of the three rows by sounding a high, medium, or low tone that corresponded to one of the three rows. He found that subjects could report almost all the letters in any of the three rows provided the tone followed the visual presentation immediately. This advantage, however, was lost if the tone came 300 milliseconds after the visual presentation. This suggested that for an extremely short duration, the entire matrix of twelve letters was available for report. This relatively large storage capacity of the icon is, therefore, sufficient to hold almost any printed word. Even though some details of Sperling's interpretations are questioned, the general finding that the iconic memory has a duration of about 200 to 300 milliseconds is confirmed by other studies (e.g., Eriksen and Collins, 1967, 1968).

Letters in a word also appear to be processed simultaneously and in parallel. In one study, Sperling (1970) presented a string of five letters for a very brief period and asked readers to report them. Within 50 milliseconds after the onset of the stimulus, however, the computer changed the fifth and final letter into another letter. During testing, the subjects reported the original letter in the string and not the substituted letter. Since 50 milliseconds is too short for processing letters serially, from left to right, Sperling concluded that letters in a string are processed simultaneously, in a parallel fashion.

Other studies have shown that letters at the two end positions of a word are processed simultaneously, before the ones in the middle (Merikle *et al.*, 1971). It is also known that when a word is presented, not all the letters of the word are relayed as a single unit but the morpheme (root word) and its suffix are segmented and processed as separate units. Taft (1985) used a lexicon decision task to investigate this phenomenon. In a lexicon decision task a string of letters which may or may not form a word (e.g., *rain* or *rane*) is visually presented and the subject is asked to indicate whether the string is a word or a nonword. In order to avoid confounding factors associated with pronunciation, a manual response such as pushing a "yes" button or a "no" button is required. Reaction time is the dependent variable. Taft found that words such as *eating* and *bigger* took longer to correctly identify than words without a suffix such as *string* and *trigger*. He concluded that the additional time was required to strip the suffixes off the root morpheme. Words such as *string* and *trigger* do not have suffixes and, therefore, require less time than words such as *eating* and *bigger*. It must be noted that during oral reading and writing, this process has to be reversed in order to produce the word with its suffix. Taft administered another lexical decision task by using nonwords with and without suffixes (e.g., *molks, widodled* vs. *porld, vodinten*) in order to locate the stage in which this parsing occurs. Again, suffixed nonwords took longer time to respond than nonwords without suffix. Since nonwords such as the ones used in this experiment are not present in the mental lexicon, parsing of the word into its root and suffix should have taken place at the prelexical stage, before it was recognized. It appears, therefore, that suffixes are treated as distinct entities and that their separation from root morphemes occurs without the help of the mental lexicon. Because, in the iconic memory, information is registered the way it looks in print, the suffix stripping probably occurs somewhere between visual encoding and word recognition. The suffix omission errors frequently seen in the reading and writing of dyslexic readers cannot, therefore, be attributed to poor visual perception or inattention.

2.2. *Short-Term Visual Memory*

The question of whether short-term memory has a status independent of long-term memory is frequently raised (see, for example, Craik and Lockhart, 1972; Crowder, 1982a). Whether it has an independent status or is an integral component of a single memory system, short-term memory, as a hypothetical construct and model, has served well in explaining certain aspects of reading behavior. For this reason, in this chapter, short-term visual memory will be treated as though it is distinct from long-term memory.

Several experimental studies have shown that visual information can be retained in memory for a few additional seconds even after it has disappeared from the icon (see, for example, Mitchell, 1982). Even though short-term visual memory differs from iconic memory in important ways, its representation is visual in nature and hence the descriptive name. Unlike the icon, short-term visual memory has a duration of about five or six seconds and it cannot be obliterated by another visual input that closely follows it (i.e., it is resistant to masking). Its capacity, however, is smaller than that of the icon. It is generally believed that all the information in the icon is transferred to the short-term visual memory which acts as a holding place. Beyond this, the fate of the visual representation of the word can be described in terms of three possibilities: It may be relayed to working-memory where its phonological representation is realized; it may be directly relayed to the semantic lexicon where its meaning is realized; or both these operations may take place concurrently.

3. THE WORD-RECOGNITION STAGE

3.1. *Working-Memory*

The concept of working-memory was introduced by Baddeley and Hitch (1974) and has been elaborated by Baddeley (1978, 1979). Even though these investigators have conceived working-memory as having more than one constitutional element, we will focus on one important component, auditory memory. In fact, working-memory can be considered to be the auditory equivalent of short-term visual memory. Working-memory, like short-term visual memory, has limited capacity (about seven to nine digits) and limited duration. However, working-memory has certain devices which it can use to overcome these limitations. Hence the name working-memory. The temporal limitation of working-memory is overcome by subvocal rehearsal and its capacity limitation by chunking the many discrete items into fewer units. For instance, the 15 letters in the word *conglomerations* can be reduced to five syllables, or chunks by applying spelling-to-sound rules. Chunking, apparently reduces the cognitive load placed on memory. Furthermore, the conversion of the visual word into its phonological equivalent by the application of spelling-to-sound rules — grapheme—phoneme conversion (GPC) — makes subvocal rehearsal possible. The working-memory, therefore, performs two functions: it converts the graphemic feature of the word into its phonological equivalent, and it holds the phonological representation in temporary store through subvocal rehearsal. It is obvious that if the first function cannot be successfully carried out, rehearsal would almost be impossible. In other words, an inability to transform written language into a phonological representation can also affect the ability to remember it. Thus, the transformation of the visual input into phonological representation is an important function performed by working-memory.

The view that the working-memory is primarily phonological in nature has been demonstrated by many studies. Conrad (1964, 1972), and Baddeley (1966) have shown that more confusion errors occur when phonologically similar items are to be remembered than when dissimilar items are to be remembered. Liberman *et al.* (1977) found that children who were good readers recalled correctly fewer words from a list of similar rhyming words than from a list of non-rhyming words. A similar confusion effect was not seen in poor readers. This finding was interpreted as evidence that the articulatory-rehearsal mechanism of the working-memory is phonological in nature and that good readers rely on phonological mediation more than poor readers do for processing written language. Dyslexic readers tend to be less confused by phonological similarity among the words they have to remember, probably because they are weak in grapheme–phoneme-conversion skill and cannot, therefore, successfully convert the visual input into its articulatory equivalent.

One important finding that has emerged from studies of memory is that GPC and comprehension process are independent. It is, therefore, possible to recognize words without using the phonological coding mechanism of the working-memory (Kleiman, 1975; Baddeley, 1979). In one study, Baddeley (1979) asked college students to repeat a series of random digits presented to them or to repeat numbers from 1 through 6. The randomly presented digits had to be kept in memory in order to be repeated (memory loading); in contrast, counting numbers 1 through 6 ties up the articulatory-rehearsal mechanism and makes it unavailable for phonological processes (articulatory suppression) but does not place a heavy load on memory. While the subjects were performing these tasks, they were shown sentences and asked to judge if each sentence was meaningful or not. Reaction time was the dependent variable. It was found that reaction time increased when subjects had to repeat random digits (loaded memory) but not when they had to count from 1 through 6. This shows that rehearsal does not interfere with the comprehension of sentences. In another study, Salame and Baddeley (1982) found that phonological property, but not the semantic property of the distractor words interfered with recall. On the basis of these studies, Baddeley concluded that the phonological component of the working-memory is not necessary for the comprehension of single words and simple sentences. Baddeley, however, adds an important proviso that the phonological system may be used as a supplementary back-up device when the short-term visual memory becomes overloaded, when the reading material is difficult, or when the order of the input must be maintained. In a language such as English which is highly constrained by the sequential order of words in the sentence, it is to be expected that working-memory plays a very important role.

It was noted in the previous section that a written word can be recognized directly by accessing the semantic lexicon for meaning or by converting it into its phonological representation and then accessing the lexicon on the basis of its pronunciation. During normal reading, both operations are likely to take place concurrently. It is also possible that efficient reading habits may not be established if the reader is not able to make good use of one or the other strategy. Reading skills may not also be easily acquired if the lexicons are poorly organized. For this reason, a knowledge of the lexicon is relevant to understanding the reading process.

3.2. *Models of Lexicon*

The mental lexicon has been studied and speculated about not only by psychologists but also by linguists. There can be little doubt that certain aspects of linguistic information are stored in an organized form in the mind. For instance, if asked to give four synonyms of the word *book*, one can, without much hesitation, come up with words such as *brochure*, *manual*, *volume*, and *publication*. Similarly, one can produce words such as *cook* and *hook* which rhyme with the word *book*. One can also easily produce a number of words which end with similar letter strings (e.g., *ough*, *though*, *through*, *tough*). It appears, therefore, that information about the meaning, pronunciation, and spelling patterns of words is ordered and stored in a systematic fashion in the mental lexicon. These three attributes of the written word, namely, meaning, pronunciation, and spelling, are referred to as the semantic, phonological, and orthographic features. Though we know words are stored in the mental lexicon in some orderly fashion, and in more than one format, how exactly they are organized is not fully understood. As a result, more than one hypothesis of the nature of the mental lexicon has been proposed and several models of the lexicon have been developed. Because the mental lexicon is a component of long-term memory, psychologists have incorporated facts known about long-term memory into models of lexicon. In fact, terms such as *semantic memory* and *long-term verbal memory* are sometimes used interchangeably to describe the lexicon (Chang, 1986).

Even though many models of lexicon have been proposed, almost all of them can be placed in one of the following three categories: (a) feature model, (b) search model, and (c) subset model. These three models are not mutually exclusive and a good deal of commonality can be seen among them. The organization of all of these models allows not only the accessing of different features of a word through a process of cross reference but also their rapid retrieval. Thus, not only is the reader able to tell correctly that *cheef* is not a word even though it rhymes with a real word (*chief*), but he can also make such decisions very quickly. Because reading problems can be caused by difficulty in accessing information from the lexicon rapidly and accurately, brief descriptions of the three models of mental lexicons are provided.

BOX 2.1
The use of models in reading

Models provide a theoretical framework for conducting research in an orderly manner and for making sense out of disparate data obtained from these studies. Models, therefore, can be of much help in arriving at diagnostic conclusions. This can best be illustrated by citing a study conducted by Vinsonhaler and Sherman (cited in Carr, 1982). These investigators made up fictitious cases of reading disability with many cases being duplicated but thinly disguised from each other. Reading specialists were then asked to make diagnostic and remedial recommendations for these cases. Vinsonhaler and Sherman found that, regarding diagnosis, there was no consensus among the specialists and that there was no agreement even about the duplicated cases. The investigators concluded that the problem was due to the fact that the reading specialists had no model and they stated:

> "Without a model they (the reading specialists) found it hard to relate the test scores to one another and to identify a meaningful pattern. The specialists had great difficulty with questions such as how many different component processes must be carried out in order to read, how these processes interact with one another, which of them seem to be the most common stumbling blocks that cause reading to break down and which tests provide information about which component process. Consequently, the specialists treated their test results as hodgepodge of independent pieces of information, focusing first on one and then on another and finally guessing about why a particular child could not read." (Carr, p. 123)

3.2.1. *The Feature Model of Lexicon*

According to this model, words are represented in the lexicon in terms of their semantic, phonologic, orthographic, and other features. Even though the organizational structure is not given much importance, words and their features are assumed to be interconnected or associated with each other in the form of a network. When the visually coded information from the short-term visual memory arrives at the lexicon, it presumably activates these representations all at once. When the summed-up contributions of these representations reach a certain threshold, the code that represents the word is activated, and the word represented by the code is recognized. It is like recognizing a person by his looks. Such a recognition is not based on individual features such as color of eyes and shape of the nose, but on a gestalt produced by the cumulative effect of these and other features. Word recognition, therefore, is based on a process of detection rather than search.

Models proposed by Morton and Patterson (1980) and Rumelhart (1984) have a general family resemblance to this conceptualization of the lexicon. According to the model proposed by Morton and Patterson, each morpheme is represented by a code called *logogen* whose main function is to collect visual and orthographic (spelling pattern) information from the sensory input. Such evidence accumulates. When a particular threshold is reached, the logogen corresponding to the accrued information "fires" and the word that corresponds to the logogen is recognized. The threshold that determines the "firing" of the logogen is variable and can be lowered by factors such as frequency and recency of the reader's encounter with a particular word. This would explain the fact that highly familiar and recently seen words are recognized more readily than are ones not seen as frequently or recently. This phenomenon is referred to as "frequency and recency effects" by experimental psychologists. Furthermore, since sensory input can activate the entire lexicon, logogens that represent words that visually resemble each other may also be partially activated. For example, when the word *throng* is presented, it could activate logogens representing words such as *through*, *thorough*, and *though*. While most often the logogen representing *throng* will be the first one to reach the critical point of recognition, it is quite possible that the reader may misidentify the word as *through* because he has seen the word *through* more often and more recently than *throng*. This model, therefore, can provide a tentative explanation of the visual reading errors often committed by dyslexic readers.

A model proposed by Stanovich (1980) shares many characteristics of the feature model but has one additional component relevant to reading disabilities. This model states that deficit in any knowledge source results in the reader's greater dependency upon other knowledge sources. For instance, a child with poor phonological and decoding skill will depend more on visual and contextual cues than a child who is competent in decoding. For this reason, Stanovich calls this the Interactive Compensatory model of reading.

The feature model of lexicon, therefore, can provide an explanation of the oral reading errors committed by dyslexic individuals as well as an understanding of their over-dependence on contextual and visual cues while reading connected text.

3.2.2. *The Search Model of Lexicon*

In this model, word recognition is thought of as being accomplished by searching the lexicon to obtain a match between the sensory input and the stored representation of the morpheme in the lexicon (Carr and Pollatsek, 1985). Morphemes in the lexicon may be coded by markers that facilitate such a search. For example, the first letter of the morpheme or its first syllable could serve as a marker or cue that facilitates the retrieval of the word. This is similar to identifying a person by hairstyle or shape of the nose. According to a version of this model proposed by Forster (1976), words in the visual-orthographic file are listed in the order of the frequency of their occurrence in the written language. The search of the lexicon, however, is mediated by an access file in which words are represented with their prefixes and suffixes removed (Taft and Forster, 1976; Taft, 1985). When a word is presented, the access file is searched in a serial manner. When a match is obtained, the corresponding entry in the lexicon is accessed and the word is restored by a recombination of the stem word and its affix. Since the lexicon is ordered on the basis of word frequency, familiar words are recognized more readily than are unfamiliar words.

The tendency to omit suffixes, seen frequently in the oral reading of dyslexic individuals, can be accounted for by this model as a defect in the reassembling of the word at the lexical level.

3.2.3. *The Subset Model of Lexicon*

In this model, all the stored features of words are not given equal status; some are subordinate to others. The grapheme—phoneme rules that are used to derive the pronunciation of the word are envisaged to be a subordinate category and, therefore, are said to be a subset. Recognition of a word can depend upon the interaction of discrete subsets. Accordingly, information gained in the subset can be used to access the primary set to make a final decision. Reading models that allow phonological mediation in word recognition could be thought of as belonging to this model. Coltheart (1978), for example, has proposed that reading (of isolated words) could be accomplished by two processes. Under one condition, the written word reaches the semantic lexicon directly and its meaning is realized. The word can be pronounced after its meaning is recovered. This is like recognizing a familiar person by his looks and then greeting him by his name. The second process involves the mediation of a conversion mechanism which assembles the pronunciation of the written word using grapheme—phoneme conversion rules. The phonological representation of the written word can then be used to realize its meaning. This is similar to recognizing a person after he states his name. This model, therefore, requires two sets of representations, one that contains the meaning of words and one that has the rules for converting print into phonology. The assemblage of GPC rules is considered as a subset because of its limited and specialized function.

In addition to the semantic lexicon and the specialized GPC-rules subset lexicon, there is evidence that another lexicon which contains the pronunciation of the words seems to exist. This can be called as the *word-specific phonological lexicon.* Studies of neurological patients have revealed that it is possible to elicit the pronunciation of a word without resorting to the semantic lexicon or the application of the GPC rules. This strategy is claimed to recover the pronunciation of the word as a single unit and is, therefore, word-specific. Schwartz *et al.* (1980) report a patient who could not understand the words she read but could read exception words. These investigators have reasoned that since she did not understand the words, her semantic lexicon could not have been used to derive pronunciation. Since the grapheme—phoneme mechanism cannot be successfully applied to pronounce exception words, she might not have been using the GPC process either. Thus, she could have been using a third mechanism which elicits the word-specific pronunciation of the exception word.

Supporting evidence for the existence of the third strategy in word recognition comes from a study of another neurological patient by Funnell (1983). The patient could not read pronounceable nonwords (because their pronunciation is not in the lexicon) and could not understand the real words he read. This meant that both his GPC ability and his semantic lexicon were impaired. Nonetheless, he could read aloud correctly most of the regular and exception words. This is taken as evidence for the existence of the word-specific phonological lexicon. By accessing this subset lexicon, any known word can be pronounced without using the spelling-to-pronunciation rules. This strategy of directly eliciting the pronunciation of the word is referred to as *addressed phonology* in contrast to *assembled phonology* which computes the word's pronunciation by applying the GPC rules (Patterson, 1982).

As this discussion shows, the existence of a major mental lexicon (the semantic lexicon) and two subsets (GPC rules and pronunciation) can be postulated. Alternatively, the semantic lexicon and the two subsets can be viewed as three independent lexicons. These subsets, however, unlike the semantic lexicon, are highly circumscribed in content and are specialized in their roles. Regardless of one's inclination to accept or reject this model of lexicon, the fact remains that dyslexic readers experience much difficulty in pronouncing written words correctly, and this disability can be explained in terms of poorly organized lexicons which contain GPC rules and whole-word pronunciations or the inability to tap these lexicons.

3.3. *Issues in Word Recognition*

Two issues of word recognition have attracted an inordinate amount of research interest. They are concerned with the unit of perception and the role of phonology in reading. In this chapter, these two issues are described briefly; their implications for reading disabilities are discussed in the next chapter.

3.3.1. *What Is the Basic Unit in Word Recognition — The Letter or the Word Itself?*

At the outset, it would appear that this issue could very well be settled on rational grounds alone, without the help of research. The argument would go somewhat like this. It is letters that make up a word and, if the letters are removed from a word, there will be no word. It is obvious, therefore, that letters have to be recognized before the word can be recognized. Reasonable as it might seem, this simple explanation has been challenged on empirical grounds. Over a hundred years ago, Cattell (1885, 1886) found that the exposure duration necessary for word recognition is slightly less than it is for a letter. He also observed that under brief exposure, a familiar word could be reported more accurately than a letter. Soon after this, Erdmann and Dodge (1898) noted that words could be identified quite readily even under viewing conditions that made letter recognition difficult. These observations gave rise to the belief that a word can be recognized as a visual gestalt. Cattell himself concluded that we do not perceive separately the letters of a word, but rather perceive the word as a whole. Proponents of this view also point out that languages such as Chinese have their entire script in the form of logographs which do not have constituent letters.

The notion that the word is the basic unit of recognition has, however, been challenged from the very beginning. One of the earliest arguments was that the word could be inferred because of the multiple cues its letters provide, an advantage the individual letter does not have (Goldscheider *et al.*, cited in Gough, 1984, p. 231). Consequently, the argument goes, if the opportunity to guess is eliminated the advantage words have will disappear. A means of eliminating guessing in word recognition experiments was devised by Reicher in 1969. Reicher presented four-letter words such as *work* for about 60 milliseconds and followed the presentation with a mask (a jumble of letter fragments that cleans up the iconic store). Subjects were required to tell which of the two letters, *k* or *d*, was in the word. Since both letters can make up a real word (*work*, *word*), the chances of guessing were reduced by 50 percent. Under this experimental set-up, letters in isolation were correctly recognized 78 percent of the time whereas letters embedded in a word were correctly reported 89 percent of the time. This advantage enjoyed by the word has been named Word Superiority Effect (WSE) and the reality of WSE has been confirmed by other investigators since Reicher's initial study.

While Reicher's study showed that the WSE was not due to guessing, it did not clarify whether its source was pre- or post-lexical. Thus, the difference in reaction time between recognizing a word and reporting it correctly can arise from at least two sources: the time it takes to recognize the stimulus or the time it takes to organize the phonology and articulate it. If the advantage is post-lexical (i.e., after recognition) and not pre-lexical, the word advantage may not necessarily mean that the word is the unit of recognition; the word-superiority effect may simply be due to some factor that enables the initiation of the pronunciation of the word sooner than that of an isolated letter.

Resolution of this problem had to wait until the lexical decision task was invented. In a lexical decision task, the subject is presented with a string of letters and is asked to indicate whether the string is a word or not by pushing a "yes" or "no" button. Performance in the lexical decision task involves the use of the semantic lexicon. Because the response is manual, pronunciation is avoided.

Research based on lexical decision tasks indicates that letters may be the basic perceptual units in word recognition. Chambers (1979) studied college students in a word/nonword lexical decision task. The nonwords differed from the real words by one letter but the place of the letter that made the word into a nonword was changed systematically so that it occupied all possible positions within the word (e.g., *motor* vs. *lotor*; *limit* vs. *lirit*). It was found that the alteration of a single letter delayed the response time regardless of the position of the letter. Chambers concluded that all the letters in a word are used for accessing the lexicon. Additional evidence that letters are perceptual units in reading comes from a study by Zola (cited in Rayner and Carroll, 1984, p. 137) in which subjects were asked to read short passages while their eye movements were recorded. Zola systematically introduced spelling errors in nouns in the sentences and found that the misspellings influenced fixation duration even when they were in the middle of a multi-letter word. This led to the conclusion that the reader encounters all the visual details that are afforded by the text.

A series of experiments conducted by Joula *et al.* (1978) also suggests that all letters in a word are processed during word recognition. Joula *et al.* administered a letter detection task to children and college students. The subjects had to push a button to indicate the presence or absence of a test letter in a word that was displayed for a very short duration. The words varied in length from three to six letters and the target letter appeared equally often in all the serial positions. Even though reaction time was shorter for end-position letters, the accuracy of decision did not vary as a function of letter position, indicating that all the letters within a word are recognized.

Some studies are based on the logic that if letters are perceptual units, longer words would take more time to process than would shorter words. Even though it could be argued that the "word length effect" may be a post-lexical rather than a pre-lexical phenomenon, longer reaction time for longer words has also been reported in lexical decision tasks by Gough and Stewart (1970), Foster and Chambers (1973), and Joula *et al.* (1978). Studies by Frederiksen and Kroll

(1976) and by Rath and Shebilske (Massaro, 1975), however, failed to find a positive relationship between word length and lexical decision time. A possible answer to these conflicting findings comes from a semantic decision study conducted by Samuels and Kamil (1984) in which children and college students were shown words that varied in length and were asked to indicate whether the word represented an animal or not by pushing a button. A positive relationship between word length and reaction time was obtained for second- and fourth-grade children but not for college students. A tendency for college students to process words as holistic units was also observed by Terry *et al.* (1976). The picture, therefore, is complicated by the possibility that factors such as reader skill and word familiarity influence the processing style. A lack of correlation between word length and response time, however, does not prove that letters are not used in perception, because letters in a word could be processed simultaneously and in parallel. All letters in a highly familiar word might be processed in this fashion. Under such a condition, the number of letters in a word would not be expected to have much influence on reaction time.

The preceding discussion shows that there is no unanimous agreement on the issue of whether the letter or the word is the basic unit of recognition. Some authorities even think that questioning whether the letter or the word is the basic unit of recognition is ill-conceived because the unit of perception depends on factors such as the nature of the script, the purpose of reading, and the proficiency of the reader (Taylor and Taylor, 1983). Assuming that this is a legitimate question, we find that a majority of studies suggest that the word may not be the basic perceptual unit of recognition under all conditions for all subjects. After a review of this issue Gough (1984) writes "more decisive research may show otherwise, but we conclude that the current evidence on word-recognition latency . . . is still consistent with the proposition that the letter is the perceptual unit of word recognition" (p. 234). If this conclusion is valid, it may imply that proficiency in reading probably is not attainable by sight vocabulary alone; mastery of spelling-to-sound relationship is also essential.

3.3.2. *Must the Written Word Be Converted into Phonological Code to Be Recognized?*

In recent years, enough evidence has accumulated to suggest that the etiology of developmental dyslexia can be traced to deficits associated with the phonological processes. If phonological mediation is not necessary for word recognition, the phonological deficit hypothesis of the etiology of developmental dyslexia may turn out to be incorrect. Resolution of this issue, therefore, has a direct bearing on the etiology of developmental dyslexia.

The question of whether the written word can be recognized without phonological mediation can be paraphrased in the following way: Does the word have to be converted into a speech code in order to be recognized, or can the meaning of the word be recovered directly by accessing the semantic lexicon without the phonological transformation of the word? Direct accessing of the semantic lexicon can utilize features such as visual spelling pattern of the word whereas phonological mediation will depend upon the pronunciation of the written word. Pronunciation of the word can be accomplished in at least three ways: by addressing word-specific pronunciation in the phonological lexicon, by pronouncing on the basis of its resemblance to other words (pronouncing by analogy, discussed below), or by assembling the pronunciation with the aid of GPC rules.

It was noted earlier that the lexicon is a hypothetical construct and could be envisaged in more than one way. It could be viewed as a unitized body constituting the semantic lexicon and the two subsets containing word-specific pronunciation and GPC rules. Alternatively, the subsets could be assigned independent status, and three lexicons containing semantic aspects of words, GPC rules, and word-specific pronunciation could be postulated. These are the semantic lexicon, the GPC lexicon, and the phonological lexicon, respectively. It may be recalled that the phonological lexicon is used to retrieve the pronunciation of the word as a unit without applying GPC rules. Because the phonological lexicon would contain the pronunciation of all the words known to the reader but not of words he has never seen, it could provide no assistance in reading unfamiliar words and nonwords. Most literate adults, however, can read nonwords such as *slint* and *blint* quite readily. It is argued, therefore, that there could exist a mechanism, distinct from the phonological lexicon, that is able to construct the pronunciation of unfamiliar words and nonwords. Another possible way is to pronounce a nonword on the basis of its spelling similarity to other words. This strategy is referred to as reading-by-analogy (Glushko, 1979). Reading-by-analogy does not, of course, require the phonological conversion of the target word. For example, if the reader knows how to pronounce the word *slant*, with a little adjustment he can pronounce *slint* without resorting to spelling-to-sound conversion procedures. Even though word recognition by analogy may be a strategy used by skilled readers, beginning readers and disabled readers may not be helped much by this strategy because they have limited sight vocabulary.

It is very likely that unfamiliar words are pronounced by applying the GPC rules. Since dyslexic readers reportedly are poor in spelling-to-pronunciation conversion ability, it becomes necessary to examine in some detail the nature of the mechanism that is used in converting the printed word into its phonological equivalent.

There is some disagreement as to whether the phoneme or the syllable is the basic unit used in computing pronunciation of the word. The grapheme—phoneme-conversion process proposed by Coltheart (1978) operates at the phoneme level and recovers the phonological representation of the written word in two stages. During the first stage, the string of letters that makes up a word is parsed into pronounceable units called *graphemes*. For example, the word *sheep* will be segmented into three graphemes /sh/ee/p/. In the next stage, an appropriate phoneme is assigned to each of the graphemes. Once extracted, the phonemes are assembled and the correct pronunciation of the word is produced. This process, therefore, is called *grapheme—phoneme conversion* (GPC).

According to the syllable-based conversion mechanism, the letter string is first segmented into syllables or some other minimally pronounceable units (Spoehr and Smith, 1973), and the phonology is computed on the basis of syllabic codes. The difference between this and the GPC mechanism is that spelling-to-pronunciation rules are not invoked in pronouncing the syllables. Rozin and Gleitman (1977) have argued that the syllable is the most natural unit of reading since it is also the basic unit of pronunciation and is also easier to access than is the phoneme. Taft (1985) proposes that the first syllable of a word is the code that is used to access the semantic lexicon.

Both the phoneme-based and the syllable-based explanations have some drawbacks. In the English language, a one-to-one relationship between the word and its pronunciation does not always exist. The GPC procedure proposed by Coltheart cannot, therefore, generate the correct pronunciation for words that do not obey conventional spelling-to-sound rules. As was noted in Chapter 1, these are called exception words. Examples of exception words are *have*, *sew*, *aunt*, and *come*. (Words that conform to spelling-to-pronunciation rules are called regular words.) The GPC mechanism will come up with incorrect pronunciations for these words (which will rhyme with regular words such as *gave*, *few*, *hunt*, and *dome*, respectively). Another problem with the phoneme-based explanation is that phonemes lack psychological reality and may be mere constructs of the written language. Because of this, it is argued that phonemes can be identified only after syllables are identified (Savin and Bever, 1970).

One of the difficulties encountered by the syllabic-parsing explanation is that it is not easy to define a syllable with accuracy. The minimum requirement of a syllable is that it contain at least one vowel and a consonant. Given this, it poses a problem for single-syllable words which contain more than one vowel (e.g., *lead*, *peel*). Should these words be treated as having one syllable or two? Similarly, some polysyllabic words with contiguous consonants also pose problems of segmentation (Should *pungent* be segmented as pun/gent or pung/ent?). Another difficulty in accepting the syllable as the basic unit of word recognition is that, unlike spoken language in which syllables are usually marked by stress patterns, syllables in written language are not set off by visual markers. The reader is, therefore, obliged to pronounce the word before parsing it into component syllables. Adams (1981), however, has argued that vowels have a high degree of redundancy and, therefore, function as markers and facilitate identification of the syllable in the written language.

When these problems are considered, the GPC procedure appears to be a more reasonable explanation than does the syllable-based procedure of word recognition. Several studies carried out at the Haskins laboratory (Liberman *et al.*, 1980; Mann *et al.*, 1984) show that children develop syllabic knowledge before they attain proficiency in phoneme identification and some children can have adequate skill in segmenting syllables even though they do not have phonemic knowledge.

The three potential strategies of word recognition (direct accessing of meaning, direct accessing of pronunciation, and GPC assembling of phonology; see Figure 2.1.) have been utilized by experimental psychologists in generating a number of hypothetical procedures that are likely to be used in recognizing the word. Some of these are:

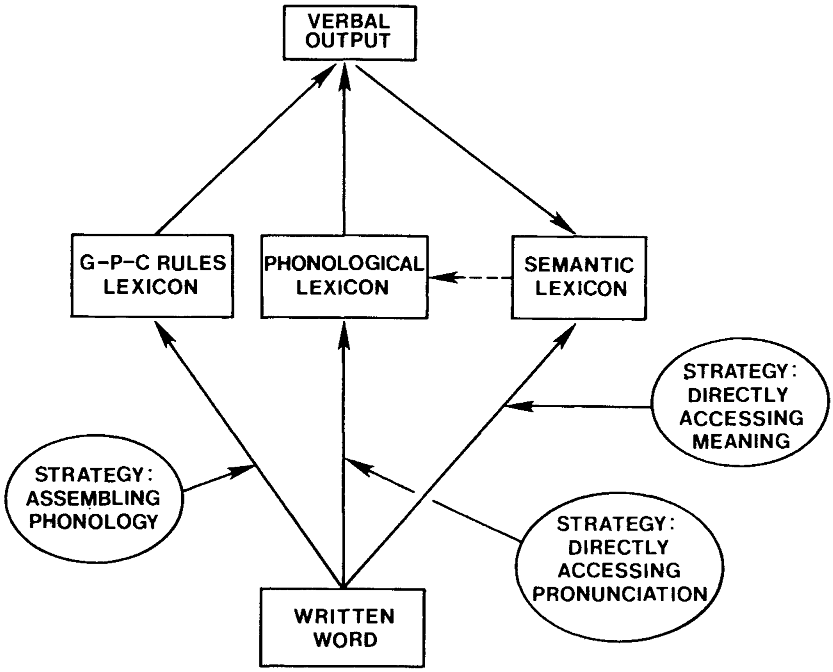


Fig. 2.1. Three potential strategies for recognizing a word. (A written word can be recognized by directly accessing its meaning, by directly accessing its pronunciation, or by constructing its pronunciation by applying GPC rules.)

(1) phonology of the word is first computed; meaning is then realized on the basis of phonology (Rubenstein *et al.*, 1971; Gough, 1972);

(2) phonology may be needed to recognize unfamiliar words; familiar words are recognized directly by accessing the semantic lexicon (Coltheart, 1978; McCusker *et al.*, 1981);

(3) phonological conversion of a word is not necessary for its recognition (Smith, 1971; Baron, 1973; Humphreys and Evett, 1985);

(4) both the processes of phonological conversion and semantic access are carried out simultaneously in parallel, but whichever process is carried out first wins (horse race model) (Meyer *et al.*, 1974);

(5) both processes are used in reading (Van Orden, 1987); phonological processing of the written word and direct semantic accessing are

carried out in parallel; but word recognition is the result of "a cooperative computation or mutual reinforcement between visual and phonological codes" (Carr and Pollatsek, 1985, p. 38). Taylor and Taylor (1983) call this the bilateral cooperative model.

Which one of these views of word recognition appears to be reasonable and whether any one of them is more acceptable than others are important questions. Unfortunately, no single answer is possible. All of these strategies appear to be used under certain circumstances and by certain readers. A knowledge of which word-recognition strategy is used by whom, when, and under what conditions requires an inspection of the evidence collected by researchers. Information regarding these questions has come from four major sources: experimental psychology, neuropsychology, developmental psychology, and studies of specific reading disability.

3.3.3. *The Role of Phonology in Reading*

3.3.3.1. *Evidence from experimental psychology.* Research studies that investigate reading related questions have, in general, used a set of procedures that are borrowed from cognitive psychology and psycholinguistics. Most of these studies are based on the assumption that regular words can be recognized in three ways: by assembling their pronunciation, by directly accessing the phonological lexicon, or by directly accessing the semantic lexicon and then pronouncing the word. Exception words cannot be pronounced by using GPC rules; they can, however, be pronounced by directly accessing either the phonological lexicon or the semantic lexicon. When the semantic lexicon is used, the word is recognized first and then pronounced; when the phonological lexicon is used, this process is reversed. The latter process, however, is not likely to be used often in reading. Under both conditions, however, the GPC mechanism is by-passed. Conversely, both the phonological and semantic lexicons can be excluded from the reading operation by presenting pronounceable nonwords. In order to read nonwords, the subject has to use GPC mechanisms.

It is thought that exception words may automatically arouse a wrong pronunciation if GPC rules are applied and that the pronunciation will be in conflict with the correct pronunciation which will increase response time. Regular words, not being subject to such conflict, will require a shorter time to initiate pronunciation. Pronounceable nonwords will require the longest time since they do not have lexical entries and are entirely dependent on spelling-to-sound conversion rules for assembling pronunciation. The time taken to recognize these three classes of words can, therefore, be expected to vary. For this reason, the regular and exception word distinction is exploited in reading experiments with response latency used as a dependent variable. The results of such experiments are discussed later in this chapter. In the following section, one of the prototypical studies is described in some detail in order to illustrate the logic used in experiments that have addressed the issue of phonological recoding vs. direct visual accessing.

Prior to 1971, researchers assessed the role of speech code by using the time taken to pronounce words as the dependent variable. As noted earlier, pronunciation time could be influenced by post-lexical factors such as the time taken to assemble the motor program and the time taken to execute it. Differences found in response latencies cannot, therefore, be attributed solely to lexical access strategies with confidence; these differences could be the result of some post-lexical factor. In 1971, Rubenstein *et al.* introduced the lexical decision task in order to avoid these post-lexical confounding factors. In one study, they used pronounceable nonwords (e.g., *plind*) and nonpronounceable nonwords (e.g., *likj*). If a word—nonword decision is made first by accessing the semantic lexicon, the reaction time for both stimuli should be the same, because neither word is in the lexicon. In contrast, if pronounceability plays any role in word recognition, there should be a difference in response time since the two classes of words differ from each other in their pronounceability. Rubenstein *et al.* found that subjects took longer time to reject the pronounceable nonword as not a real word than the time they took to reject a nonpronounceable string of letters. In another study, they used "homophones" and "nonhomophones." Real words that sound like each other (e.g., *meet*, *meat*) are homophones; words that do not have a similar-sounding matched word are nonhomophones (e.g., *lamp*). If words are recognized without phonological mediation, the reaction time for these two types of words should not differ since both are words; if there is a difference in reaction time, it should be due to the homophone (pronunciation) effect. It was found that homophones took longer to be accepted as words. They also found that pseudohomophones (words that sound like real words, but are not, e.g., *leed* and *slic*) took even longer to reject as nonwords than did nonpseudohomophones (e.g., *melp*). Rubenstein *et al.* concluded that the recognition of visually presented words is accomplished through phonological recoding.

Even though Rubenstein *et al.* had controlled factors such as word length and frequency of the word's appearance in print (which correlates with familiarity), critics have argued that visual similarity of the stimuli (*brane/brain*) rather than phonological similarity could have produced the differences obtained in decision time. Nevertheless, the study by Rubenstein and his colleagues marks the beginning of a series of investigations that is based on information processing techniques.

A few such studies are selected and summarized in Tables 2.1., 2.2., and 2.3. The summary is not intended to be exhaustive but is used for illustrative purposes only. Taken as a whole, the findings of these experimental studies provide no unequivocal support to the view that word recognition can always be accomplished by directly accessing the semantic lexicon.

TABLE 2.1.

Experimental studies that support phonological mediation in word recognition

Procedure: Conrad (1972). Letters were visually presented very briefly and subjects uttered the word *the* during viewing.
Results: Recall of the letters was severely disrupted by the interference task.
Comment: The results can be interpreted to support the phonological mediation hypothesis. However, the interference task might have affected phonological recoding at a post-lexical stage. Interference effect is also seen only when subjects are forced to use phonological code (such as reading nonwords) and not in normal reading (Waters *et al.*, 1985b).

Procedure: Spoehr and Smith (1973). A tachistoscopic study compared the response accuracy of subjects in reporting one- and two-syllable words. In 1978, Spoehr studied pronunciation accuracy of words made up of four phonemes (e.g., *shark*) and words of similar length and frequency but made up of five phonemes (e.g., *stark*).
Results: A syllable effect was found; monosyllabic words and words with four phonemes were more accurately reported than were multisyllabic words and words with 5 phonemes.
Comment: The syllable and phoneme effect may indicate that word recognition is mediated by phonology. However, the effect could be post-lexical in the sense that it may take more time to organize and execute the motor program of a multisyllable word than is necessary for a monosyllable word.

Procedure: Rubenstein *et al.* (1971). The time it takes to make a word/nonword response was determined with the aid of a lexical decision task in which subjects pushed "yes" or "no" button. Subjects were not required to make any oral response.

Table 2.1. (continued)

Result: Decision time was longer for pronounceable nonwords than for nonpronounceable nonwords; latency was longer for homophones than for non-homophones. The conclusion was that recognition of a visually presented word entails phonemic recoding.
Comment: Visual similarity rather than pronounceability of the words could have caused time difference.

Procedure: Stanovich and Bauer (1978). Lexicon decision latencies for regular and exception words were studied.
Results: Exception words took more decision time than did words with regular pronunciation. Thus, pronounceability of a word plays a role in recognition.
Comment: An exception word such as *pint* may take longer to accept as a word not because it cannot be pronounced by applying the GPC rules, but because when it directly reaches the semantic lexicon, it might activate words with similar orthography (such as *dint*, *hint*). Pronunciation obtained post-lexically from such an analogy procedure, however, does not match the real pronunciation of *pint*. This may create conflict and cause delay in decision making.

Procedure: Treiman *et al.* (1983). These researchers examined lexical decision time using sentences.
Results: Subjects took more time in deciding whether a sentence made sense when the sentences contained exception words than when the sentences had regular words. Longer time was also required for words with similar orthography but dissimilar pronunciation (e.g., 'He made a *hasty nasty* remark').
Comment: Phonological mediation plays a role in word recognition. However, judgments regarding the meaningfulness of a sentence require higher level decisions, and, therefore, post-lexical cognitive factors such as inference making could have played a role.

Procedure: Parkins and Underwood (1983). Lexical decision time for making word—nonword decisions was studied using regular and exception words.
Results: Lexical decision time was shorter for regular words than for exception words.
Comment: The findings support the phonological mediation of word recognition since the regular word can be accessed using more than one strategy and decision is based on the fastest of these strategies. An exception word can be accessed only through the visual strategy.

Procedure: Meyer *et al.* (1974). They examined lexical decision latency with reference to word pairs that are similar in orthography and pronunciation (*bribe*, *tribe*), similar in orthography but not in pronunciation (*couch*, *touch*), and dissimilar in both ways (*break*, *tribe*).
Results: The latency was shorter for word pairs that were similar in orthography and pronunciation; it was longer for graphemically similar but phonologically dissimilar pairs.

Table 2.1. (continued)

Comment: The results were interpreted in the following way: The first word in the pair "primes" phonology. Since this creates a conflict in the *couch* — *touch* word pair, extra time may be necessary.

Procedure: McCusker *et al.* (1981). Subjects were asked to detect misspelled words in a proofreading task.
Results: Misspellings in pseudohomophones were harder to detect than were similar errors in nonhomophones.
Comment: The results show that phonological mediation is involved in word recognition. Proofreading, however, may call for processes other than the ones involved in reading and the findings may not be generalizable to reading.

TABLE 2.2.

Experimental studies that do not support phonological mediation in word recognition

Procedure: Kleiman (1975). Subjects had to shadow (repeat) auditorilly presented digits while they decided if a visually presented pair of words or a pair of sentences had same pronunciation or similar meaning.
Results: Shadowing did not affect synonymity (meaning) judgment of words but judgment of sentences was affected.
Comment: It was concluded that words can be processed for meaning without phonological mediation. In order to comprehend a sentence, however, words have to be retained in some phonological form in working short-term memory to enable extraction of meaning. The phonological conversion, therefore, occurs post-lexically, after the word is recognized.

Procedure: Waters *et al.* (1985b). Subjects had to read and comprehend prose passages while concurrently performing verbal and nonverbal tasks.
Results: Shadowing interfered with processing only in tasks such as the reading of pronounceable nonwords in which subjects were forced to use phonology. No interference was found in normal reading tasks.
Comment: It was concluded that phonology may not be required for normal reading. It may not be necessary even for post-lexical retention as Kleiman claimed.

Procedure: Foster and Chambers (1973). Naming time and lexical decision time for words, nonwords, and low-frequency (unfamiliar) words were compared.
Results: Naming time and lexicon decision times were similar for words but not for nonwords. Lexical decision time was shorter for words than for nonwords and shorter for high-frequency words than for low-frequency words.
Comment: Nonwords and low-frequency words may need phonological mediation for recognition but highly familiar words may be accessed directly for meaning without phonological mediation.

Table 2.2. (continued)

Procedure: Baron (1973). In a lexical decision task subjects were asked to classify phrases as meaningful or sounding as though they were meaningful. Three types of phrases were used: for example, "my new car," "my knew car," and "my no car."
Results: Quickest responses were obtained for meaningful phrases. There was no time difference in rejecting meaningless phrases.
Comment: The results were explained this way: Meaningless phrases required the shortest time since a decision can be reached by visual check alone. If phonological mediation is involved there should have been some difference between meaningless and meaningful phrases (ii) and (iii). It has to be added that subjects committed more errors in dealing with the second example, suggesting a speed-accuracy trade off.

Procedure: Coltheart *et al.* (1977). Homophone effects were studied with better control for word frequency and visual similarity than in the Rubenstein *et al.* study.
Results: Differences in lexical decision time were found for pronounceable nonwords but not for homophonic real words.
Comment: Phonological mediation may play a role in the processing of nonwords, but such a recoding may not be necessary for familiar words.

Procedure: Frederiksen and Kroll (1976). They studied pseudohomophonic effect to see if lexical decision would take longer for pseudohomophones (e.g., *slic*) than for nonpseudohomophones (e.g., *sluc*). They also examined syllable effect.
Results: They failed to obtain pseudohomophonic and syllable effects.
Comment: Because similarity in pronunciation of the nonword to a real word did not influence decision time, it was concluded that the phonological features of a letter string do not play a role in word recognition. Words are likely to be recognized by directly accessing the semantic lexicon.

Procedure: Coltheart *et al.* (1978). Subjects were administered a lexical decision task in which regular, exception, and pronounceable nonwords were used.
Results: The "no" decision for nonwords took the longest time; there was no difference between the "yes" responses for regular and exception words.
Comment: The results were interpreted as follows: The phonological and visual routes operate in parallel. Regardless of whether a word is regular or exceptional, the visual route is used. Nonwords have no semantic entry and, therefore, the use of the phonological route becomes obligatory. Hence, a "no" decision is slower. Bauer and Stanovich (1980) have, however, argued that the regular word list used by these experimenters contained many inconsistent words (e.g., the regular word *hale* is inconsistent with the irregular word *have*). This could have made the processing of regular words such as *hale* as slow as exception words and masked the potential difference in response latency.

Procedure: Glushko (1979). Subjects were asked to pronounce, as quickly as possible, four kinds of words: regular consistent words that do not have any exception neighbor (e.g., *pink*), exception words (e.g., *pint*), nonwords that resemble regular consistent

Table 2.2 (continued)

words (e.g., *bink*), and nonwords that resemble exception words (e.g., *bint*). If all nonwords are pronounced the same way through phonological mechanism, the time taken to pronounce *bink* and *bint* should not differ.
Results: Exception words such as *pint* took longer to pronounce than regular words such as *pink*. However, words such as *bint* also took longer to pronounce than words such as *bink*.
Comment: The observation that it takes longer to pronounce *pint* than *pink* cannot be attributed to the additional time required for phonological conversion of exception words because a similar distinction is observed between *bink* and *bint*. Visual input arouses orthographic and phonological representations. If there is congruence between these two representations (as in *pink* and *bink* pronunciation will take less time than when there is not as in *pint* and *bint*). Phonological activation of the visual input takes place in parallel along with orthographic activation.

Procedure: Bauer and Stanovich (1980). Regular and exception words were presented in a lexical decision task. Some of the stimulus words were made up of a mixture of upper and lower case letters.
Results: Reaction time was shorter for regular words than for exception words whether the letters were of mixed case or not.
Comment: Mixing of the letter cases should have affected the direct visual processing of words and increased the reader's reliance on the phonological route. This will increase the reaction time distinction usually found between regular and irregular words. Since this was not seen, visual access might have preceded phonological recoding and the usually observed regularity effect might be post-lexical.

Procedure: Patterson and Marcel (1977). They asked deep dyslexic neurological patients to make word—nonword decisions.
Results: Even though the patients could not read aloud the nonwords, they could still recognize them as nonwords.
Comment: The phonological conversion mechanism of these patients must have been impaired since they could not read nonwords. The fact that they could make lexical decisions indicates that word recognition can be accomplished through visual route alone.

TABLE 2.3.

Experimental studies that support a combination of phonological and direct visual—semantic access

Procedure: Meyer *et al.* (1974). Subjects were required to decide whether a given visual word was a member of a category, for example, a fruit. The test word was an actual member (*pear*), a homophone (*pair*), or a nonmember (tail). The homophone

Table 2.3. (continued)

forces the subject to make decision on the basis of the spelling of the word. Under another condition, subjects were asked if the word sounded like the name of a fruit.
Results: Deciding *tail* is not a fruit was faster than deciding *pair* is not a fruit; deciding *pear* sounds like a fruit was faster than deciding *pair* sounds like a fruit.
Comment: The first result could have happened because *pair* may induce a conflict between the phonological and visual inputs. The second result is obtained because *pear* sounds like a fruit and is a fruit while *pair* sounds like one but is not a fruit therefore creating a conflict between phonological and visual inputs. If phonology is not involved in reading, such conflicts will not arise. Thus, both mechanisms operate in parallel and whichever accesses the lexicon first will influence word recognition.

Procedure: Davelaar *et al.* (1978). They studied response latency in a lexical decision task in which homophones (*sail/sale*) and pseudohomophones (*brane*) and nonwords (*slint*) were used.
Results: Response time was longer for homophones but not for nonwords.
Comment: The investigators decided that graphemic and phonemic encoding occur simultaneously but that the reader has some control over the use of phonological coding.

Procedure: Seidenberg (1985). Subjects were asked to read aloud words which varied on two dimensions: frequency and regularity. The reaction time was the dependent variable.
Results: Higher-frequency words were named faster than were lower-frequency words; exception words were read more slowly than regular words only when they were of low frequency.
Comment: The results could be due to some post-lexical factor. Nevertheless, the findings show that word recognition is not a simple phonology versus visual access issue but is determined by several interacting factors.

Procedure: Van Orden (1987). In a semantic categorization task, college students were asked to decide whether a word such as *rows* was a "flower" or not. In order to rule out that their response was not influenced by orthographic cues, they were also given words such as *robs* which orthographically are not very different from *rows*.
Results: Subjects often misidentified homophones such as *rows* as a flower. They did not make such errors for orthographically similar words such as *robs*. This effect was seen even in brief-exposure pattern-masking conditions indicating phonology plays a role quite early in word identification. These effects were obtained for both low- and high-frequency words.
Comment: The author concluded that phonology plays a role in reading even by skilled readers and that phonology is used even in recognizing high frequency words. Results of this study challenge the notion that highly familiar words are directly accessed for meaning (without the help of phonological mediation).

3.3.3.2. *Evidence from neuropsychology.* In recent years, literate adults who have lost some of their reading skills as a result of stroke have been extensively studied. Loss of reading skill as a consequence of brain damage is referred to as *acquired dyslexia.* Because the patients with acquired dyslexia show different patterns of deficit, they provide a unique opportunity to investigate the normal reading process. A few studies of acquired dyslexia that are relevant to developmental reading disabilities are described in the following section.

It was noted in Chapter 1 that Marshall and Newcombe (1966, 1973) proposed a system which classifies acquired reading disorders into "deep" and "surface" dyslexias. The syndrome of deep dyslexia is characterized by the following symptoms: difficulty in reading nonwords, presence of semantic paralexic errors in reading, poor reading of function words as compared to content words, and the presence of visual and derivational reading errors. These symptoms suggest that the ability to convert letter strings into their phonological representation is impaired in these patients. The presence of semantic errors in their reading indicates that these patients have retained at least partial ability to access the meaning of words. Their performance in lexical decision tasks supports this conclusion. For example, Patterson and Marcel (1977) and Patterson (1979) found that, in lexical decision tasks, deep dyslexic patients can judge correctly whether or not letter strings are real words. These findings suggest that the semantic lexicon and the route leading to it from print are to some extent functional in these patients; as a result, these patients could capture the general meaning of a word even though they could not pronounce it correctly. It should, however, be noted that the reading skill of these patients is far from perfect.

Patients with surface dyslexia, on the other hand, show a somewhat different pattern of deficits. They are able to read regular words better than exception words; the exception words are often regularized and pronounced in a mechanical way; at times, understanding of the word is based on its pronunciation; and nonwords are sometimes produced as output (Newcombe and Marshall, 1985). In lexical decision tasks, the surface dyslexics tend to falsely accept visually presented nonwords that sound like words (e.g., *slic*) as words (Kay and Patterson, 1985). These features are interpreted to mean that in these patients, the nonlexical route to phonology is intact whereas the route to semantic lexicon or the lexicon itself is impaired. It is argued, therefore, that these two forms of acquired dyslexia provide support for the view that two separate mechanisms and two routes are involved in reading.

It was noted in the previous section that some patients present symptoms which suggest that a word-specific pathway exists which can access the pronunciation of the word directly without using spelling-to-sound conversion (Schwartz *et al.*, 1980). The patient described by Funnell (1983) could neither understand words nor pronounce non-words but could pronounce common words almost perfectly. This suggests that both the visual route to the semantic lexicon and the ability to convert print into phonology were impaired but that a third route was used to access word-specific pronunciation. Goldblum (1985) has given a detailed account of a case in which the patient could not read low frequency words well but had no difficulty in reading familiar words. This is taken as additional evidence for the existence of the direct phonological route. It should be noted that this route can be used only for pronouncing familiar words.

While the studies described above are interpreted as evidence for the existence of independent mechanisms that are used in recognizing words, such an interpretation is not without its detractors. Henderson (1982), for example, has argued that the hypothetical operations involved in reading postulated on the basis of a "subtractive method" applied to neuropsychological symptoms may not be truly representative of the normal reading process. In the case of the surface dyslexia, for example, the reading errors (e.g., *unite* as *unit*) actually may reflect an improper application of the GPC rules rather than its overuse. Furthermore, it is pointed out that regularity effect (i.e., being able to read regular words better than exception words) reported in patients with surface dyslexia is too variable to be considered a reliable symptom. Patterson *et al.* (1985) also indicate that surface dyslexia is not a single, stable syndrome with a precise list of diagnostic criteria. Comprehension of deep dyslexic patients is also not entirely accurate as the following examples of misreadings show: *act* as *play*; *afternoon* as *tonight*; *uncle* as *cousin*; *tall* as *long* (Marshall and Newcombe, 1980). Therefore, the interpretation that the phenomenon of deep dyslexia as proof that reading can be accomplished without phonology should be accepted with reservation.

These acquired dyslexic symptoms indicate that even though the pronunciation and understanding of a word can be accomplished in more than one way, the precise recognition of the word depends upon the integrity of both the phonological and semantic systems. While a direct-meaning-based approach can take the reader to the ball park, landing on the precise target requires guidance from the phonological mechanism. Conversely, the phonological mechanism alone is not sufficient for reading, as surface dyslexic patients show. It may not be unreasonable to conclude that for efficient and accurate reading both mechanisms are necessary.

3.3.3.3. *Evidence from developmental psychology.* From the time children enter school, their ability to recognize words increases steadily. Furthermore, word-recognition ability appears to follow a systematic pattern starting with phoneme awareness followed by blending skills and, finally the ability to decode even unfamiliar words. One of the prerequisites of decoding is phoneme awareness, a knowledge that the written grapheme may represent one or more sounds which can be different from its name. Wagner and Torgesen (1987) reviewed the studies that examined the relationship between phoneme awareness and reading skill and concluded these two are positively correlated. Even though some children appear to start reading by recognizing words from context, soon they go through a stage in which the spelling-to-sound relationship comes to play an important role. Mason (1980), for instance, observed nursery school children for nine months during which time they received informal reading instruction. It was found that all children made progress in reading and, by the end of the school year, a few were reading on their own. Mason identified three stages of reading progress: a stage when words were read on the basis of their context, followed by the use of letter—sound cues to identify words, and ending in a stage where full use of the spelling-to-sound relationship was seen. There is also evidence that at least some preschoolers begin to read words incidentally in the absence of specific instruction and eventually discover the spelling-to-sound rules for themselves (Soderbergh, 1977). The progress of a majority of children, however, depends on their receiving specific instructions in decoding and blending.

Whether the acquisition of reading skill depends on such training or reading can be taught successfully by using the sight-word method continues to be an issue and has been called "the great debate" by Chall (1967). After reviewing a number of studies, Chall concluded that word pronunciation was facilitated more by phonics than by sight-word training; but when it came to meaning, there was no clear-cut advantage for phonics. It should, however, be noted that since pronunciation can be used to identify unfamiliar words, the phonics-trained child has a definite advantage over the child who does not know how to pronounce an unfamiliar word. In other words, a beginning reader who knows the spelling-to-sound rules can, in essence, teach himself to read without the teacher's continuous instruction (Baron, 1981). Consequently, children who lack this skill make very slow progress in reading acquisition.

Experimental studies show that beginning readers rely on pre-lexical phonological conversion in order to recognize words. Reitsma (1984) studied reaction time latencies of children aged 7 through 12 in a lexical decision task. The task required the child to decide whether the word that would appear on the screen belonged to a certain category (e.g., *Is* Bunny *an animal*?). Before the word was shown, however, a speech sound was presented and the child was required to repeat it until the lexical decision was made. Reitsma found that, when the sound was part of the visual word (e.g., *ba* in the case of *bunny*), it facilitated lexical decision. This priming effect was found only in the case of beginning readers and not in older children. Reitsma concluded that beginning readers translate print into sound before they retrieve the meaning of the word.

A study by Doctor and Coltheart (1980) used a somewhat different strategy but arrived at a similar conclusion. These investigators required children aged 6 through 10 to decide whether a sequence of printed letter strings was a meaningful sentence. They found that meaningless sentences that were meaningful when phonologically recoded (e.g., 'He ran threw the street') produced more incorrect responses than did meaningless sentences that remained meaningless when pronounced (e.g., 'He ran sew the street'). The difference in error rates between the two types of sentences diminished as a function of age. They concluded that very young readers rely extensively on phonological recoding when they read for meaning.

But do children, once they have attained proficiency in reading, abandon phonological recoding and are able to read by directly accessing the meaning of the written word? A study by Samuels *et al.* (1978) addressed this question by requiring children from grades 2, 4, and 6 and college students to pronounce words of differing lengths. It was found that there was an increase in response latency as a function of word length for second- and fourth-grade children but not for sixth-graders and college students. The results were interpreted to mean that students in grades 2 and 4 use component letter-by-letter processing but with increasing skill the size of the unit of recognition increases. Thus, a developmental trend of decreasing reliance on phonological mediation was seen. A similar view is expressed in the form of the "probability-efficiency" theory which states that with age, the probability of reading a word by the visual route increases and, conversely, the probability of reading it by the phonological route decreases, but the efficiency of using both routes increases with age (Jorm and Share, 1983).

Even though the reader depends less on the phonological conversion strategy as he becomes more proficient in reading, it is very unlikely that the GPC strategy is relinquished completely at any stage. The study of college students by Van Orden which is described in Table 2.2. showed that phonological mediation plays a role in word recognition. Another study of college students by Marsh *et al.* (1977) also supports this view. These researchers investigated the pronunciation strategy of fifth-grade children and college students by testing their nonword reading ability. The investigators specifically compared a grapheme—phoneme-correspondence strategy with an analogy strategy which is similar to whole-word reading by sight. The nonwords used in the study were constructed in such a way as to bring out this difference. For example, if a GPC strategy was used, the /ph/ in the nonword "*tepherd*" would be pronounced /f/ as in *telephone*, since such a pronunciation is common and rule based. If an analogy strategy is used, /ph/ will be pronounced /p/h/ as in *shepherd.* They found that fifth-grade children used GPC rules on 50 percent and analogy on 39 percent of the trials. In contrast, college students used GPC rules on 30 percent and analogy on 59 percent of the trials. This study shows that both phonological-recoding and whole-word strategies are used by readers of widely different age levels even though the extent of their dependency may vary according to reading experience. Snowling (1980) found that progress in normal reading was characterized by an increase in grapheme—phoneme-decoding ability whereas delayed development of this ability led to an excessive reliance on sight-word reading which eventually impeded acquisition of reading skills. Taken together, these observations show that an inability to utilize the phonological cues may, in part, be responsible for reading disability.

In summary, spelling-to-sound conversion skill appears to play an important role in reading, particularly during the early stages of reading acquisition. It is also reasonable to assume that since the phonological strategy can be used to recognize low frequency and unfamiliar words, this skill is not divested at any stage. Available evidence suggests that an inability to use decoding skills effectively is one of the causes of reading disability at all age levels.

3.3.3.4. *Evidence from studies of specific reading disability.* An inability to learn to read well can be multiply caused. A study by Curtis (1980) identified two major etiological factors: poor decoding skill and poor listening comprehension. In this study, word naming, nonword naming, and listening comprehension tasks were administered to children of high and low reading ability from grades 2, 3, and 5. In addition, a lexical decision task which used pairs of letters, words, and nonwords was also administered. It was found that poor readers and good readers differed from each other in word reading and nonword reading (decoding) ability. In was also found that decoding measures accounted for more observed variance in unskilled readers than in skilled readers. While decoding skill accounted for a substantial amount of variance at all grade levels, listening comprehension accounted for more variance among the third- and fifth-grade skilled readers. This finding is in accordance with the view expressed earlier that for word recognition, children in beginning grades rely more on spelling-to-sound relationship than do children in later grades. The study also showed that at lower grades there were some children who were weak in decoding but not in listening comprehension and others who were poor in both skills. Perfetti and Hogaboam (1975) used a vocalization latency task and a semantic decision task to compare children of differing reading ability. In a semantic decision task, a word is flashed on a screen and the viewer has to decide if the word represents a particular category (e.g., animal). The differences in vocalization latencies between good and poor readers were greater than were the differences found between these two groups in the semantic decision task. This suggests that differences seen in reading skill in children may be largely due to differences in phonological skills.

Frederiksen (1981) studied high school students of differing levels of reading ability by administering word-naming tasks. It was found that when test items became more difficult, poor readers took much longer to decode than good readers did. Decoding, under such circumstances, became an attention-demanding task and affected comprehension.

These results indicate that poor decoding affects reading at upper age levels as well as at lower age levels and that it can indirectly affect reading comprehension.

A recent study by Olson (1985) supports the view that an ability to visually recognize the word (without being able to decode it) alone is insufficient for efficient reading. This study compared 70 disabled readers ranging in age from 7.8 years to 15.3 years with matched groups of normal readers. A phonetic coding test and an orthographic coding test were administered to these subjects. The phonetic coding test was a lexical decision task that required the subject to indicate, by pressing a button, which one of the two visually presented "words" sounded like a real word (e.g., *kake*, *dake*). The orthographic coding task required the subject to indicate which one of two similar-sounding, visually presented words was a real word (e.g., *deep*, *deap*). Analysis of the results showed that even though the two groups did not differ significantly in the orthographic coding task, the disabled readers were inferior in the phonetic coding task. In other words, having adequate skills to recognize words visually did not prevent these children from becoming disabled readers.

Additional support for the importance of phonological mediation in reading comes from studies that specifically focused on the effect of providing training in grapheme—phoneme-conversion skills (Litcher and Roberge, 1979; Williams, 1980). Williams provided supplementary training in phoneme analysis and blending to a large number of reading disabled children. At the end of the training period, reading disabled children who had received training were significantly better in reading unfamiliar words than were children in the control group.

Results of training studies, however, have to be interpreted with caution because the cause—effect relationship, in these experiments, may not be clear. For instance, it can be argued that practice in word recognition improves phonological analysis skill rather than vice versa. A related condition is the "rich get richer" phenomenon (Stanovich, 1986b) which means that children who have adequate decoding skill read much and this, in turn, helps improve their decoding skills even more while those with poor decoding skills read little and remain poor decoders.

A few studies have investigated the issue of whether practice in word recognition improves decoding skill or practice in decoding improves word recognition. Perfetti (1985) studied the cause—effect relationship between phoneme analysis, phoneme synthesis, and reading practice. Phoneme analysis refers to the ability of the reader to decompose a word such as *cat* into its constituent phonemes (sounds) /k/æ/t/. This ability is tested by asking the child to delete the first sound /k/ and then pronounce the word. Phoneme synthesis is the opposite process in which the three units of sound are put together and the word is pronounced. These skills may also be tested by asking the child to transpose the initial phonemes of two consecutive words (e.g., *big dog* becomes *dig bog*). Together, these two skills are referred to as phoneme awareness. In Perfetti's study, tasks which assessed phoneme awareness were given to 82 beginning readers. The beginning readers were further split into three groups: Group 1 were taught direct correspondences between letters and phonemes as well as blending; Groups 2 and 3 were taught in the conventional way using basal readers. Of the latter two groups, Group 2 was more advanced in reading than was Group 3. At the end of the year, the children were tested for phoneme awareness and nonword reading ability. A relatively complicated picture emerged from Perfetti's study. It was found that while most of the children who had received direct training in decoding skills had mastered phoneme synthesis, only 70 percent of these children could perform phoneme analysis tasks successfully. In contrast, 90 percent of the children in Group 2 who were taught through basal readers were successful in phoneme synthesis tasks. Children in Group 3, however, were poor in both phoneme analysis and synthesis. Perfetti interpreted the results in the following way: Phoneme synthesis precedes progress in nonword reading, whereas phoneme analysis follows progress in nonword reading; learning to read depends partly on phonemic knowledge and partly produces it.

Other studies, however, strongly suggest a causal role for phoneme awareness skills. In a longitudinal study (Stanovich *et al.*, 1984), a group of kindergarten children were administered ten phonological awareness tasks. A year later, when the reading achievement of these children was assessed, it was found that seven of these ten tasks collectively emerged as strong predictors of reading ability. Since preschoolers receive little or no formal reading instruction, the high correlation between phoneme analysis skill and reading achievement cannot be attributed to experience in reading.

Besides using preschoolers, another way to control for the reading experience effect is to compare older disabled readers with younger normal children who read at the level of the disabled readers. This experimental design is called "reading-level match design" (Bryant and Goswami, 1986). In a study that used this design, Bradley and Bryant (1978) compared a group of normal readers aged 6.10 years with a group of poor readers aged 10.4 years who were reading at about 6-year-old level. These children were given an oddity rhyming task which required them to tell which of the four words did not belong (e.g., *weed, need, peel, deed*). It was found that, in this task, the performance of the group of poor readers was inferior to that of the younger normal readers. Since the additional four years of exposure to reading failed to increase the phonemic awareness of the poor readers, phoneme-related skills may play a causal role in reading. A study by Frith and Snowling (1983) in which 10- to 12-year-old dyslexic children were matched for reading age with younger normal readers also found the dyslexic readers to be significantly inferior to normal readers in their ability to pronounce nonwords. The repeated finding that college-aged dyslexic students are also deficient in decoding (discussed in the next chapter) suggests that phonological skills, as applied to reading, do not show significant improvement with reading experience.

In summary, studies of disabled readers strongly suggest that the ability to convert the written word into its corresponding phonology is an important skill involved in reading acquisition. Failure to adequately master this skill can be a major impediment to reading acquisition.

3.3.4. *Conclusions*

The question of whether phonology is obligatory for reading cannot be answered in a yes-or-no fashion. As noted earlier, the answer has to be qualified with reference to the skill of the reader, the purpose of reading, and the material that is read. Experiments that indicate reading can be accomplished without phonological conversion of the word have to be interpreted with caution, because these studies have used single words or word lists to test the hypotheses. These stimuli are only remotely related to real-life reading situations and, therefore, are not readily generalizable to the reading of prose. Reading does not involve merely the recognition of words; a great deal of inferential and metacognitive factors are also brought into play. The notion that a whole-word-direct-access strategy is sufficient for fluent reading is sometimes based on the argument that some languages such as Chinese are written entirely in nonalphabetic script. Learning to read a logographic script such as Chinese depends heavily on rote associative learning and, therefore, places an enormous burden on memory systems. As Tzeng and Hung (1981) observe, "Learning a limited number of Chinese characters does not qualify a person as a successful learner of Chinese. The essential difficulty of Chinese script lies in its huge number of distinctive characters" (p. 246). The nature of the Chinese script is sometimes given as a reason for low literacy in China (Rozin and Gleitman, 1977).

Evidence from the four sources — experimental psychology, neuropsychology, developmental psychology, and studies of disabled readers — converge on the importance of the phonological process in reading. There is a remarkable consistency among studies comparing good and poor readers regarding the importance of the ability to convert print into its phonological equivalent in reading. After reviewing the studies that addressed the role of decoding in reading, Stanovich (1982a, 1986a) concluded that the use of phonological code to access the lexicon is strongly related to reading fluency and that children, at some point, must acquire skill for breaking the spelling-to-sound code which is a prerequisite to fluent reading skill. Wagner and Torgesen (1987), in their review, note that research attention should focus on finding out which aspects of phonological processing (phonological awareness, phonological recoding, and role of phonological recoding in short-term memory) are causally related to which aspect of reading (word recognition, word analysis, and sentence comprehension). This remark implies that phonological processes are involved in all aspects of reading.

There are several reasons for considering *both* the GPC skill and the direct semantic accessing skill to be essential for accurate and fluent reading of connected prose: Even though deep dyslexia patients demonstrate an ability to comprehend isolated words, such a comprehension is imprecise. This may indicate that accessing the exact word in the lexicon has to be guided by the phonological mechanisms. Poor decoding skill, even in mature individuals such as college students, is associated with developmental dyslexia; poor decoding skill, as evidenced by poor spelling in some apparently normal readers, is associated with subtle reading deficits (discussed in Chapter 5).

Furthermore, in order to comprehend the meaning of a sentence, the component words or clauses have to be kept in working-memory. It was noted earlier that the phonological or articulatory representation of the written language is the most convenient format in which linguistic information can be kept in memory. Because disabled readers are not likely to have an extensive sight vocabulary, they cannot convert into phonological representation all the written words they encounter. This increases their dependency on decoding skills for such a transformation.

We may answer the question "Can the word be recognized without phonological mediation?" by stating that a skilled reader may be able to recognize a limited number of highly familiar words without phonological mediation. Since connected prose contains an assortment of words of varying familiarity, text reading will be affected by poor decoding skills. For the acquisition of reading skill, the grapheme–phoneme-conversion skill is, therefore, a necessary but not a sufficient requirement. Skilled reading is facilitated by phonological as well as semantic processes.

4. READING COMPREHENSION BEYOND THE WORD LEVEL

Knowing the meaning of individual words does not by itself guarantee that the meaning of a sentence can be apprehended. This is because a good deal of information in a sentence is not explicit but is implied. As a result, reading comprehension can be accomplished only by relating the sentence or parts of the sentence to the knowledge the reader already has. Since new knowledge is gained in relation to preexisting knowledge, comprehension is an interactive and constructive process. Three major factors facilitate such an interactive process: the nature of the text, the linguistic ability of the reader, and the reader's cognitive competence. In the following section, the role played by these factors in comprehending written sentence and text as well as the role played by metacognition is examined.

4.1. *Sentence-Level Comprehension*

Psychologists and linguists have rather extensively studied factors that underlie reading comprehension. Based on the findings of these studies, it is possible to draw a general description of the process of sentence comprehension. As the reader moves down the line, words that make up the sentence are recognized and transformed into representations of meaning. A sequence of words that represents a unit of meaning is called a *proposition* (Kintsch, 1977). The proposition is similar to the clause except that the clause is a linguistic unit whereas the proposition is a semantic unit. Also, a clause may contain more than a single proposition. In fact, some experts believe that the clause is a more natural unit of reading than the proposition (Taylor and Taylor, 1983). Comprehension of a complex sentence is thought to proceed by breaking down the sentence into several propositions or clauses. A list of such propositions makes up the microstructure of the text. (The overall meaning of the text which is obtained by relating several propositions obtained from the sentences constitutes the macrostructure of the text.) The sorting of a sentence into propositions cannot, of course, be accomplished until the words in the clause or the sentence (if it is a short one) are recognized. As a result, each word, as it is being recognized, has to be kept in the memory store until all the words in the clause or sentence are recognized. As noted earlier, this temporary storage which acts as a buffer is called working-memory. Because working-memory has storage capacity limitations, special strategies such as chunking and rehearsal are required to process the information successfully.

Experimental psychologists believe that words in a clause or a short sentence that are kept in the working-memory are quickly reconstituted into propositions and then processed further into long-term memory (see, for example, Kintsch and van Dijk, 1978; Kintsch and Miller, 1984). Since maintaining continuity between propositions is of importance for extracting meaning of the entire sentence, it is thought that more than one proposition is held in working-memory before being relayed to long-term memory. If, in spite of such a partial overlap, coherence among propositions breaks down, the reader must search his long-term memory for a proposition that can be reinstated in working-memory. If this attempt fails, the reader must make an inference and generate an appropriate proposition from his previous knowledge, relate it to the existing propositions, and recover the meaning of the entire sentence (Kintsch and Miller, 1984). Thus, propositions are, to some extent, "constructed" and depend upon the reader's previous knowledge and his ability to draw inferences. It is for this reason that tests of reading comprehension not only assess the reader's memory, but also his ability to draw inferences.

The restructuring of a sentence into related units of propositions involves not only the decomposition of the sentence into propositions but also their rearrangement. Evidence for such rearrangement comes from experiments of memory for sentences. For example, a sentence such as 'The boy who was watching the football game fell down and is in the hospital' is likely to be recalled as 'The boy who fell down is hospitalized.' Hasan (1984) has proposed several cohesive devices that link propositions and help rearrange them into meaningful units. These include the use of referents such as pronouns (e.g., 'John came but *his* friends did not'); substitutions such as using a noun for a name (e.g., 'Johansen is clever; *the boy* has a good head'), and lexical units where repetitions and conjunctions are used (e.g., 'Leslie has a good mind *and* a good heart'). There is also evidence that redundant information is dropped and congruent propositions are brought together. For example, subjects who read the sentences "The man bought the dog *and* The child wanted the animal" reported having read the sentence "The child wanted the man's dog" (deVilliers, 1974). Thus, what is heard or read is pruned, integrated, and transformed before it is relayed on to long-term memory. By eliminating redundant and superfluous information, the memory load of the cognitive system is considerably lessened. This makes the handling of newly arriving information easier.

An inability to carry out these transformational operations can tax the working-memory capacity and interfere with comprehension. The integration of related proposition is thought to take place at the end of clauses even though it can take place within a clause (Mitchell, 1984). There is also evidence to show that information is stored not verbatim but in the form of meaning. Comprehension at the sentence level, therefore, depends upon the reader's syntactic ability, semantic knowledge, memory capacity, and previous stored knowledge. All these factors make comprehension an interactive process.

4.2. *Text-Level Comprehension*

Texts differ from sentences in important ways, and, therefore, additional strategies are required to deal with the extra features of the text. Some of the special features of the text will be described in this section. Text usually contains a coherent theme and is, therefore, a more natural unit than are isolated words or sentences. Generally speaking, sentences within text are arranged in such a way as to present information in a cohesive manner and not to excessively tax the cognitive resources of the reader. Stories, for example, generally contain a theme, a plot, and a resolution of the plot. These features or informal rules are referred to as the grammar of the story. The large amount of information contained in a story places a great deal of demand on the memory of the reader. These memory demands can be minimized by being sensitive to the grammatical features of the story as well as by integrating thematically related propositions and by discarding irrelevant items so that a compact and coherent theme emerges. These constitutional processes are sometimes expressed as formalized rules such as deletion, generalization, and construction (Kintsch, 1977). Deletion denotes the ignoring of irrelevant and redundant material, generalization refers to synthesizing propositions with similar information content, and construction refers to the process of summarizing a sequence of actions and events. According to Kintsch, even children as young as four years old are sensitive to these operations in their efforts to understand stories. All these operations are critically dependent on the knowledge the reader already possesses. Such organized knowledge of the world is sometimes referred to as a "schema."

According to Rumelhart (1984), schemata are packets of knowledge or "generic concepts" stored in memory. They may be considered as frames of reference that are useful in integrating sentences in the text so that meaning of the text can be constructed. Experiments that have used ambiguous sentences illustrate the facilitating effect of schema on comprehension. For example, the sentence "The haystack was important because the cloth ripped" (Bransford and McCarrell, 1974) is easy to understand if the reader is told, beforehand, that it is about a parachute accident. In the absence of proper schema, the material, at times, would be almost impossible to understand. For example, a group of British psychologists found it difficult to understand the following passage until they were given a schema of the American football scene: "Chicago hosts the LA Rams to determine the NFC's Super Bowl representative. There will be no sideshows in this one as it doesn't need any. Walter Payton running one way and Eric Dickerson the other is plenty, and add to that the Refrigerator and friends snacking on Ram quarterback Dieter Brock" (Hunt, 1986). In order to understand this passage, the reader (or listener) has to have schemata of the cities in the U.S.A., the organization of professional football games, the nature of side-shows in American football games, the organizational pattern of professional football, and, of course, the Refrigerator.

Anderson (1984) has assigned to schema several functions that facilitate learning and remembering. According to him, a schema provides a slot or frame of reference, facilitates allocation of attention, enables the making of inferences, facilitates orderly search of memory, and facilitates summarizing. Difficulty at the schema level can seriously impede comprehension by affecting any or all of these functions.

Several studies show that problems of text comprehension can occur under two conditions: when the reader does not have an appropriate schema and when he cannot activate the relevant schema he has. In one study, Spilich *et al.* (1979) identified high-knowledge and low-knowledge groups on the basis of the subjects' previous knowledge about baseball. Both groups were presented with an account of a half-inning of a fictitious baseball game. The subjects were required to recall the narrative and were also given a 40-question test. Analysis of the data showed that both qualitative and quantitative differences existed between the two groups. Not only did the high-knowledge group's protocols contained more propositions but the propositions were also of greater significance to the game. The low-knowledge group not only tended to recall fewer propositions but also recalled information irrelevant to the game. It appears that members of the low-knowledge group were hampered in their comprehension by not having proper schemata.

The possibility that the reader may have the necessary schema but may not be able to use it was demonstrated in a study by Bos and Flip (1982). In this study, average and poor seventh-grade readers were asked to read two passages and answer comprehension questions. Both passages contained inconsistent statements. The students were not told of these inconsistencies before they read the first passage but were cued about the inconsistencies before they read the second passage. It was found that the average readers could detect the inconsistencies without being informed of them. The poor readers failed to detect inconsistencies present in the first passage but reported as many inconsistencies as the normal readers did in the second passage. This shows that the poor readers could not activate the appropriate schema spontaneously without outside help.

4.3. *Metacognition*

Knowledge of one's own cognitive processing and the ability to undertake deliberate corrective actions when comprehension fails are necessary for successful reading. The self-appraisal and execution of compensatory strategies are considered metacognitive skills. Because many poor readers are said to have poor metacognitive skills, this has become an important area of research. Consequently, the question, "Will making the poor reader aware of his own cognitive processing improve his comprehension?" has received a considerable amount of attention in recent years.

The importance of prompt and accurate feedback for efficient learning is a recognized fact in the psychology of learning. Reading comprehension is no exception to this. Being aware of one's own cognitive processing is the basis of such feedback information. This is also a prerequisite for being able to initiate corrective action when necessary. These two components of metacognition — self-awareness and the ability to take self-corrective measures — can be assessed by a variety of techniques. These include verbal reports, on-line monitoring measures, and self-confidence estimates. Verbal reports may make use of hypothetical situations (e.g., "What would you do when you come across a word you don't know?") or *post-hoc* analysis of the reader's performance. On-line processing measures utilize information about regressive eye movements which may indicate a reexamination of difficult parts of the sentence, self-corrections during oral reading, and performance in Cloze reading tests in which furnishing the correct word depends on comprehension of the preceding material. Confidence estimates usually require the subjects to make predictions about their own performance. Significant discrepancy between one's own prediction and actual performance indicates unrealistic expectations and, therefore, poor metacognitive skills. Many studies have attempted to see if good and poor readers differ from each other in metacognitive skills by using these evaluative techniques. A few representative studies of metacognition in reading process are presented in the following section.

4.3.1. *Verbal Reports*

Myers and Paris (1978) interviewed second- and sixth-grade children and asked them questions to assess their knowledge about the strategies involved in reading. Among other differences observed between the two age groups was that younger children were poor in their awareness about coping with words and sentences they did not understand. The younger children were less likely to suggest using the dictionary, or context, or asking an adult for help as problem-solving strategies than were older children. Canney and Winograd (1979) presented passages with and without syntactic and semantic errors to children in grades 2, 4, 6, and 8 and asked them if each type of passage could be read and if not, why not. It was found that children in the second and fourth grades and poor readers from grade 6 failed to notice syntactic and semantic errors in the sentences and focused their attention on the ability to produce a word correctly rather than on getting the meaning of statements. Good readers from grade 6 and all children from grade 8 focused on meaning and were able to recognize their own difficulties in comprehending anomalous sentences.

4.3.2. *On-line Processing Measures*

Eye movement studies provide reasonably reliable information regarding on-line processing of information. A number of studies have shown that, in the normal reader, eye movements are governed by higher-level cognitive decisions. Regressive eye movements, therefore, indicate that the reader has encountered a comprehension problem and is reexamining the source of the difficulty. According to Levin and Cohn (cited in Baker and Brown, 1984), good readers adjust their eye movements when faced with difficult materials and also adapt the movements according to the purpose of reading. Several studies have also reported that, in oral reading, poor readers make fewer self-corrections than good readers do. Weber (1970) found that good readers in first grade spontaneously corrected more grammatical errors than poor readers did. Kavale and Schreiner (1979) report that average readers in sixth grade self-corrected fewer meaning-distorting errors than above-average readers did. After reviewing these and other studies, Baker and Brown (1984) concluded that even good readers from first grade correct themselves if they make an error that does not fit the context but not if the error committed is semantically acceptable. This indicates that even very young readers are capable of monitoring their own comprehension as they read along. It was noted earlier that the Cloze technique can be used to study comprehension monitoring ability. Di Vesta *et al.* (1979) administered Cloze tests to high- and low-reading-ability students from grades 6, 7, and 8 and high school. In one test, the missing word could be arrived at on the basis of the previous context; in the second test, the reader had to read beyond the missing word to figure out the missing word. They found that even though poor readers did worse on both tests, the difference in their performance between the two tests was greater than the difference for good readers. These results suggested that poor readers did not anticipate the text beyond the point they were reading because they were deficient in the knowledge that the text they had already read did not contain sufficient information to solve the Cloze problem. Neville and Pugh (1976) tested fifth-grade children on different kinds of Cloze tests. Of these, one was constructed on the traditional format where finding the correct word depended on making inference on the basis of what had already been read; another Cloze test provided incomplete information. It was found that good readers were much affected when complete information was not available; poor readers were no more affected by such a test than the standard form of the Cloze test. This finding indicates that poor readers are deficient in on-line monitoring of reading comprehension.

4.3.3. *Confidence Estimates*

Forrest and Waller (1979) gave stories to children from grades 3 and 6. After the children had read the stories they were administered a test of comprehension. After the test, the children were asked to rate their confidence in their answers. It was found that older children and better readers had a relatively more accurate evaluation of the correctness of their answers than did younger and poorer readers. In a similar study, Myers and Paris (1978) found that 8-year-old children, when compared with 12-year-old children, were less aware of reading strategies such as rereading and paraphrasing. The younger children were also found to view reading as an orthographic-verbal translation problem rather than a meaning-construction and comprehension task.

Because continuous monitoring of one's own progress in reading and the ability to take appropriate corrective actions are vital to efficient and accurate reading, deficits in these aspects of metacognition can be expected to affect reading performance.

5. COMPONENTS OF READING: DECODING AND COMPREHENSION

5.1. *Studies of Componential Analysis*

Even though many factors can influence the reading process, the two major components of reading are word-processing skill and comprehension. This observation is based on a number of experimental studies. Jackson and McClelland (1979) tested two groups of university undergraduates differing in verbal ability on a number of information processing tasks. In addition, they also measured these subjects' listening comprehension, reading comprehension, and reading speed. Reading speed was defined as the speed of accessing memory codes for visually presented letters. Analysis of data yielded two variables that accounted for nearly all of the variance seen in reading ability. The two variables were: speed of accessing codes for visually presented letters and the ability to comprehend spoken material. Together, these two variables accounted for nearly 75 percent of the variance seen in reading skill. These two variables seem to correspond to decoding and comprehension, respectively. The correlation between these two variables was insignificant, demonstrating that decoding and comprehension are independent skills. Frederiksen (1982) who investigated high school graduates reached a similar conclusion regarding the componential nature of reading. In a recent study Palmer *et al.* (1985) investigated the relationship between reading speed and reading and listening comprehension in college students of differing verbal abilities. They administered information processing tasks (such as visual matching of letters and words) and linguistic processing tasks (such as word/nonword judgment, semantic categorization) and found that reading speed varied with visual word processing while reading comprehension varied with nonvisual linguistic processing. They concluded that reading speed and comprehension should be treated as distinct abilities and that reading speed is more related to elementary information processing tasks than is reading comprehension. These investigators also obtained a correlation coefficient of 0.82 between listening comprehension and reading comprehension which led them to conclude that reading comprehension is indistinguishable from listening comprehension and that "reading comprehension can be predicted almost perfectly by a listening measure" (p. 80).

A study by Stanovich *et al.* (1984b) arrived at essentially similar conclusions. These investigators compared the reading performance of children from grades 1, 3, and 5 with measures of intelligence (Raven's Progressive Matrices and Peabody Picture Vocabulary Test), listening comprehension, and nonword reading (decoding) skill. The investigators found that reading performance is multiply determined and that verbal comprehension, phonological awareness, and decoding speed are the three most important but independent factors that contribute to it.

Consistent with other studies, the correlation coefficient between reading comprehension and listening comprehension rose from 0.37 in grade 1 to 0.59 in grade 5. At all levels, listening comprehension was found to be a better predictor of reading achievement than were measures of intelligence. A recent study by Aaron *et al.* (1987) lends additional support to the view that decoding and comprehension are two major components of reading. Among other instruments, the Passage Reading Comprehension subtest from the Woodcock Reading Mastery tests was administered to 98 children from grades 4 through 9. The alternate form of the Woodcock Passage Comprehension subtest was read to the children and their listening comprehension was assessed. Their decoding skill was assessed on the basis of their ability to read a list of pronounceable nonwords. The following correlation coefficients were obtained between listening comprehension and reading comprehension for grades 4, 5, 6, 7, 8, and 9, respectively: 0.87, 0.39, 0.87, 0.73, 0.66, and 0.73. For the entire group of 98 children, the correlation coefficient was 0.76; listening comprehension thus accounted for more than 50 percent of the variability seen in reading comprehension. The correlation coefficient between decoding and reading comprehension for the entire group was 0.52. Together, decoding and listening comprehension accounted for 67 per cent of the variance seen in reading comprehension ($r = 0.82$). This study is more fully described in Chapter 6.

The remainder of this chapter will be devoted to a brief examination of the nature of the relationship between listening and reading. Because reading and listening depend on different modalities, certain differences between these two forms of processing information can be expected. For example, the spoken language is constrained by temporal factors while written language is spatially distributed and relatively permanent; the reader has better control over the rate and amount of visual input than the listener has over spoken language; and oral language is redundant while written language is much less repetitive. Furthermore, spoken language is syntactically lax, whereas written language adheres strictly to rules of grammar. Finally, in spoken language prosodic features such as stress and pause are explicit while in written language these are virtually nonexistent. As a result, perception of syllables and clauses is more easily accomplished in spoken language than it is in written language.

These obvious differences between reading and listening are, however, limited to the surface characteristics of the language. Once past the initial transformation of surface features, the two forms of representation are more similar to each other. As Sticht *et al.* (1974) put it, auding (listening comprehension) and reading differ primarily in the manner in which the individual receives the stimulus words, but they are both similar in the sense that they are both receptive communication acts that require a central language conceptualizing base. Nickerson (1981) who has compared these two forms of language concludes that in spite of the apparent dissimilarities "the differences between the two types of processes become more apparent when one focuses on the stimuli and the sensory systems that transduce them than when one considers the cognitive activity that must be involved in the determination of meaning" (p. 284).

For these reasons, comprehension, the second component of reading, is a common denominator of both reading and listening. This view is based on the assumption that, even though reading and listening use different modalities, they share the same cognitive mechanisms for comprehension. If this view is correct, deficits in comprehension of spoken language should be considered a problem common to listening *and* reading, whereas deficits of decoding should be considered a reading-specific problem and not part of the comprehension process. Crowder (1982b) expresses this idea by stating: "Proper subject matter of reading leaves off more or less where comprehension begins" (p. 5).

5.2. *Reading Comprehension and Listening Comprehension*

5.2.1. *Experimental Studies*

During the course of standardizing his reading test, Durrell (1969) administered tests of reading and listening comprehension to a large number of children. He found that listening and reading vocabulary were equal by about grade 8 and reading and listening comprehension of sentences by grade 6. Listening comprehension tended to be superior at lower grades and reading comprehension was slightly superior to listening comprehension at higher grades. The effect of an experience factor is not altogether unexpected since at lower grades children have not yet acquired sufficient reading skills. Kintsch and Kozminsky (1977) administered reading and listening tasks to college students and found surprisingly small qualitative differences in the production of structural elements and propositions. They concluded that "reading and listening involve identical comprehension skills" (p. 498). Aaronson and Ferres (1984) studied reading comprehension by manipulating variables such as reader's age (5th grade and college level), task requirements (recall vs. comprehension), and ability levels. The dependent variable was reaction time as measured in a subject-paced presentation that involved the use of a computer. They concluded that the processes used for obtaining meaning may be similar, regardless of the mode of presentation. Aaronson and Ferres also noted that the slow reader may be affected by structural features such as word length and frequency of the written word rather than by meaning which is common to both reading and listening.

An indirect means of examining the relationship between reading and listening comprehension is to assess the speed with which both tasks can be carried out. Studies conducted by Carver (1973, 1977) show that the optimal speed of processing is about 300 words per minute for college students and this upper limit is the same for reading as well as listening. It appears, therefore, that both reading comprehension and listening comprehension share the same mechanism. Direct evidence that supports this view comes from training studies which tried to improve listening-comprehension skills and tested if a concomitant improvement was seen in reading comprehension. Sticht and Glasnapp (1972) required young men of low and high verbal ability to listen to materials of fifth, eighth, and fourteenth grade-level difficulty and subsequently administered Cloze tests. They found that auding the passage before taking the reading test facilitated the performance on the reading test for men of both ability levels and the transfer was not limited to recall but also included comprehension. Kennedy and Weener (1973) found that comprehension training through listening or reading had a mutual transfer effect. Sticht *et al.* (cited in Danks, 1980) report that of the twelve studies that measured transfer of auding training effect to reading, ten reported significant transfer while two failed to find such transfer. Training studies therefore, lend additional support to the notion that listening and reading comprehension are very closely related.

Baker and Brown (1984) have examined the relationship between listening comprehension and reading comprehension within a metacognitive framework. After discussing a number of relevant studies, they conclude that the evaluation component of comprehension monitoring is similar in the two stituations; both listeners and readers may use the same criteria to evaluate their state of understanding.

Studies that have investigated the relationship between reading and listening comprehension from a reading-disability perspective also support the view that, regardless of the modality of input, comprehension is a unitary process. Smiley *et al.* (1977) gave good and poor readers from seventh-grade reading and listening tasks. The test that was subsequently administered was carefully designed to assess comprehension rather than memory. Analysis of data showed a correlation coefficient of 0.85 between reading and listening comprehension. They concluded that poor readers are poor listeners and that "auding and reading comprehension depend upon the same basic process(es)" (p. 387). Berger and Perfetti (1977) studied two groups of fifth graders differing in reading skills. They were tested on their paraphrase-recall and literal-recall abilities. It was found that the performance of the skilled readers exceeded that of less skilled readers by equal amounts for reading and listening. They concluded that reading comprehension and listening comprehension depend on the same general language processing skills.

5.2.2. *Review Studies*

Several review studies that examine the relationship between listening and reading comprehension are available. Duker (1965) reviewed 23 such studies, and later Kennedy (1971) reviewed twelve additional studies. The correlation coefficients reported in these studies ranged from 0.45 to 0.82. Sticht *et al.* (cited in Danks, 1980) examined 27 studies and reported correlations between auding and reading for grades 1 through 12. Mean correlation coefficients rose from 0.35 in grade 1 to about 0.60 by grade 4 and remained steady thereafter. Danks (1980) has critically reviewed the similarity between listening comprehension and reading comprehension. While noting that it is unlikely that a direct comparison of listening and reading comprehension is possible, he suggests one should not expect a simple correlation since many factors influence both processes and, in some situations, there may even be greater similarity between listening and reading comprehension than that found within either listening or reading. In a recent review, Sticht and James (1984) plotted the relationship between listening and reading comprehension on the basis of data collected in some three dozen studies (Figure 2). It can be seen that an orderly pattern emerges with the correlations increasing from 0.35 in grade 1 to about 0.60 in grade 4 and holding steady thereafter. The authors concluded that auding ability is indicative of potential for reading.

In summary, existing research shows that reading comprehension is determined primarily by two major components: decoding and a general verbal comprehension. The similarity between reading comprehension and listening comprehension is well documented and recognized by linguists (Fries, 1963; Carroll, 1964), psychologists (Thorndike, 1973;

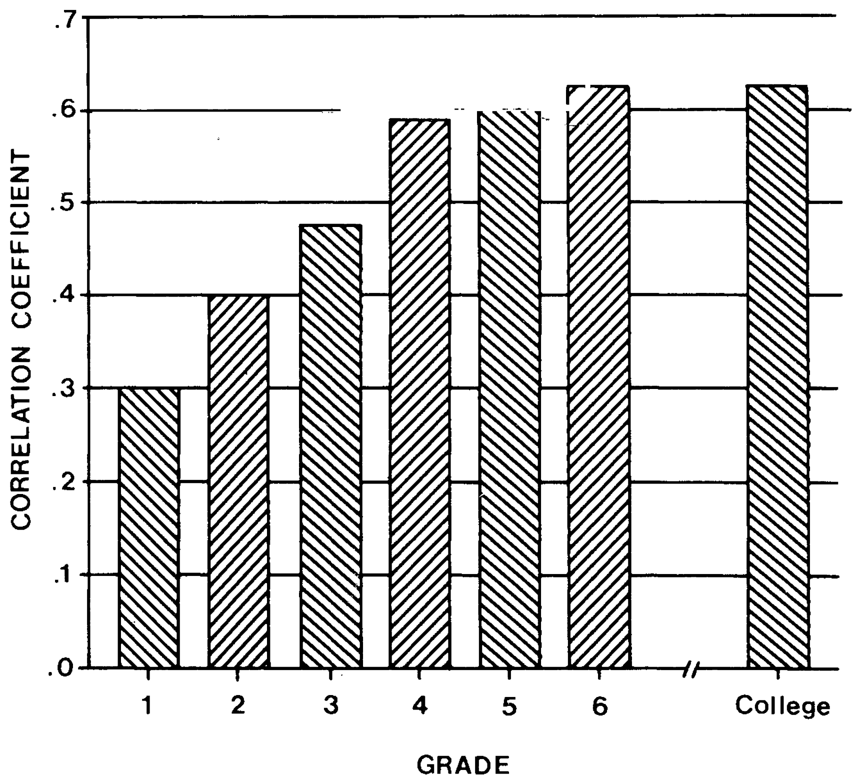


Fig. 2.2. Relationship between reading comprehension and listening comprehension. (The correlation coefficient between reading comprehension and listening comprehension rises after grade 3, reaches a maximum point by grade 6, and stays steady thereafter. Based on data from Sticht and James, 1984.)

Gibson and Levin, 1975), and reading specialists (Goodman, 1968; Smith, 1971). It may, therefore, be concluded that once past word recognition, the process of comprehending speech and print do not appreciably differ from each other.

5.2.3. *Implications*

Over a decade ago Carroll (1977) mused if it would be desirable to produce a test of reading with two equated components: a printed comprehension scale and an oral comprehension scale. He also noted that if developed, such a scale would satisfy the great need for a device that could be used to identify, separately, reading problems that are due to comprehension deficits and those arising from features that are peculiar to the written language. Thus, once the listening comprehension of the subject was determined, it could be used to predict his reading comprehension. If reading comprehension were significantly lower than that predicted by listening comprehension, the reading comprehension deficit could be due to some feature that is peculiar to the written language. This is because poor decoding skill can indirectly affect reading comprehension but not listening. The diagnostic procedure discussed in Chapter 6 is based on such a rationale.

NOTE

[1] In their book, Harris and Sipay (1985) use *word recognition* to refer to the process of associating the word with its pronunciation. *Word identification* is used to refer to understanding the meaning of the word. In this book, *word recognition* is used to refer to the process of recognizing the word by *both* its pronunciation and meaning. The term *word recognition*, as used here, is, therefore, equivalent to Harris and Sipay's *word identification* and *recognition.*

OUTLINE OF CHAPTER 3
['ETIOLOGIES OF DEVELOPMENTAL DYSLEXIA AND HYPERLEXIA']

1. Introduction
2. Developmental Dyslexia
   - 2.1. The Visual Encoding Stage
     - 2.1.1. The Icon
     - 2.1.2. Short-Term Visual Memory
     - 2.1.3. Conclusions
   - 2.2. Word-Recognition Stage
     - 2.2.1. Working-Memory
       - 2.2.1.1. Working-Memory: Capacity
       - 2.2.1.2. Working-Memory: Strategies
       - 2.2.1.3. Working-Memory: Speed of Retrieval
       - 2.2.1.4. Working-Memory: Phonological Coding
     - 2.2.2. Conclusions
   - 2.3. Reading Comprehension Beyond Word Level
     - 2.3.1. Syntactical Ability of the Dyslexic Reader
     - 2.3.2. Semantic Ability of the Dyslexic Reader
     - 2.3.3. Studies of Listening Comprehension
   - 2.4. Etiology of Developmental Dyslexia
     - 2.4.1. Phonological Deficit
     - 2.4.2. The Phonological Deficit Hypothesis
3. Hyperlexia
   - 3.1. Word-Recognition Stage
     - 3.1.1. Word Decoding
     - 3.1.2. Word Comprehension
   - 3.2. Reading Comprehension Beyond Word Level
     - 3.2.1. Sentence-Level Comprehension
     - 3.2.2. Text-Level Comprehension
   - 3.3. Etiology of Hyperlexia: Deficit in Assembling Comprehension

CHAPTER 3

ETIOLOGIES[1] OF DEVELOPMENTAL DYSLEXIA AND HYPERLEXIA

1. INTRODUCTION

We saw in Chapter 2 that reading is accomplished in three stages in which visual encoding, word recognition, and sentence—text-level processing of the written language take place. It was also noted that reading is an interactive process and that operations of different stages take place concurrently. Consequently, deficiency in any one of the operations, regardless of the stage in which it occurs, can affect reading. In this chapter, developmental dyslexia and hyperlexia are examined to see if the difficulties of dyslexic and hyperlexic readers can be traced to operation(s) at one or more of these stages.

2. DEVELOPMENTAL DYSLEXIA

2.1. *The Visual Encoding Stage*

It may be recalled that the two components of the visual encoding process studied extensively by psychologists are the icon and visual short-term memory. Since hyperlexic readers do not encounter difficulty in pronouncing individual words, it is reasonable to assume that they do not encounter difficulties at the visual encoding stage. The discussion on visual encoding, therefore, will be limited to developmental dyslexia.

2.1.1. *The Icon*

In this section, the question "Do dyslexic readers have deficits in iconic storage functions?" will be addressed. Since the icon acts as a temporary store of the visual input, either an inability to store the information for sufficient duration or a failure to clear it soon enough to make room for the subsequent input can adversely affect the reading process. Of these two potential hazards, the latter has been thought to be more serious and has been investigated. Researchers have used two methods to tackle this issue. The first method involves presenting the visual stimulus and following it with a mask at varying intervals to see if the interval between the onset of the stimulus and the mask (stimulus—onset asynchrony) is greater for dyslexics than it is for normal readers. If this turns out to be the case, it can be concluded that dyslexic readers take longer than normal readers to clear the icon. The second method involves presenting two different stimuli (such as a short horizontal line and a short vertical line) in rapid succession and increasing the interval between the presentation of the two stimuli (interstimulus interval) until the subject reports that he sees two distinct stimuli rather than a single composite figure (in this instance, a cross). If dyslexic subjects require a longer interstimulus interval to perceive the separate figures than normal readers do, it may be concluded that dyslexic and normal readers differ from each other in the duration of iconic persistence.

Even though some researchers have reported positive findings, many studies that have employed these techniques have failed to find a significant difference between poor and good readers in iconic duration. Stanley and Hall (1973), O'Neil and Stanley (1976), and Lovegrove and Brown (1978) reported longer iconic persistence in dyslexic children than in normal readers. Later on, Stanley (1976) failed to replicate this finding. While Fisher and Frankfurter (1977) reported shorter iconic persistence in dyslexic children, a study by Arnett and DiLollo (1979) found no difference between these two types of readers. Morrison *et al.* (1977) also failed to obtain differences between normal and dyslexic children at the iconic stage. This appears to be true of adolescent readers as well. Aaron *et al.* (1984) presented either consonants or photographs of human faces for a duration of 50 milliseconds and followed each with a mask. The interval between the stimulus and the mask was progressively increased from 10 milliseconds until the subject was able to correctly identify five consecutively presented consonants or pictures of faces from an array of multiple-choice items. The subjects were four dyslexic college students and four normal readers. The results showed that there was a great deal of variation within each group but the difference between groups was statistically insignificant. Even though the number of subjects used in this study is too small to allow any generalization, the great amount of intersubject variability seen within the group of normal readers casts doubt that deficits in the iconic stage are the source of the reading disability of the dyslexic reader.

In a recent study, DiLollo *et al.* (1983) noted that the duration of visual persistence was longer in dyslexic children if the same retinal receptors were stimulated but not if stimuli were made to fall on different parts of the retina. On the basis of this observation, they concluded that neural recovery from stimulation was slower in dyslexics than in normal readers and that iconic storage duration may interact with the retinal location of the stimulus. This conclusion, however, is based on the questionable assumption that, in reading, the same retinal receptors are repeatedly stimulated.

Apart from the fact that many studies have failed to detect any abnormality in iconic storage in dyslexic readers, the iconic storage deficit hypothesis of dyslexia can be questioned for the following reasons:

(i) dyslexics have difficulty not only reading sentences where continual clearance of successive words in the iconic memory is obligatory but also reading isolated words where a rapid clearance of the icon is not necessary;

(ii) the retarding effect produced by the slow operation of the icon may be expected to affect the reading speed of the dyslexic subject. By slowing their rate of reading, however, dyslexic readers could avoid visual confusions. As it turns out, dyslexic subjects not only read slowly but also commit many errors while reading. The iconic mechanism cannot readily explain the origin of such reading errors.

For these reasons, it is unlikely that the etiology of developmental dyslexia can be due to problems associated with the iconic storage mechanisms. Other investigators who have discussed this issue have also concluded that there is insufficient evidence to show that a deficit at the iconic stage contributes to developmental dyslexia (see, for example, Ellis and Miles, 1978a; Vellutino, 1979; Mitchell, 1982).

2.1.2. *Short-Term Visual Memory*

It may be recalled that short-term visual memory is considered to be independent of iconic memory and that it has a longer duration but less capacity than the icon.

Do dyslexic readers have deficits in short-term visual memory? A number of studies have investigated the possibility that dyslexic readers may have poor visual memory. Unfortunately, a majority of these studies have used verbal stimuli (such as words) or verbalizable stimuli (such as geometric figures) to test short-term visual memory. Many studies have also required the subjects to respond orally. Since verbal stimuli and oral responses can act as confounding factors, differences seen among readers in these studies can be the result of differences in their verbal skills as well as in their visual skills. For this reason, only those studies which used nonverbalizable stimuli and required nonverbal responses are discussed here.

Vellutino (1979) reports the results of two studies he and his associates conducted to test if dyslexic readers from grades 2 through 6 had poor visual memory. The stimuli used were words made up of Hebrew letters. Since the subjects were not familiar with Hebrew orthography, verbal coding of the stimuli would have been extremely difficult, if not impossible. Words of various lengths were presented with the aid of the tachistoscope for short durations and the children were asked to reproduce them by writing what they had seen. It was found that poor readers reproduced the Hebrew words as well as normal readers did. In a second study, the children were tested on a recognition task immediately after the initial exposure of the Hebrew words, after 24 hours, and after six months. It was found that the recognition scores of the two groups of readers were similar even after a delay of six months. Similar results are reported for second-grade children by Liberman and Shankweiler (1978) who tested children's ability to recognize previously presented nonsense designs, photographs of faces, and nonsense syllables. The poor readers were found to be slightly better than the good readers in memory for nonsense designs, and both groups did equally well on the face recognition task. Normal readers, however, recognized more nonsense syllables than poor readers did.

In a backward masking task, Ellis and Miles (1978a) tested dyslexic and normal readers by presenting, for a duration of one second, "random chessboard" designs in which half the cells were randomly filled. After varying intervals, they presented a second chessboard design and asked the child to decide whether it was the same as the one seen before. Even though masking was used in this study, the one-second-exposure duration is sufficient for the transfer of the visual representation from iconic store to short-term visual memory. The investigators found that the dyslexic children's performance was not significantly different from that of normal readers regardless of the length of the interstimulus interval. In the study described earlier, Aaron *et al.* (1984) tested the four dyslexic college students for their visual memory and compared their performances with those of four normal readers. The stimuli used were photographs of faces, and the subjects were tested under two different conditions. Under one condition, the photograph of a face was presented with the aid of a slide projector for a period of 200 milliseconds. This was followed immediately by a multiple-choice test stimulus which had photographs of four faces one of which was the target stimulus. The subject had to identify the face seen before. In the second condition, 41 photographs of faces were used. The photographs were placed in an album with one photograph per page. The subjects were shown the 41 photographs consecutively, one at a time, and without interruption. Each photograph was exposed for five seconds. After viewing all 41 photographs, the subjects were tested on a multiple-choice recognition task. Each test item had an array of four faces, one of which was a photograph seen before. There was no significant difference between the groups on the two tasks even though the dyslexic readers had a higher recognition score on the second task. A ceiling effect can be ruled out because no subject from the control group had a perfect score even though one dyslexic subject obtained a perfect score in the first task.

Some studies have used both verbalizable and nonverbalizable stimuli and have compared the visual memory of dyslexic readers with that of normal readers for the two types of stimuli. These studies have shown that differences observed in short-term memory of the two groups of readers are limited to verbal stimuli and that dyslexic readers may not have visual short-term memory deficit. Holmes and McKeever (1979) studied 15 adolescent dyslexics and 15 normal readers. After presenting 20 words or 20 pictures of faces, the subjects were tested for recognition memory. It was found that dyslexics differed significantly from normal readers only in their memory for words. The experimenters concluded that dyslexic subjects' memory deficit is material-specific. Liberman *et al.* (1982) tested children's memory for nonsense designs, faces, and three-letter nonsense syllables and found that poor readers were deficient in recognition memory for nonsense syllables only. Similar results are reported by Done and Miles (1978), Swanson (1978), and Hulme (1981). Using reaction time as the dependent variable, Ellis and Miles (1978a) came to the conclusion that dyslexic children are not likely to have difficulty in dealing with the visual characteristics of letters. They used the "Posner paradigm" in which the reaction time for judging whether two letters are the same is used as a measure of the speed with which a decision is reached. The letters can be the same visually and phonologically (e.g., *AA*), can be dissimilar visually and phonologically (e.g., *Ab*) or similar phonologically but dissimilar visually (e.g., *Aa*). Ellis and Miles studied children 10 to 15 years of age and found that retarded readers did not differ from normal readers when a decision could be made on visual feature alone (e.g., *AA*) but retarded readers were slower than controls when the decision had to be made on the phonological basis (e.g., *Aa*). This lends further support to the conclusions reached by other studies that developmental dyslexics are not deficient in visual processes, but may have difficulty in processing information that is phonological in nature.

In addition to the many experimental findings that show that dyslexic readers are not deficient in visual short-term memory, there are other rational grounds to reject the visual short-term memory deficit hypothesis of developmental dyslexia. Poor spelling is a constant accompaniment of developmental dyslexia and poor readers are also poor spellers. Any hypothesis of the etiology of developmental dyslexia should, therefore, be able to explain not only deficits that are seen in the input stage (i.e., reading) but also in the output stage (i.e., spelling). Since visual-process-related hypotheses deal only with perceptual deficits, they cannot explain defects of expression such as spelling errors. A second reason is that dyslexic subjects show a word-class effect in the reading errors they commit in the sense they misread more function words and word suffixes than content words and root words (Aaron and Phillips, 1986; Blank, 1985). Defective visual processing could be expected to affect words uniformly regardless their grammatical status. Finally, if dyslexics have deficit in the visual processing mechanism, it should affect their ability to process accurately not only visual language but all forms of visual stimuli. Such comprehensive visual defects have not been reported in dyslexic subjects.

2.1.3. *Conclusions*

There is insufficient evidence to show that dyslexic readers have significant deficits in the icon or the visual short-term memory. Some of the studies discussed in the previous section, however, suggest that they do perform poorly in tasks which require the visually presented stimuli to be phonologically encoded. Since phonological encoding is mediated by working-memory and deficits of phonological encoding lead to difficulties in word recognition, we turn our attention to working-memory and its role in word recognition.

2.2. *Word-Recognition Stage*

2.2.1. *Working-Memory*

Many experimental studies show that a major component of working-memory is phonological in nature and this enables information to be reorganized into chunks and retained for a considerable length of time through the process of phonological rehearsal.

The question "Do dyslexic readers have deficit at the working-memory stage?" can, therefore, be answered by assessing their phonological skills as well as their ability to chunk input information and maintain it through rehearsal. It is not intented to review the numerous research studies that have examined these aspects of working-memory. A few representative studies will be described in order to see if working-memory is implicated in developmental dyslexia, and if so, to probe the nature of the working-memory deficit. Excellent discussions of research studies that have explored the relationship between phonological coding, working-memory, and reading disability are available (See, for example, Jorm, 1983a; Jorm and Share, 1983; Perfetti and McCutchen, 1982; Stanovich, 1986a; Torgesen, 1985).

Several methods have been used to investigate the working-memory skills of dyslexic readers. These investigations have tried to decide whether the cause of specific reading disability is poor capacity of the dyslexic reader's working-memory, inefficient use of the strategies of working-memory, or slow retrieval of information. It has to be noted that memory capacity and memory strategies are not mutually exclusive but are highly interdependent since poor memory strategies can affect memory capacity (Chi, 1976). Working-memory capacity can, nevertheless, be viewed as the number of "slots" available to hold information and can be estimated with the aid of techniques that measure the memory span of the subject, by using instruments such as the digit-span subtest of Wechsler Intelligence Scales.

Working-memory strategies, particularly rehearsal, have been studied by examining the recall of verbal material for "primacy and recency" effects, by interfering with the rehearsal operation of working-memory and noting the effects of such a disruption on recall, and by presenting input information at a rate too fast to carry on rehearsal. Drawing inferences about rehearsal by examining the primacy and recency effects is based on the beliefs that in a verbal learning task, words at the beginning of the list have to be transferred to long-term memory as the learner progresses through the list and that rehearsal may facilitate the transfer of these words from working-memory to long-term memory. Since words in the latter part of the list are to be remembered for a relatively short length of time, a minimum amount of rehearsal may be sufficient to retain them in working-memory. Because words in the beginning of the list are likely to be well rehearsed, many of these words are likely to be recalled (primacy effect); many words from the end of the list are also likely to be recalled since the interval between learning and recall is relatively short (recency effect). Typically, fewer words from the middle of the list are recalled apparently because they are neither in the long-term memory nor in working-memory. A failure to show the primacy effect in verbal learning tasks can, therefore, be taken as an indication of poor rehearsal.

Interference of strategies is accomplished by requiring the subject, during learning, to articulate syllables or digits which are different from the test stimuli. As noted earlier, presenting words at a very fast rate can also interfere with rehearsal. If such manipulations have no significant effect on recall, it can be concluded that the reader is not using rehearsal strategy for retaining information in working memory.

The speed with which information can be retrieved is expressed as latency score which is measured by noting the time it takes to name a visually presented stimulus. Studies that measure the speed with which information is retrieved have obtained a positive relationship between speed and memory span. It has to be noted, however, that working-memory capacity, the ability to use strategies, and the speed with which information is retrieved are all influenced by long-term memory since the grapheme–phoneme-conversion rules needed for chunking and rehearsal are stored in the mental lexicon. Slow retrieval of these rules from the long-term memory can, therefore, interfere with the efficient operation of the working-memory. In the following discussion, these three aspects of working-memory — capacity, strategy, and speed of operation — and their relationship to reading disabilities are presented.

2.2.1.1. *Capacity.* A direct means of testing working-memory capacity is to present stimuli such as digits or pronounceable nonwords that can be retained in phonological form and requiring the subject to recall them. It was noted earlier that studies which compared retention of visual information with retention of verbal information show that, in general, dyslexic subjects have poor memory for verbal items but have adequate memory for nonverbal items. Investigations that have used the digit-span test of the Wechsler Intelligence Scales or similar instruments also indicate that poor readers have a reduced memory span (Rugel, 1974; Byrne and Arnold, 1981). Not all disabled readers, however, have a reduced working-memory capacity as measured by the digit-span test. Torgesen and Houck (1980) have, for instance, described eight reading-disabled children who had average digit-span memory. One of the dyslexic college students described by Aaron *et al.* (1980) obtained an extremely high-scaled score of 17 in the WAIS digit-span test even though his reading performance was at the 4.7 grade level. It appears, therefore, that the reading difficulty experienced by dyslexic readers may not be due entirely to capacity limitations of the working-memory. It is known that dyslexic subjects make errors in oral reading of single words and pronounceable nonwords, even when allowed ample time. Such errors cannot be directly linked to deficits of working-memory capacity.

In summary, capacity limitations of memory alone cannot readily explain the difficulties of the dyslexic reader. It is possible that memory-span deficits and reading disability are not causally related to each other but may have a common origin.

2.2.1.2. *Strategies.* As noted earlier, working-memory strategies have been investigated by observing the primacy—recency effects in learning, the effects of interfering with working-memory strategies, and by preventing the use of rehearsal. In the following section, the results of some of these studies are presented.

Studies that investigated primacy and recency effects include the one by Bauer (1977) in which the recall performance of dyslexic children for primacy and recency effects was examined. Two groups of 9- and 10-year-old dyslexic and normal readers were presented with lists of monosyllabic nouns that were to be recalled either immediately or after 120 milliseconds of presentation. The delay was either filled or unfilled by an irrelevant counting task. It was found that in the immediate free recall task, recall of items that were at the beginning of the list was poor (primacy effect) for disabled readers, whereas there was no difference between the groups in the recall of items that were at the end of the list (recency effect). In the delayed-recall task, items learned first as well as those learned last were poorly recalled by more dyslexic than normal readers. Bauer concluded that there is a rehearsal or retrieval deficit in children with learning disabilities. Using lists of varying lengths, Bauer also found that poor readers were inferior to normal readers in recalling words that were at the beginning and end of the lists.

The primacy effect, however, was not obtained by Byrne and Arnold (1981). They tested a group of dyslexic children and a group of normal readers. The task was to learn 20 lists of ten monosyllabic words presented at speeds of one-item-per-second or one-item-every-two-seconds. Subjects in both groups tended to recall more of the recently presented items and there was no difference between the groups in the number of words recalled from the beginning part of the list. When tested for digit-span capacity, the poor readers were, however, inferior to normal readers. These investigators concluded that reading deficit is not associated with immediate memory deficit and that digit-span capacity reflects some process other than immediate memory.

Studies have also examined the effects of interfering with working-memory strategies such as rehearsal. The study by Bauer discussed above found that rehearsal affected the recall of both dyslexic and normal readers. Done and Miles (1978) studied the effects of rehearsal by asking adolescent disabled and normal readers to reproduce a series of seven digits in the same order they had been presented through a tachistoscope. There were two conditions of recall: immediate and delayed. During delay, articulation was suppressed by making the subjects say the word *the*. It was found that in the immediate-recall condition, when rehearsal was not interfered with, normal readers recalled significantly more digits than did the dyslexic readers. In the delayed-recall condition, when articulation was suppressed, the two groups did not differ significantly in their recall. Done and Miles concluded that interfering with rehearsal reduced the recall of normal readers to the level of that of the dyslexic readers and that normal readers depend more on verbal rehearsal than do poor readers.

In general, interference studies suggest that the recall of normal readers is more affected by interference than is the recall of dyslexic readers. This is taken as evidence that dyslexic readers do not make good use of the rehearsal strategy. On the other hand, there is no general consensus among studies that examined primacy and recency effects in dyslexic readers. Also, articulatory suppression may affect memory at basic levels by interfering with attentional and long-term memory processes.

Some studies have examined the role of rehearsal in reading by minimizing the opportunity for the use of rehearsal in memory-recall tasks. If the rehearsal strategy rather than some other aspect of working-memory is responsible for reading disabilities, then eliminating or curtailing the opportunity to rehearse should affect good readers more than poor readers and thereby reduce the differences seen in the reading performance of normal and disabled readers. This, however, does not appear to happen. Torgesen and Houck (1980) presented digits aurally at four different rates ranging from four digits per second to one digit every two seconds. The investigators assumed that presenting four digits per second was too fast to permit any rehearsal. There were three groups of subjects: one group of poor readers with poor digit-span score, another group of poor readers with normal digit-span score, and a group of normal readers. It was found that even at the fastest rate of four digits per second, when it was highly unlikely that rehearsal was possible, the difference between the performance of the children with poor digit-span score and the other two groups remained large. Similar results are reported by Cohen and Netley (1978). In the Torgesen—Houck study, presenting digits in grouped form did not erase the group differences, indicating that inducing poor readers to use the strategy of chunking was not of much help. Thus, it appears that differences neither in the rehearsal nor in the use of strategies may be able to explain the differences seen between good and poor readers.

Using a somewhat different procedure, Cohen and Netley (1981) administered digit-span tests to children of differing reading skill and required them to recall aurally presented digits from a list whose length was not known to the children. In spite of the lack of knowledge of list length, differences between good readers and poor readers were obtained. The investigators argued that since the subjects did not know when the digit presentation would end, they could not have known when to start and stop rehearsing. Consequently, the difference seen in the recall of good and poor readers could not be attributed to rehearsal strategy. After reviewing the topic of memory span, Dempster (1981) also concluded that individual differences in memory span are largely due to faster item identification rather than to the use of strategies such as rehearsal and chunking.

In summary, some studies have found poor readers to be deficient in the use of strategies believed to be components of working-memory whereas others have failed to find such deficits. This statement is particularly true of the rehearsal strategy. It is quite possible, this lack of consensus among experimental studies may be due to the fact that poor phonological ability may be the source of working-memory deficits and efforts to manipulate memory strategies alone may not affect phonological processes uniformly in all subjects.

2.2.1.3. *Speed of retrieval.* Since reading is a cognitive operation that is carried out extremely rapidly, it is reasonable to expect an inability to retrieve the necessary information rapidly and accurately will affect reading. The speed with which readers can retrieve information has been studied by presenting stimuli such as words and pictures and asking them to name them as quickly as they can. Some investigators have used a series of stimuli that are to be named in rapid succession. Using this procedure, several investigators have reported that poor readers are slower than good readers in reporting the names of pictures, colors, and digits (Spring and Capps, 1974; Spring, 1976). Denckla and Rudel (1976a) consider a longer than usual latency of response as a form of subtle dysnomia or naming disorder. In one study, Denckla and Rudel (1976b) administered the "rapid automatized naming test" which required the subject to name, as rapidly as possible, a series of stimuli such as colors, numbers, lower-case letters, and pictures of objects. The subjects were groups of 7- to 13-year-old dyslexic children and normal readers. A third group of children who were considered learning disabled but not reading disabled was also studied. The investigators found that although the groups did not differ in the number of items recalled, the dyslexics took longer to respond to the stimuli than did the other two groups. Other studies, however, have produced less clear-cut results. A recent study by Wolf and Goodglass (1986) observed a group of 89 kindergarten children for three years. The children were within the average range of intelligence as determined by their performance on the Peabody Picture Vocabulary Test and by teachers' judgments. These children were administered the Boston Naming Test in which 85 line drawings are shown one at a time and the child is asked to name them. They were also administered the rapid automatized naming test described earlier. When the children reached the second grade, they were given a standardized reading test and, on the basis of the test results, 14 of them were classified as reading impaired. It was found that the poor readers had correctly named significantly fewer pictures than had normal readers. Many of the poor readers had also been slower in responding. However, there were some poor readers who were fast or faster than average readers in naming continuously presented colors and objects. The investigators concluded that "an underlying general rate or access speed disorder can neither explain all dyslexics' retrieval problems nor be eliminated as an explanation for some" (p. 165). In this study, poor vocabulary can be ruled out as a causal factor since the poor readers' receptive vocabulary, as determined by the Peabody Picture Vocabulary Test, was equal to that of the normal readers. While this study suggests that slow retrieval of names may contribute to the reading problems of some dyslexics, it can by no means be considered a universal defect.

Stanovich (1986a) has observed that a good deal of caution has to be exercised in interpreting results of research where name retrieval speed is studied as a dependent variable. Specifically, he points out that significant differences in reading speed are obtained only when subjects with extreme reading disability are studied. The type of test used also may have an influence on the findings since tasks that require continuous serial naming of a list of items yield greater differences between reader groups than do tasks that require the naming of isolated words. Finally, the speed of retrieval is not exempt from the perennial problem of cause—effect relationship in the sense that reading speed differences may be the product of poor reading habits and not vice versa.

In summary, the speed with which verbal labels are retrieved may depend upon several factors including the type of stimulus, previous experience, and the nature of reading disability. Furthermore, as pointed out earlier, developmental dyslexia is not simply being slow in reading or at executing linguistic operations; dyslexic readers commit reading and spelling errors even when they are under no time pressure and when the speed with which information is retrieved is unimportant. Given that there are individual differences in the speed with which verbal labels are retrieved, such differences may not be exclusively due to some defect at the working-memory level, but could be ascribed to differences in the organization of the phonological lexicon in long-term memory. In fact, phonological coding may be the common denominator of working-memory capacity, the speed of its operation, and the strategies used.

2.2.1.4. *Phonological coding.* So far we have discussed the reading process and its relationship to working-memory capacity, its strategies, and the speed of information retrieval. While there is evidence that each of these is associated with developmental dyslexia, there are also instances where such a relationship is not obvious. It may be that these factors are associated with developmental dyslexia but caution has to be exercised in ascribing causal status to them. In contrast to this situation of uncertainty, studies that have explored the relationship between phonological coding and specific reading disability show an impressive degree of agreement in their findings. Jorm (1983a), who has reviewed related literature, concludes that "the notion of a phonological coding deficit in retarded readers seems to be fairly consistently supported by the literature" (p. 334).

Researchers have investigated the relationship between phonological recoding skill and reading disability by using several experimental procedures. Results of three such experimental procedures are presented in this section. The general design of these experimental procedures includes: (a) requiring the subject to read aloud pronounceable nonwords, (b) requiring subjects to memorize a list of similar-sounding words and study the effect of phonological confusion in the recall, and (c) requiring readers to make certain pronunciation-based judgments about visually presented words.

A simple and straightforward procedure involves assessing the ability of the subject to read aloud pronounceable nonwords. Since pronounceable nonwords cannot be read easily without successfully applying the grapheme—phoneme-conversion rules, poor performance in this task provides a relatively pure measure of the phonological decoding skill of the reader. The ability to sound out nonwords is thought to be such an important component of reading skill that it is incorporated in many standardized tests of reading.

Almost all the studies that have assessed the decoding ability of dyslexic subjects by using pronounceable nonwords show that dyslexic readers are weak in this skill (see, for example, Firth, 1972; Jorm, 1981; Aaron and Phillips, 1986). The possibility that problems of pronunciation originate at the phonological coding stage of working-memory and not at the articulatory output stage is demonstrated by a study in which children had to select between alternate pronunciations that matched printed nonwords by putting a mark against their choice (Snowling, 1980). It was found that dyslexic children were poor in the matching task when compared with normal readers. The phonological coding disability is not limited to children but tends to persist through adolescence. Aaron *et al.* (1985) tested five dyslexic college students and a group of normal readers. Four different kinds of verbal stimuli were presented with the aid of a projection tachistoscope for a period of 500 milliseconds. The four categories of stimuli were three-letter content words, function words, three-letter pronounceable nonwords (e.g., *CVC*), and three-letter nonpronounceable nonwords (e.g., *CCC*). Each test slide contained four stimuli of the same category and in each category, there were 20 slides. Data obtained showed that dyslexic students recalled significantly fewer pronounceable nonwords and function words than did normal readers. Even though the dyslexic subjects recalled fewer concrete words than the normal readers did, the difference did not reach significance. As far as the *CCC* stimuli were concerned, there was little difference between the two groups. It was concluded that pronounceability and meaningfulness of the stimuli had strong influence on the ability to recall verbal stimuli and that the ability to pronounce letter strings was the skill that separated good readers from dyslexic subjects.

The second method that is used to study the relationship between phonology and reading disability is to present phonologically similar words and note the effect of phonological confusability on recall. Since working-memory is thought to depend on phonological coding for organizing input information into chunks and retaining them through rehearsal, good readers are thought to make optimal use of phonological coding. If this is the case, good readers would be expected to be more susceptible to confusion than poor readers when asked to memorize similar sounding words. This confusion will adversely affect the recall of good readers. Since dyslexic readers are thought not to rely much on phonology, they are not likely to be affected by similar sounding words to the same extent that good readers are. Many studies show this to be the case.

A study by Liberman *et al.* (1977) required superior and inferior readers from grade 3 to write down, from memory, arrays of rhyming and nonrhyming strings of letters visually presented for a period of three seconds. The children reproduced the stimuli they had seen either immediately after the presentation or after a delay of 15 seconds. It was found that good readers recalled more letters than poor readers from nonrhyming lists but their performance declined sharply when they had to recall confusable items. In contrast, phonological confusability did not have such a marked effect on the performance of poor readers. This differential effect was more pronounced in the delayed-recall condition. One of the interpretations of these results was that poor readers rely less on phonological codes for processing information.

Similar results are reported for orally presented words also. Byrne and Shea (1979) presented a series of words to second-grade children and required them to indicate whether the word had been previously presented. Some of the test stimuli were phonologically similar to the target words, while some were semantically similar. Good readers erroneously identified a significantly larger number of similar-sounding words than did poor readers. In contrast, poor readers made more errors than did good readers by wrongly identifying words with similar meanings, even though the difference was not statistically significant. These results were interpreted to indicate that poor readers do not make optimal use of the phonological code, particularly when the sound code was in competition with meaning. The phonological-confusion-effect difference between good and poor readers has been shown to be true at the sentence level also (Mann *et al.*, 1980).

The third experimental technique used to study the phonological process in reading requires the subject to match visually presented letter strings with some other standard stimuli. Because accurate matching of the two stimuli can be accomplished only on the basis of their pronunciation, this task indirectly assesses the phonological skill of the subject. There are several variations of this technique. The study by Olson (1985) described in Chapter 2 tested the ability of dyslexic children to generate phonological codes with the aid of the matching technique. In this study, normal and reading-disabled children were given a phonetic coding task and an orthographic coding task. In the phonetic coding task, subjects were asked to indicate, by pressing a button, which of the two visually presented letter strings sounded like a real word (*kake* — *dake*); in the orthographic coding task, they were asked to decide which of the two visually presented letter strings was a real word (*rain* — *rane*). The dyslexic readers were found to be inferior to normal readers in the phonetic coding task but not in the orthographic decision task. Since the phonetic coding task (*kake* — *dake*) requires the generation of the phonological code and cannot be solved by visual comparison, it was decided that dyslexic subjects were poor in phonological coding skills.

The possibility that working-memory deficit seen in dyslexic readers may not be caused by capacity limitations but may be related to poor phonological coding ability is supported by a study (Snowling, 1980) which utilized a modified form of the matching technique. In this study, a group of 36 normal readers and a group of 18 children diagnosed as dyslexic were compared. The stimuli used were four-letter pronounceable nonwords whose middle two letters, when transposed, would still create pronounceable nonwords (e.g., *sond* — *snod*; *dron* — *dorn*). In this experiment, a nonword was presented and was followed by another nonword which could be the same as the target word or a nonword with the middle two letters transposed. Thus the target string *snod* would be followed either by *sond* or *snod*. The child was required to indicate by putting a check mark if the target and test stimuli were the same or a plus sign if the two stimuli were different. Four different conditions of presentation were used: both target and test words presented visually ($V - V$), both presented auditorilly ($A - A$), or the target was presented in one modality and tested in another modality ($V - A$; $A - V$). Snowling found that the dyslexic children differed significantly from the control group only in the visual presentation—auditory testing condition ($V - A$). She concluded that the $V - A$ condition closely resembled real reading and that normal readers might have phonologically coded the visual stimulus into an auditory form quite readily whereas the dyslexic readers could not do so.

2.2.2. *Conclusions*

In summary, studies discussed in Chapter 3 as well as those described in Chapter 2 (e.g., Curtis, 1980; Frederiksen, 1981; Perfetti and Hogaboam, 1975) indicate that dyslexic readers have poor phonological coding skills. Recently, Seymour (1986) studied 21 "dyslexic" subjects by administering a number of cognitive tasks and he concluded that "all of the subjects in the dyslexic sample gave some evidence of phonological dyslexia defined in terms of inaccuracy or reaction time delays in reading nonwords" (p. 246). In fact, almost all the studies that have investigated the phonological aspect of developmental dyslexia concur on this point. This author is not aware of any study which has found dyslexics to have adequate decoding ability. The only exception may be cases of the so-called surface dyslexia, considered by some to be a form of developmental dyslexia (Coltheart *et al.*, 1983), of which very few cases have been reported. The status of surface dyslexia, as a form of reading disability, is uncertain and, as a matter of fact, many researchers consider surface dyslexia not to be a subtype but to represent a substage in reading acquisition (for example, Bryant and Impey, 1986; Olson and Wise, cited in Coltheart, 1987). We can conclude this section by noting that there is consensus among studies that dyslexic readers experience serious problems at the word-recognition stage and that this difficulty is associated with deficits in phonological coding.

2.3. *Reading Comprehension Beyond Word Level*

It is reasonable to expect anyone who has difficulty in recognizing the written word to have difficulty in understanding the written sentence. In order to conclude that, in addition to word-recognition problems, the dyslexic reader has difficulty in comprehending sentences, it becomes necessary to partial out the difficulties encountered in word recognition and examine those processes that are unique to comprehension. A majority of studies that report comprehension deficits in dyslexic readers can be faulted because they have failed to isolate true comprehension deficit from decoding deficits that originate at the word-recognition level. Since this is a rather difficult task to accomplish, very few studies have addressed the issue of comprehension directly. A good proportion of information available in this regard comes as a "spin-off" from studies that have explored other aspects of reading. In addition to decoding problems, the syntactical complexity of the sentence is yet another confounding factor that can affect comprehension of sentences. The observation that sentences which are syntactically more complex take longer to process than do sentences of similar length but less complexity shows that the syntactic structure of a sentence is an important variable that can affect comprehension. The situation is further complicated by the possibility that phonological and syntactic aspects of language are closely intertwined. Neuropsychological studies of aphasic and alexic patients show that syntax is closely related to phonology and is relatively independent of comprehension. The close relationship between phonology and syntax is apparent in the pattern of language breakdown seen in neurological patients with Broca's aphasia. Bradley *et al.* (1980) have shown that language faculty is decomposable into a complex of subsystems and that sentence form (based on phonology and syntax) is relatively independent of sentence meaning which is based on lexical elements. Coslet *et al.* (1985) have provided neuropsychological evidence which shows that the phonological and semantic systems involved in reading are functionally independent. Kean (1977) has argued that deficits of grammar seen in Broca's aphasia can be traced to deficits in phonology since grammatical morphemes, lacking in meaning, depend on phonology for processing. This view receives support from the observation that patients who have difficulty in reading grammatical morphemes also have difficulty in assembling phonology, that is, they are poor in reading nonwords and in spelling (Patterson, 1982; Langmore and Canter, 1983). Chomsky and Halle (1968) have expressed this relationship in the following psycholinguistic terms. According to them, in spoken language, "the syntactic component of the grammar generates surface structure which is converted by readjustment rules that mark phonological phrases . . . to a still more superficial structure. The latter then enters the phonological component of the grammar" (p. 10). In receptive language, the process is likely to be reversed. The postulated intimate relationship between syntax and phonology is also congruent with the belief that syntactic organization and phonological function are automatized aspects of language processing whereas lexical production and comprehension are voluntary and propositional and, therefore, involve the conscious use of language mechanisms (see, for example, Fromkin, 1971). For this reason, an individual with poor phonological and syntactic skills need not necessarily have deficits of similar magnitude in comprehension. In the following sections, syntactical and comprehension abilities of the dyslexic reader are discussed separately.

2.3.1. *Syntactical Ability of the Dyslexic Reader*

Even though several studies have reported an association between poor reading performance and poor syntactical skills, many of these findings may not be applicable to dyslexic readers because of laxity in subject selection. One of the earliest studies of syntactic structures involving children with learning disabilities was carried out by Semel and Wiig (1975). The study found that the 34 learning-disabled children investigated obtained scores lower than the controls on the receptive part of the Northwestern Syntax Screening Test (Lee, 1969). Since the IQ of some of the learning-disabled children in this study was below the average range, not all the children studied by Semel and Wiig could be considered dyslexic. The standard deviation of the scores of the poor readers in this study was almost five times higher than that of the normal readers indicating the heterogeneous nature of the poor reader group. A study by Newcomer and Magee (1977) also examined the syntactic skills of reading-disabled children. As in many other studies, the intellectual ability of the reading-disabled children varied widely with IQs ranging from 85 to 125. The authors concluded that although the mean scores of the reading-disabled children on tests of spoken language fell within the normal range, a significant proportion of them scored below the normal mean.

Even when rigid selection criteria are not insisted upon, unequivocal evidence for syntactical deficits in poor readers has not been obtained. Vogel (1985) assessed various aspects of linguistic abilities of 20 "dyslexic" and 20 normal readers. She found that dyslexic children were significantly inferior to normal readers in discriminating between declarative and interrogative sentences, repeating orally presented sentences, and inflecting nonwords that were embedded in sentences. The two groups, however, did not differ from each other in their ability to identify grammatically correct and incorrect sentences or in their comprehension of syntax as measured by the Northwestern Syntax Screening Test. A recent study by Mann (1984a) which tested the syntactic skills of children by requiring them to enact the meaning of active and passive sentences by manipulating toys failed to find significant differences between average and poor first-grade readers. While it is not unreasonable to expect subjects with poor syntactic skills to be poor readers, such a finding does not warrant that the reverse condition is true.

In recent years, investigators have used more refined measures of language. One of these is Developmental Sentence Analysis (DSA; Lee, 1974) in which the different categories of grammatic morphemes (such as pronoun, verb, and conjunction) found in a corpus of the subject's spontaneous utterance are counted and scored. Another index that has been used to assess the syntactical complexity of a sentence is the T-unit which is defined as one main clause plus any subordinate clause or nonclausal structure that is attached to or embedded in it (Hunt, 1970). A computer program that combines some of the features of the DSA and the T-unit is called Syntactic Density Scoring (SDS; Golub and Kidder, 1974). Belanger (1978) has introduced a mathematical correction to the SDS to overcome some of its drawbacks (CSDS). Using CSDS, Simms and Crump (1983) analyzed the oral language of learning-disabled and normal children whose ages ranged from 9 through 15 years. They found that learning-disabled children produced significantly more T-units than did control subjects even though the T-units produced by poor readers were shorter than those of the controls. The differences in length, however, were not statistically significant. It should also be noted at this point that in language assessment, there has recently been a shift away from an over-emphasis of psychometric data and normative tests which are considered measures of superficial aspects of language to the utilization of ecologically valid approaches which take into account pragmatic features such as speech acts and intents, semantic functions and relations, anaphoric reference and adjusted messages, and role taking (Muma *et al.*, 1982).

Studies that have assessed the syntactic ability of mature dyslexic readers by evaluating their oral language also have produced inconclusive results. Kean (1984) investigated six adult dyslexic subjects and compared their performance in a sentence judgment task with that of groups of college students, adult volunteers, 10- and 11-year-old children, and adults who had developmental neurological disorders such as hydrocephalous and seizures. The subjects were required to judge whether a sentence they had heard was "good" or "bad" and also to answer a probe question (e.g., 'Sally promised Mary to do the dishes, and she did them.' Question: Who did the dishes?). A total of 75 sentences which reflected 16 aspects of sentence structure (such as conjunction, pronoun, and prepositions) was used. Kean found that the performance of one dyslexic subject was the worst among the five groups studied and resembled that of the neurological patients. For the various sentence types considered, the performance of the five remaining dyslexic subjects was similar to that of the adult control populations with the exception of those sentences which tested knowledge of noun—pronoun referential relations. The study by Aaron *et al.* (1985) described earlier compared the performance of five dyslexic college students with that of five matched normal readers on various aspects of syntactic ability. The syntactic skill of the dyslexic readers was assessed by using four different tasks. One task required the subjects to judge whether a list of sentences was grammatically correct or incorrect. The list contained 12 sentences, half of which were grammatically incorrect. The second task required subjects to listen to 20 sentences and answer a probe question on each. The sentences were similar to the ones used by C. Chomsky (1969) and Cromer (1970) and were used to test subjects' knowledge of morphemes such as *ask, tell, wondered, promised, easy to see* (e.g., 'The fish in muddy water are not easy to see.' Question: Who does the seeing?). The third task required the subjects to make up oral stories as responses to two pictures from the Stanford-Binet Intelligence Test. The stories were evaluated for mean number of words per sentence, embedded clauses, and grammatical errors. The stories were also evaluated for their grammatical complexity with the aid of Developmental Sentence Analysis (Lee, 1974). The fourth task was a modified version of the shadowing technique and was used to assess the subjects' ability to generate syntactic elements. Shadowing is an experimental procedure wherein the subject is asked to repeat a sentence as he hears it. A delay of about 250 milliseconds is usually introduced between stimulus onset and subjects' initiation of response. The continuous and relentless input of the stimulus allows little time for the subject to indulge in deliberate correction of errors should they be present in the input message. Consequently, any change introduced by the subject in his reponse is made without any conscious effort. In this study, the subject was asked to start repeating the sentence which he heard through headphones as soon as he saw a flash of light on the screen in front of him. There was a delay of 500 milliseconds between the onset of the auditory input and the visual signal. The auditory input consisted of 50 sentences in which syntactic or semantic errors were present. There were two types of syntactic errors, one involving bound morphemes and the other free grammatical morphemes (e.g., 'The map is avail*ed* in London's many souvenir shop;' 'At sixty cents, the information *which* reasonable'). The stimulus sentences were taped at normal reading speed and the subject's responses were taped and later analyzed for the number of errors that had been corrected as well as for the number of morphemes omitted. In both tests of knowledge of syntax, the groups did not differ significantly from each other. The two groups also did not differ from each other in the mean length of sentences or in their Developmental Sentence Scores. The shadowing test also failed to find statistically significant differences between the two groups in their ability to generate syntactically appropriate morphemes. These findings showed that if these dyslexic subjects had had syntactical deficit during their early years, they had outgrown it.

Occasionally, researchers have examined the language ability of adolescent poor readers by analyzing their written language. It has to be remembered that dyslexic children find the production of correct spelling, as compared to speaking, a resource-demanding operation which interferes with the operation of the working-memory. Consequently, errors of syntax seen in the written language of dyslexic readers could be the result of deficient phonological processes rather than poor syntactical skills. Ganschow (1984) analyzed the writing samples of a dyslexic college student with an IQ score at superior range and found that the subject could produce syntactically complex structures comparable to those of nondyslexic writers. The dyslexic student, however, committed spelling errors and produced grammatical errors by making inappropriate use of determiners, conjunctions, and prepositions. Vogel (1985) compared the written expository essays of 33 learning-disabled college students with those written by normal college students. The learning-disabled group had a mean IQ score of about 100. She found that the two groups did not differ from each other in the overall Corrected Syntactic Density Scores (CSDS) even though the disabled readers did poorly on measures of main clause word length and the number of subordinate clauses per T-unit. There were no differences between the two groups in the seven remaining variables that contribute to the CSD scores. Vogel also cautioned that the differences obtained between the two groups could have been due to the subnormal spelling proficiency of the poor readers which could have affected written language fluency.

To sum up, research evidence that implicates poor syntactic skill as an etiological factor in developmental dyslexia is equivocal. After examining this issue, Mann (1986) concludes that "research . . . does not suggest that poor readers have any difficulty with syntactic structure above and beyond the difficulties brought about by their memory constraint" (p. 146). The studies discussed in this section indicate that intersubject variability as well as developmental factors also confound experimental results. In addition, syntactic deficits reported in studies that have used complex tests (such as the Token Test; Noll, 1970) may be due to the heavy demands placed on the memory system of the dyslexic reader and, therefore, are not easy to interpret. Furthermore, clinical observations also show that the oral language of the dyslexic individual is clearly superior to his written language. All these observations suggest that dyslexic readers may not have poor syntactic skills per se but the reported deficits may be the byproduct of poor phonological skills and associated working-memory deficits. A striking illustration of the difference between oral and written language of a dyslexic subject is shown in Figure 3.1.

Fig. 3.1.
Written oral and language output by a dyslexic subject

I like Car

I like all Kinds of Car, I like Corvair because of a rear engen in then and to they are air cooled. They are good on gae and fun to work on. They are a flat 6 with 2 Carbe and fun to drive, I know because i have 3 Corarair and i think They are a good Car.

Grandma was sitting in her rocking chair, while the children snuggled on the floor.
As grandma tells her story and uses her hands to describe it, she does not notice that in the kitchen the steam pot is boiling with the water in it, and it looks like her potatoes have boiled over onto the fire and there's the big smoke and steam in the air.
Yet grandma was blind sort of, so she can't see and the kids are so enthused about her story that they're not paying attention, and grandma keeps telling the story for two minutes.
As the story goes on, the kids are still not noticing that the fire the house is huh, huh. . .smokey filled with smoke, and it looks like a common kitchen, with a gas stove. And the story is finished and grandma notices the house is full of smoke and steam and then she goes over and takes the stuff off the stove and cleans the mess up.

2.3.2. *Semantic Ability of the Dyslexic Reader*

In Chapter 2, it was seen that reading comprehension and listening comprehension are very closely related to each other and that many studies have found poor readers to be poor in listening comprehension. A majority of poor readers investigated in these studies cannot, however, be considered dyslexic since they had IQs below average. Very few studies which have clearly delineated their population by adhering strictly to the definition of dyslexia report unequivocally that dyslexic readers have deficits in language comprehension. True, in tests of reading which assess comprehension, dyslexic readers perform poorly, but this may be due to their deficits in word-recognition skill, and not due to their comprehension. The poor comprehension scores obtained by dyslexic subjects in timed reading tests may be due to poor decoding skill which can act as a rate-limiting factor and thus depress reading speed. The low comprehension scores obtained in timed tests may, therefore, be due to slow rate of reading rather than poor comprehension. This view is supported by the observation that the level of reading comprehension of many dyslexic readers tends to be above their level of reading speed (Aaron, 1985).

Researchers have used two techniques to minimize the confounding effects associated with word recognition in studies of reading comprehension. One technique is on-line monitoring of comprehension which evaluates the subject's comprehension as he reads; the other involves completely eliminating the visual word-recognition requirement by administering tests of listening comprehension. A frequently used on-line comprehension monitoring technique is the Cloze test which requires the reader to supply words that have been systematically deleted from the text. A modified version of this test is the Maze Cloze test which requires the reader to choose the correct word from a choice of words as he reads a sentence. The on-line comprehension monitoring tests usually employ words familiar to the subject and allow ample time for reading. By doing so, it is believed that the demands of decoding are minimized.

Siegel and Ryan (1984) investigated various aspects of reading in 58 reading-disabled and 137 normally achieving children, 7 to 14 years of age. Among the many tests administered were a Cloze test and a sentence repetition task. The investigators found that the reading-disabled children experienced no more difficulty than the control group in supplying the missing nouns, but experienced significant difficulty in inserting function words. In the sentence repetition task, reading-disabled children of all ages had difficulty in repeating, verbatim, sentences with complex structures (e.g., 'The bird that the cat sees is in the tree'). Even though making sentences complex changes the sentence structure, it does not alter the meaning of the sentence. For example, the meaning of the above sentence can be expressed in the form of a simpler sentence: "The cat sees the bird in the tree." It was concluded that in spite of short-term memory, decoding, and syntactic deficits, the reading-disabled group was able to perceive and generate meaning in spoken and written language.

Frith and Snowling (1983) compared the performance of eight dyslexic children on a Maze Cloze test with that of eight autistic children and ten reading-age-matched normal readers. These children were tested for their ability to select the semantically appropriate word from a choice of three words. It was found that normal and dyslexic groups performed equally well in this test but the autistic children were significantly inferior. These investigators also tested the children's semantic competency by requiring them to read sentences which contained homographic words with different pronunciations (e.g., 'He had a pink *bow*' vs. 'He made a deep *bow*'). In this test, the dyslexic children showed the best performance and austistic children the worst. The differences among the groups were statistically significant. The dyslexic children, however, did poorly on many tasks that assessed their phonological skills. Frith and Snowling concluded that these results were "evidence for an occasionally voiced but hitherto speculative notion that dyslexic children have intact comprehension despite word decoding problems" (p. 339).

An analysis of acoustic parameters of speech prosody was used to test the on-line comprehension monitoring in five dyslexic college students (Aaron *et al.*, 1985). Prosody is measured in terms of suprasegmental features such as stress, pause, and the duration it takes to utter a syllable. Cooper and Cooper (1980) have shown that the speaker's acoustic output is influenced by the nature of the syntactic code and, ultimately, the semantic factor. Consider the following example provided by Cooper and Cooper (p. 7).

(a) When John leaves Kathy will be upset.

(b) When John leaves Kathy we'll be upset.

When adult subjects were asked to read these sentences, Cooper and Cooper found that the word *leaves* in (a) and the word *Kathy* in (b) were lengthened. A difference in stress was also observed, the readers placing more stress on the word *Kathy* in (a) than on the same word in (b). It is quite likely that a reader who has not understood the difference in the meaning of these two sentences will place similar stress and assign similar duration to these words in both sentences. It is, therefore, possible to make inferences regarding the semantic and syntactic capabilities of the reader by measuring suprasegmental features of oral reading.

The five dyslexic college students were tested for their ability to process semantic aspects of sentences by analyzing these suprasegmental features of their oral reading. Ten pairs of sentence complexes were used for this purpose. Within each pair of sentence complexes, there was a lead sentence followed by a tag sentence. The lead sentences within a pair differed from each other in meaning and thus provided the disambiguating context for the tag sentences, which were identical. The following is an example of a single pair of sentence complexes used in the study.

(a) Jane's parents were poor. They always fed her dog biscuits.

(b) Mary's parents were rich. They always fed her dog biscuits.

The subjects were asked to read each pair of sentences, first silently and then aloud. There was no time restriction. The oral reading was taped and then analyzed for stress and duration. Analysis of results showed that the two groups did not differ from each other on the parameters of stress and duration. These results were interpreted as evidence that these dyslexic subjects were able to recover deep structure of sentences from the surface structure as well as normal readers could. In other words, the dyslexic readers were not inferior to normal readers in this test of reading comprehension.

2.3.3. *Studies of Listening Comprehension*

It was seen in Chapter 2 that beyond the modality of input, listening comprehension and reading comprehension may represent a single operation and that listening comprehension can be used as an estimate of reading comprehension. Because the confounding effects of decoding are removed, tests of listening comprehension provide a relatively pure measure of comprehension. In a study conducted by the author, the listening comprehension of twelve dyslexic children was assessed. Eight of these twelve children were part of a larger group who had been referred to the Porter School Psychology Clinic for their reading problems. The remaining four children were from groups of children identified as reading disabled by teachers from two different school systems. These twelve children were identified as dyslexic because their IQ scores were within the normal range but their reading achievement, as measured by standardized tests, was at least one year below their grade placement. The twelve children were tested for reading comprehension and listening comprehension. Reading comprehension was assessed by administering Form A of the Passage comprehension subtest of the Woodcock Reading Mastery Tests. Listening comprehension was assessed by converting the Passage comprehension subtest (Form B) of the Woodcock Reading Mastery Tests into a listening test and then reading it to the child. These comprehension tests are in a Cloze format and require the child to supply the missing word. Results of these tests are shown in Table 3.1. It can be seen that dyslexic children's listening comprehension scores are close to or above grade level and well above their reading achievement. Listening comprehension is also better than reading comprehension even though the reading comprehension of some children is better than their overall reading achievement. This is because, given sufficient time, many dyslexic readers are able to "figure out" the meaning of most sentences. Many standardized tests of reading achievement do not allow this luxury. In addition, being composite tests, they also include nonword reading which is intended to assess the word attack skills of the child. Data obtained from the above study suggest that the depressed reading performance of dyslexic readers is due to difficulties associated with the processing of the phonological features of the language and not due to difficulties in processing its semantic aspects. More specifically, the reading comprehension deficit is specific and limited to written language.

In conclusion, studies that have used divergent techniques have failed to uncover significant comprehension deficits in dyslexic readers when phonological and syntactical factors are controlled. These findings suggest that the frequently reported reading comprehension deficit seen in dyslexic subjects may not be a fundamental defect in itself but may be the consequence of poor working-memory or deficient phonological skills. The observation that some dyslexics can be extremely poor in phonological skills but can have IQs as high as 120 and the fact that it is possible to select groups of dyslexic children who have average or above average scores on tests of listening comprehension and vocabulary indicate that poor reading comprehension of the dyslexic subject may be a secondary and not a primary problem.

Research studies presented in this chapter do not indicate that dyslexic readers have deficits in visual processes. A majority of the studies presented in this chapter are in general agreement that word-recognition difficulties experienced by dyslexic readers are associated with deficits of the phonological processes. The phonological deficit may act as a limiting factor and affect reading speed; it may also affect syntactic and comprehension skills indirectly by affecting working-memory. Studies also have demonstrated that under certain circumstances, the dyslexic subjects' reading comprehension as well as their listening comprehension can be normal. For these reasons, it can be argued that poor phonological skill and no other aspect of language is responsible for the reading difficulties of the dyslexic individual. In this

TABLE 3.1.

Performance of dyslexic children on tests of reading and listening comprehension

Subjects	Grade	IQ[a]	Reading[b] achievement	Comprehension (Woodcock passage)		Grade norms of listening comprehension		No of Ss norms are based on
				Reading	Listening	mean	S.D.	
M.J.	4.6	94	2.6	2.6	4.2	4.5	1.3	26
B.K.	4.6	104	3.5	3.6	5.4			
S.A.	4.6	110	2.5	4.9	5.5			
J.B.	4.6	110	2.4	3.9	4.8			
J.B.	4.6	98	2.4	4.1	5.0			
T.S.	4.6	93	3.0	4.0	4.5			
C.G.	5.6	115	3.5	4.0	5.9	5.8	1.2	14
S.H.	5.6	120	4.6	5.9	8.1			
M.L.	6.6	92	4.6	4.7	6.6	6.2	1.6	15
R.C.	7.6	108	6.2	5.7	7.2	5.9	1.5	18
R.G.	8.0	102	4.0	4.0	7.8	6.7	2.4	13
K.C.	9.3	119	6.0	6.2	9.2	9.3	2.0	11

[a] WISC-R, Full-scale IQ.

[b] Reading achievement and listening comprehension scores are in grade equivalents. Reading achievement is based on performance in different standardized tests.

book, this view will be referred to as the *phonology deficit hypothesis* of the etiology of developmental dyslexia. If this hypothesis is valid, then a clear knowledge of the nature of phonological skill and its role in reading will be helpful in understanding developmental dyslexia.

2.4. *Etiology of Developmental Dyslexia*

2.4.1. *Phonological Deficit*

Studies presented in the previous section indicate that developmental dyslexia is not caused by visual processing deficits, but that it is linked to phonological deficits. Since phonology is a feature that is shared by written and spoken languages, it would be logical to expect phonological deficit to affect not only the processing of written language but also aspects of spoken language. Available research supports the expectation that dyslexic readers are poor in processing phonological aspects of both visually and auditorilly presented words. Over 25 years ago, Wepman (1961) proposed that reading disability could be associated with poor *phoneme discrimination* skill. Even though Wepman's hypothesis has received some support, many studies have failed to find a positive relationship between auditory discrimination and reading ability (Atchison and Canter, 1979). In contrast, several studies indicate that dyslexic readers are poor in *phoneme analysis* skills.[2] The reason for this discrepancy appears to be due to the fact that phoneme discrimination and phoneme analysis are different skills (Wallach *et al.*, 1977). For instance, distinguishing between the two phonemes such as /k/ and /r/ (as in *cat* and *rat*) is a skill different from the ability to segment the /k/ sound in *cat* and the /r/ sound in *rat*. The former involves a comparison of phonemes, whereas the latter involves analysis and isolation of phonemes. Recent studies indicate that dyslexic readers are deficient in phoneme analysis skill even though they may be able to successfully discriminate phonemes (Brady, 1986; Snowling *et al.*, 1986). Because decoding of the written word is crucially dependent on phonological analysis and because this skill is a good predictor of reading achievement in early grades, a discussion of the relationship between phonological aspects of written and spoken language is presented.

Snowling *et al.* (1986) administered lists of high- and low-frequency words and nonwords to one group of 10-year-old dyslexic children and two groups of normal readers matched with dyslexic children for chronological age and reading age. The words were spoken to the children under three background conditions — no background noise, low noise, and high noise — and the children were required to repeat what they had heard. It was found that dyslexic readers could repeat high-frequency words as well as age-matched controls could, regardless of noise level. The dyslexic children, however, made more errors than age-matched controls when they were required to repeat low-frequency words and nonwords even under the no-noise condition. When compared to reading-age matched controls, dyslexic children were found to do poorly in repeating nonwords only. Snowling *et al.* explained the results by postulating two mechanisms for the repetition of the spoken word: recognizing the word first and then retrieving its pronunciation stored in the phonological lexicon; and assembling the articulatory output by subjecting the input to a phonemic analysis. As seen in Chapter 2, these two mechanisms are referred to as "addressed phonology" and "assembled phonology," respectively. Because dyslexic subjects are deficient in phonological analysis, they have difficulty in assembling the pronunciation of low-frequency words and nonwords. They do not, however, encounter difficulty in processing familiar words since these words can be recognized, addressed, and reproduced without assembling the pronunciation.

On the basis of the findings of a series of studies, Brady (1986) also reached the conclusion that dyslexic readers have a generalized difficulty in the use of phonology, independent of input modality. In one study by Brady *et al.* (cited in Brady, 1986), good and poor readers from third grade were presented auditorilly monosyllabic and multisyllabic words and pronounceable nonwords. The children tried to repeat the stimuli and measures of reaction time and accuracy were obtained. It was found that poor readers were significantly less accurate than good readers in reporting multisyllabic words and nonwords but not in reporting monosyllabic words. There was, however, no difference between the two groups on latency of responses. In another study, Brady *et al.* (1983) tested good and poor readers from third grade for their ability to repeat monosyllabic nouns. They were also presented environmental sounds such as the croaking of the frog, and ringing of the bell. The stimuli were presented under two conditions, with or without background noise. Under the no-noise condition, there was no difference between the groups; under the noise condition, however, the groups differed from each other in their ability to repeat nouns but not their ability to repeat environmental sounds. Brady (1986) summarized these findings by stating that the many difficulties seen in poor readers can be parsimoniously explained by deficiencies of the phonological component of language.

These studies show that dyslexic children have difficulty in analyzing phonemes in spoken language but do not have difficulty in recognizing familiar spoken words. Dyslexic readers, therefore, appear to have difficulty in assembling phonology but not in addressing phonology. The reason they do not have listening-comprehension deficit is probably because recognizing the spoken word and understanding it involve addressing the phonology and do not require phoneme analysis. Since perception of the spoken word is not crucially dependent upon an analysis of the constituent phonemes, listening comprehension is not affected in dyslexic readers to the same extent reading comprehension is.

The possibility that phonological processing deficits can affect the recognition of the written word is further supported by developmental studies that have tested phonological awareness and its relationship to reading in young children (Fox and Routh, 1975, 1976, 1980, 1983). In the 1975 study, Fox and Routh asked children aged 3 to 7 years to repeat a sentence, segment each word into syllables, and break the syllables into phonemes. They found that all the children above the age of 4 years could successfully repeat the sentences and segment words into syllables. The ability to segment the syllables into phonemes, however, did not reach a ceiling until the age of 6. For instance, many children could say that the word *cater* has two syllables but could not identify the three phonemes /k/, /æ/, /t/ in the word *cat*. In their 1980 study, Fox and Routh tested first-grade children on the phoneme analysis task and found that children with severe reading disability were significantly worse than good readers in phoneme analysis. These investigators again tested ten poor readers and ten good readers from this group three years later. Even though by now all the poor readers performed at ceiling level on the phoneme segmentation task, eight of the ten children continued to have reading problems. On the basis of these studies, Routh and Fox (1983) concluded that learning to analyze and synthesize spoken language at the level of phonemes is important to the development of proficient reading and spelling skills.

In a similar study, Stanovich *et al.* (1984a) administered ten different phoneme analysis tasks to a group of kindergarten children. The battery included three rhyming tests and seven tests that assessed phoneme analysis skills in a variety of ways. A year later, when the children were in first grade, they were given reading tests. The investigators found that the three rhyming tasks were too easy for the kindergarten children and did not predict reading performance well. The seven phoneme analysis tests, on the other hand, were found to be strong predictors of reading ability. The combined predictive power of the seven phoneme analysis tasks was equal to or better than that of intelligence or reading-readiness tests.

The close relationship between phonological skills of the spoken language and written language raises the question: In what way are deficits in the ability to identify phonemes in spoken language related to difficulties in processing written language?

Psycholinguistic studies show that recognition of the spoken word involves two processess: identification of the critical phonemes of the input and utilization of the listener's stored phonologic and semantic information. As it is in reading, these correspond to the "bottom-up" and "top-down" processes, respectively. Bottom-up process is data driven and makes use of orthographic and phonological features of the language; top-down process is concept driven and utilizes stored knowledge, concepts, and schemata. On the basis of their own research findings and those of others, Marslen-Wilson and Welsh (1978) have proposed that word recognition in continuous speech is the product of an ongoing interaction between the stimulus input and the phonetic, syntactic, and semantic knowledge of the listener. Evidence for the interactive nature of language comprehension comes from experiments which show that the subjects can successfully repeat words after hearing the first two or three phonemes of a multiphonemic word even before they have heard the entire word. Thus, it appears that during listening, a complete analysis of the phonological features of the word is not necessary because the knowledge the listener has about the word is utilized in compensating for the incomplete phonological information. If a representation of the input word does not exist in the mental lexicon of the listener (as in the case of nonwords and unfamiliar words), he will have to depend entirely on phoneme analysis skill for word recognition.

If the listener lacks phoneme analysis skill, recognition and subsequent reproduction of such words will be seriously affected. It was noted earlier in this section that dyslexic readers are poor in repeating orally presented nonwords. Poor phoneme analysis skill can compromise the reading process in a similar way by affecting the identification of the relationship between graphemes and phonemes and the subsequent conversion of the written word into its phonological representation. Thus, difficulties at the phonological level can affect processing of information regardless of the modality of input.

Neuropsychological studies of spoken language suggest that phoneme identification and analysis is a highly automatized, fundamental operation of the linguistic system which is functionally independent of comprehension skill. For this reason, poor phonological ability need not necessarily imply a concomitant poor comprehension ability. The independence of the phonological and semantic systems is demonstrated in an investigation by McCarthy and Warrington (1984). These investigators studied two patients with conduction aphasia and one patient with transcortical aphasia. The two patients with conduction aphasia had relatively well-preserved spontaneous speech but had great difficulty in repeating sentences; the patient with transcortical aphasia had an opposite pattern of deficit, that is, he had severely impaired spontaneous speech but was able to correctly repeat polysyllabic words. Because of this pattern of dissociation, McCarthy and Warrington have proposed that speech production and repetition are mediated by two independent systems — an auditory—phonological transcoding system and a direct semantic—phonological transcoding system — and that for normal speech perception and production, both systems are necessary. According to this model, the auditory—phonological system plays a role in the initial selection of the word and in error monitoring. It may be noted that with its direct semantic route and indirect auditory analysis route, this model closely resembles the one proposed for reading. It is, therefore, reasonable to expect individuals with poor phonological transcoding skills to have difficulties in the phonological processing of nonwords and unfamiliar words in both listening and reading. Because the auditory—phonological system also plays a role in error monitoring, they also may be poor in recognizing their own errors. They may, however, have a tendency to depend more on the intact direct semantic route for processing information. Since the two routes are functionally independent, one can expect two types of individuals with language disorders: those who have a normal ability to comprehend familiar material but have poor phonological skills, and those who have a poor ability to comprehend but normal phonological skills. These two patterns of language disabilities correspond to developmental dyslexia and hyperlexia, respectively.

2.4.2. *The Phonological Deficit Hypothesis*

Taken together, studies which have investigated different aspects of the dyslexic readers' information processing skills show that there is a clear link between phonological ability and reading skill. It is, therefore, proposed that phonological deficit is a major etiological factor of developmental dyslexia. Some important facts have been established about the disorder of developmental dyslexia that must be taken into account by any hypothesis of its etiology. In order to be considered as a viable etiological factor, any hypothesis should be able to provide a parsimonious explanation of *all* the known characteristics of developmental dyslexia. How well does the phonological deficit hypothesis of the etiology of developmental dyslexia fare when compared to the syntactic, semantic, and other deficits proposed as etiological factors of developmental dyslexia?

Research studies and clinical observations indicate that developmental dyslexia is marked by the following characteristics.

(1) Developmental dyslexics have difficulty in both input (reading) and output (spelling) stages.

(2) They are very poor in reading nonwords and low-frequency words but do not appear to have difficulty of similar magnitude in reading familiar and high frequency words.

(3) Dyslexic readers cannot decode successfully a large number of unfamiliar words and nonwords even when they are not under time pressure.

(4) Their oral reading shows the "word class" effect since they tend to omit or misread more function words than concrete words; they also tend to omit or substitute inflectional morphemes.

(5) Their reading comprehension is better than the accuracy of their oral reading.

(6) Their listening comprehension is better than their reading comprehension.

(7) Dyslexic readers have difficulty in analyzing phonemes not only in written language but also in spoken language.

(8) Dyslexic readers have average or superior IQs.

How well does the phonological deficit hypothesis explain the above eight characteristics of developmental dyslexia?

(1) As in reading, spelling also involves two processes: a direct visual process and a phonological assembly process. Incomplete mastery of the GPC rules can, therefore, be expected to affect both reading and spelling.

(2) It was seen in Chapter 2 that the written word can be recognized in at least two ways: by direct semantic access or by indirect phonological conversion. While familiar words can be recognized by utilizing the direct semantic pathway, nonwords and unfamiliar words have to be transformed into phonological representations in order to be recognized. The dyslexic reader, not being deficient in visual processes, is able to recognize familiar words which can be processed as "gestalts" without subjecting them to phonological analysis. He, will, however, have difficulty in recognizing nonwords and unfamiliar words because of his poor phonological skills.

(3) The phonological conversion difficulty experienced by the dyslexic reader is probably not because he cannot retrieve the grapheme—phoneme-conversion rules rapidly but because such rules are not accurately formulated in his lexicon. In other words, the dyslexic reader has not mastered the spelling-pronunciation relational rules. As a result, even when ample time is available, he is not able to pronounce unfamiliar words and nonwords.

(4) The dyslexic reader's tendency to commit a disproportionate amount of errors in reading function words can also be explained in terms of phonological deficiency. Being devoid of meaning, function words cannot be recognized by accessing the semantic lexicon. Consequently, they may have to be recognized by applying GPC rules or by retrieving the pronunciation by addressing the phonological lexicon and then keeping it in working-memory in the form of some acoustic representation. Being poor in phonological skills, dyslexics may "lose" many of these morphemes and commit many errors that lead to the "word class" effect.

(5) It was noted in the early part of this chapter that during word recognition, working-memory could be bypassed and the semantic lexicon accessed directly to realize meanings of words. It appears, therefore, that dyslexic readers are capable of comprehending the general meaning of the written language by directly accessing the semantic lexicon even though they commit many errors in oral reading.

(6) Because reading involves the decoding of unfamiliar and low-frequency words, and listening comprehension does not involve a similar decoding process, the dyslexic reader's listening comprehension is better than his reading comprehension. Being weak in decoding skill, the dyslexic reader must allocate a large amount of attention and other cognitive resources to the task. This interferes with his comprehension. In contrast, spoken language does not require an equivalent amount of phonological processing, since spoken language employs a vocabulary that is less varied than written language, and a vast majority of the words encountered in speech are already known to the listener. The cognitive resources of the dyslexic individual could, therefore, be allocated almost entirely to the extraction of meaning of the spoken sentence.

(7) Current studies show that the phonological difficulty of the dyslexic reader is not limited to grapheme—phoneme conversion alone but goes deeper to the level of phoneme identification. Phoneme analysis is a fundamental skill needed for processing both spoken and written words which cannot be accessed directly for meaning.

(8) It is generally believed that phoneme identification and phonological coding operations become highly automatized in a skilled reader and can be carried out without awareness. These operations, therefore, are not resource demanding. For this reason, phonology related operations can be considered "modular" and independent of resource demanding operations that make up intelligence (G-factor) (Aaron, 1985). Therefore, it is conceivable that a child can have adequate general intelligence but still be deficient in the phonology "module."

The phonology based hypothesis of developmental dyslexia appears to provide the most parsimonious explanation of the etiology of developmental dyslexia. Other hypotheses may be able to explain some but not all of the characteristics of developmental dyslexia.

The phonology deficit hypothesis of the etiology of developmental dyslexia can be successfully used to explain the etiology of specific reading disability with reference to sequential and simultaneous information processing strategies, generally attributed to the left and right cerebral hemispheres, respectively. Das *et al.* (1979), as well as Reynolds (1981) have provided evidence to show that cognitive skill is made up of two strategies: sequential and simultaneous. Developmental dyslexia can be considered as the consequence of poor sequential information processing skill and a compensatory dependency on simultaneous processing skill (Kershner, 1977; Aaron, 1978). Das *et al.* (1979) label these strategies as "successive" and "simultaneous" and believe that both strategies are involved in reading. Leong (1974) studied a group of 58 ten-year-old children with specific reading disability and compared their performance on a number of tests with that of a matched group of normal readers. Factor analysis of the data suggested that retarded readers might not be making good use of sequential strategy. Leong concluded that both successive and simultaneous processing are necessary for competent reading. It was noted in Chapter 1 that similar conclusions were reached by Kirby and Robinson (1987).

The Geschwind—Galaburda hypothesis that an anomalous development of the left cerebral hemisphere and a concomitant compensatory development of the right hemisphere (discussed in Chapter 1) can be accommodated within the sequential—simultaneous imbalance explanation of developmental dyslexia. The phonology deficit hypothesis can also be accommodated within a neuropsychological framework by postulating a left-hemispheric deficit and a compensatory right-hemispheric dependency (Witelson, 1977). Because the right hemisphere appears to be deficient in phonological skills, dependency on the right hemisphere can be expected to lead to reading difficulties associated with phonological processes. Such a neuropsychological hypothesis and the phonology deficit hypothesis of developmental dyslexia are, therefore, not mutually exclusive. In fact, the simultaneous—successive and the right—left cerebral hemisphere explanations of developmental dyslexia are compatible with the phonology deficit hypothesis.

A pilot study provides psychological support to the Geschwind—Galaburda hypothesis. Analysis of the intelligence test scores of eight boys[3] presented in Table 3.1. showed that *all* the eight dyslexic males tested obtained higher than average scores on the Block-design subtest of WISC-R and low scores on the digit-span subtest. The mean scaled score of the eight dyslexic males was 13.8 for Block design whereas it was 7.9 for digit span. There was one pair of MZ twins among the eight dyslexic males and their performance on the subtests was analyzed. Data presented in Table 3.2. show the striking similarity between the two boys' performance. The differences between verbal IQ and performance IQ (40 and 50 points) are incredibly large. Such a big discrepancy usually is interpreted as a sign of left-hemispheric damage.

The fact that both boys show a similar degree of discrepancy renders birth injury an unlikely factor. The influence of prenatal genetic-neurochemical factors is a more likely explanation.

TABLE 3.2.

Performance of MZ twins in various tests

Subject	C.A.	Grade	Reading Achievement	Listening comprehension	Digit span	Block design	VIQ	PIQ	FIQ
J.B.	10.9	4.6	2.4	5.0	9	16	80	120	98
J.B.	10.9	4.6	2.4	4.8	9	19	86	136	110

Non-dyslexic poor readers (who have below-average scores in both reading and listening comprehension) do not show such a discrepant pattern of performance; they are below average *both* in digit-span and Block-design subtests.

3. HYPERLEXIA

3.1. *Word-Recognition Stage*

3.1.1. *Word Decoding*

One of the characteristics of hyperlexia is an unusually superior ability to decode the printed word. Such an ability is out of proportion to the child's intellectual and linguistic abilities. This phenomenon is even more paradoxical because, as many investigators have reported, it is learned without any formal instruction. Because hyperlexic children have no difficulty in decoding, poor icon or poor short-term visual memory cannot be considered contributing factor to the reading problem. In fact, some investigators, in an attempt to explain how the often mentally retarded hyperlexic child learns to decode words, have hypothesized that the child may have very superior visuo-spatial skill which makes him process the printed word as an unanalyzed visual pattern. Research findings, however, are equivocal about such an explanation. Cobrinik (1982) presented nine hyperlexic boys with words which were degraded by deleting the salient features of individual letters. The hyperlexic children identified more degraded words (poorly oriented words) within a given time limit than did a control group of normal readers. Cobrinik concluded that hyperlexics process the written word rapidly as a configuration rather than as single letters in a serial manner. Goldberg and Rothermel (1984) presented visually deviant words to eight hyperlexic children in a reading task. The words were distorted in several ways by altering case, orientation, linearity, and the insertion of signs between letters. It was found that hyperlexic children's performance remained unaffected by these changed conditions except when signs were inserted between letters. The investigators concluded that because the decoding performance of the hyperlexic children was unaffected by these orthographic alterations, the superior word-decoding skill of these children cannot be explained in terms of photograph-like processing alone.

Several investigators have reported that on the WISC, hyperlexic children did better on the Block-design subtest than on vocabulary, digit-span, and coding subtests (Fontenelle and Alarcon, 1982; Goldberg and Rothermel, 1984). However, because many hyperlexic children also do poorly in the Picture-completion and Picture-arrangement subtests of WISC, Aram and Healy (1987) concluded that hyperlexic children may be skilled in visual-perceptual tasks that require visual discrimination and untransformed visual memory, but they may be impaired in tasks which require decision making and judgment.

Hyperlexic children are not dependent solely on visual memory for decoding but are capable of making use of the grapheme—phoneme-conversion rules. This is shown by studies which required these children to read pronounceable nonwords. Six of the twelve hyperlexic children tested by Healy *et al.* (1982) scored higher than one standard deviation above mean for age and the other six scored within 1 SD above or below mean in their ability to read nonwords. In most cases, their syllabic stress was also accurate. These investigators concluded that all twelve children were able to generalize basic phonic rules to unknown words. The 39-year-old adult hyperlexic studied by Aram *et al.* (1984b) was also able to read correctly almost all the nonwords from the Woodcock Reading Mastery Tests. However, other investigators have reported some variability in the nonword reading ability of hyperlexics. Goldberg and Rothermel (1984), in a multiple-choice test, found that five hyperlexic children were proficient in identifying written nonsense words when they were pronounced by the examiner; three children, however, were not successful in this task. The twelve hyperlexic children studied by Aram *et al.* (1984a) fell into two groups, in part distinguished by their ability to read nonwords: Eight children showed flawless performance in nonword reading while the other four demonstrated only an elementary knowledge of phoneme–grapheme-correspondence rules.

Spelling performance of hyperlexic children has not been carefully examined. Studies that have investigated spelling incidentally (Aram *et al.*, 1984a; Goldberg and Rothermel, 1984) indicate that hyperlexic children are good in spelling even though the words they can spell correctly are limited in number.

In their review, Aram and Healy (1987) conclude that a majority of hyperlexic children have an exceptional ability to read nonwords and may follow a different developmental course in reading. In general, hyperlexic children differ dramatically from dyslexic children in their ability to read pronounceable nonwords.

Hyperlexic children do not rely exclusively on the grapheme–phoneme-conversion rules to decode words. Available evidence suggests that they can pronounce words also by directly addressing the phonological lexicon and by retrieving word-specific pronunciations. The ability of some hyperlexic readers (Aram *et al.*, 1984a) to pronounce irregular words along with the fact that word imagery and frequency have an effect on their pronunciation lends indirect support to the view that they are capable of pronouncing the word without resorting to spelling–sound rules. The adult subject studied by Aram *et al.* (1984b) committed very few errors in reading a list of 39 exception words. All the eight children studied by Goldberg and Rothermel (1984) read high-frequency and high-imagery words better than low-frequency and low-imagery words. The presence of nonsense words in the oral reading of hyperlexic children and the absence of semantic paralexic errors in their oral reading suggest that they make minimal use of the semantic lexicon for word reading. In other words, they do not pronounce the word only after knowing what that word is. These observations indicate that for pronouncing words, hyperlexics rely on two strategies: assembling of pronunciation by applying the GPC rules and addressing the word-specific pronunciation directly. In contrast, they do not appear to be proficient in reading directly for meaning.

3.1.2. *Word Comprehension*

In this section, we will examine the possibility that the language comprehension deficit of the hyperlexic reader may originate at the word level. The reading performance of hyperlexic children suggests that they do have a semantic lexicon even though it is of very limited scope. This statement is based on the observation that hyperlexic children can understand the meaning of some concrete words but not abstract words. A good deal of variability is also seen in their ability to understand words probably because of differences in their age and intellectual ability. A few research studies that have investigated word-comprehension ability of hyperlexic readers are discussed in this section.

In a word-reading comprehension test which required reading and completing word analogies (*boy — girl*; *man —* ?), Aram *et al.* (1984a) found that the word-comprehension skill of four children from a group of twelve was at or above grade level; the word-comprehension ability of the remaining eight children was below grade level. Goldberg and Rothermel (1984) assessed hyperlexic children's auditory comprehension and their ability to make lexical decisions. The semantic—lexical decision task was in the form of a list of 25 real words intermixed with 25 nonwords. Subjects were asked to read each word aloud and then indicate whether it was a real word or not. The Peabody Picture Vocabulary Test was used to assess their word-comprehension skill. The children's performance on the vocabulary test indicated that they had limited auditory vocabulary. On the lexical decision task, three children averaged 90 percent correct responses. The remaining five children were so poor in linguistic competence that they could not even grasp the significance of the task.

In conclusion, some hyperlexic children seem to be able to understand the meaning of isolated words even though the comprehension ability of most hyperlexic children is far from being satisfactory. Thus, a good deal of intersubject variability is seen. These observations suggest that the etiology of the comprehension deficit associated with hyperlexia cannot be unequivocally attributed to deficits at word level even though such difficulties mark the beginnings of the problem.

3.2. *Reading Comprehension Beyond Word Level*

3.2.1. *Sentence-Level Comprehension*

Investigators have used various techniques and tools to assess the ability of hyperlexic children in comprehending sentences. The instruments used range from standardized tests to tasks that are specially constructed for assessment purposes. The overall finding of studies that have used these tests and tasks is that while some hyperlexic readers can comprehend simple sentences, a majority of these children are extremely deficient in understanding complex sentences. Furthermore, a great deal of intersubject variability in sentence comprehension has also been reported. Healy (1982) administered the Stanford Diagnostic Reading Test to the twelve hyperlexic children and evaluated their comprehension skills. Part A of the test consists of single-sentence items, mainly literal in content, which require a picture recognition response. The children were able to choose the correct picture for most of these questions indicating fairly good comprehension of simple sentences. Other investigators, however, report much less impressive performances on other tests of comprehension. Huttenlocher and Huttenlocher (1973) studied the comprehension of three hyperlexic children by requiring them to follow directions that were presented in written as well as spoken form. All three children performed poorly as compared to a control group of normal children of comparable chronological age. The hyperlexic children did not do better when they read the instruction than when they heard it. Mehegan and Dreifuss (1972) also noted that only two of the twelve children they studied could execute directions after reading them. Snowling and Frith (1986) studied eight mentally retarded advanced decoders and eight autistic advanced decoders and compared them with normal readers matched for mental and reading age. They found that in a sentence-to-picture matching task, some hyperlexic children could perform as well as normal controls. Other hyperlexic children, however, were much impaired when the units to be understood were larger than a single sentence.

Aram *et al.* (1984b) asked their 39-year-old subject to read 40 sentences in which half the sentences contained words which, during pronunciation, have the first syllable stressed if the word is used as a noun and the second syllable stressed if the word is a verb (e.g., *detail*, *subject*, and *suspect*). The hyperlexic subject's typical pattern was to stress the second syllable of the word whether it was a noun or a verb. He did apply stress to a few first syllables, but this was done without regard to the grammatical status of the word. These results indicated that the subject had no grasp of the difference in the meaning of the sentences. Goldberg and Rothermel (1984) altered some paragraphs by changing the punctuation marks, making the comprehension of the sentences difficult. Such an alteration did not have significant effect on the reading speed of the hyperlexic children they studied. This indicated that these children read sentences without heed to their meaning.

Sentence reading has also been investigated by studying the syntactical ability of hyperlexic children. A variety of tests have been employed to assess the syntactic ability of hyperlexic children. These include Token Test (Goldberg and Rothermel, 1984), Northwestern Syntax Screening Test, Test of Language Development (Healy *et al.*, 1982), and the Illinois Test of Psycholinguistic Abilities (Fontenelle and Alarcon, 1982). Goldberg and Rothermel administered the Token Test (which requires the subject to perform orally given commands such as "touch the red square after you touch the blue circle") to the hyperlexic children they studied. It was found that the children could correctly carry out only about half of the 16 commands, a performance well below expectation. In general, studies that evaluated this particular ability of hyperlexic children indicate that these children have poor syntactical ability.

In conclusion, the comprehension ability of the hyperlexic reader appears to be poor except for very simple, concrete sentences. Such a comprehension deficit in the understanding of complex sentences arises from two sources: poor syntactical ability and poor abstraction ability.

3.2.2. *Text-Level Comprehension*

Investigations of hyperlexic children's ability to understand passages are in general agreement that these children are uniformly poor in text-level comprehension skill. Healy (1982) tested the comprehension of twelve hyperlexic children by administering Part B of the Stanford Diagnostic Reading Test which requires the child to read short passages and choose the correct word in a Cloze test. Choosing the correct word in this test requires not only the comprehension of the sentences but also relating them to one another. The children did very poorly in this test.

In a study involving ten hyperlexic children, Richman and Kitchell (1981), using a Standard Reading Inventory, arrived at the conclusion that their story comprehension was considerably below their oral reading level. Goldberg and Rothermel (1984), in their study, also found that after reading the passages from Durrell Analysis of Reading Difficulty, hyperlexic children could answer no more than one third of the comprehension questions correctly. Snowling and Frith (1986) report that mentally retarded and autistic children who had advanced decoding skill but poor verbal ability could not make use of general knowledge in order to answer questions about the stories they had read. These children were particularly impaired in their ability to comprehend large units of meaning. These investigators concluded that this impairment, that is, poor comprehension of large units of meaning, is the true mark of hyperlexia.

These studies show that although there may be some variability in the ability of hyperlexic readers to comprehend sentences, they are all deficient in understanding passages and stories. Comprehension of these large units requires the reader to relate the individual sentences within the passage with one another, continually interpret information in terms of appropriate schema and make inferences where information is not explicit. In other words, the reader must go beyond the information given. The hyperlexic reader is unable to perform these functions. Because these children are poor in comprehending written as well as spoken language, their problem appears to be due to a generalized cognitive deficit.

3.3. *Etiology of Hyperlexia: Deficit in Assembling Comprehension*

The statement that hyperlexic children are poor in their ability to comprehend passages because they have cognitive deficits does not amount to an explanation of the reading problem; rather it is only a description of the problem at another level. Snowling and Frith (1986) think that the hyperlexic child remains focused on small units of meaning and is unable to integrate word meanings into larger units. Even though these children are able to comprehend material on a rote one-to-one basis, they are unable to assemble concepts and construct meaning of passages. The characterization of hyperlexic children as having rote associative skill but poor abstraction and generalization ability can also be viewed in terms of automatized and control processes. Pronouncing words and apprehending the meanings of isolated words can be carried out almost automatically in a rote fashion, whereas comprehending sentences is dependent on constructive operations that involve the use of controlled processes that are under conscious control. In this respect, hyperlexic children differ from dyslexic children. That is, hyperlexic children are proficient in the use of automatized word-reading operations whereas dyslexic children are not.

Any speculation about the etiology of hyperlexia will have to answer three questions satisfactorily: (i) What is responsible for the poor comprehension ability of the hyperlexic reader? (ii) What factor is causally associated with the superior decoding skill?, and (iii) Are superior decoding and poor comprehension ability causally associated with each other? We can confidently dispose of the last question because there are children who are superior in both decoding and comprehension; there are also children who are deficient in both areas. Consequently, superior decoding skill cannot be thought of as a causal agent of comprehension deficit. The etiology of poor comprehension could be attributed to any one of several factors such as not having adequate schema, not being able to make inferences, not being able to focus on units larger than a single word or a short sentence, or not being able to execute effectively controlled processes. Poor comprehension may be the product of a combination of all these factors. The mechanisms responsible for the advanced decoding skill of the hyperlexic child, however, remain obscure.

NOTES

[1] The term "etiology" is used to refer to proximal causal factors such as decoding and comprehension and not to distal factors such as neurological impairment and genetic characteristics.

[2] In this book, the terms "phonological analysis" and "phoneme identification" are used interchangeably. These differ from "phonetic skill" which refers to an ability to name letters of the alphabet. For instance, recognizing that the word "cat" has three phonemes (/k/æ/t/) involves phoneme analysis; naming the three letters of the word (c,a,t) is phonetic skill.

[3] The remaining four children were girls.

OUTLINE OF CHAPTER 4
['DEVELOPMENTAL DYSLEXIA AND HYPERLEXIA: DELINEATION OF THE DISORDERS']

1. Developmental Dyslexia
   1.1. Overgeneralization of the Concept
   1.2. Reading—Language Relationship
   1.3. Dyslexia and Other Forms of Reading Disability: A Componential Differentiation
   1.4. An Operational Definition
2. Hyperlexia
   2.1. Overgeneralization of the Concept
   2.2. Hyperlexia and Dyslexia: Differentiation of the Syndromes
   2.3. An Operational Definition of Hyperlexia
3. A Model of Reading and Reading Disabilities

CHAPTER 4

DEVELOPMENTAL DYSLEXIA AND HYPERLEXIA: DELINEATION OF THE DISORDERS

1. DEVELOPMENTAL DYSLEXIA

The history of reading disabilities presented in Chapter 1 shows that, at present, there exists neither a general agreement regarding the description of developmental dyslexia nor a universally accepted definition of it. It is not surprising, therefore, to see a great deal of variation among the populations of poor readers defined as dyslexics by different investigators. Even the recommendation of the committee assigned the task of defining developmental dyslexia — "until more is known, each research project must formulate its own working definition as needed" (Adams, 1969, p. 632) — is not strictly adhered to and the dyslexic population is not clearly defined in many studies. This leads to an overgeneralization of the syndrome of developmental dyslexia and results in a failure to separate disorders that are specific to reading from the ones which are associated with spoken language.

1.1. *Overgeneralization of the Concept*

Rutter (1978) has proposed that there are two broad categories of reading disabilities: "specific reading retardation" and "general reading backwardness." Children with specific reading retardation show a marked discrepancy between reading potential, as predicted by age and IQ, and actual achievement. In contrast, children who are classified by Rutter as backward are well below average in intelligence and have a general cognitive deficit. Even though Rutter did not equate specific reading retardation with developmental dyslexia, the proposed difference between the two groups of poor readers can be used as a criterion to distinguish developmental dyslexia from other forms of reading disabilities because dyslexia is defined as a form of reading difficulty occurring in the presence of adequate intelligence.

According to Rutter, five population studies have shown that extreme degrees of specific reading retardation occur as a "hump" at the bottom of the normal curve of statistical distribution of children's reading scores. This anomalous group of readers constituted about 3.5 percent of the total population of the children studied. Recently, Miles and Haslum (1986) investigated 10,992 children by administering simple forms of reading tests. In conformity with Rutter's statistical data, they also found that about 4.3 percent of the children fell below 2.58 standard deviations of the mean, more than could be expected according to normal statistical distribution. They considered these children to be dyslexic. The statistics provided by Rutter and by Miles and Haslum indicate that application of selection criteria that lack rigor is a major reason for the failure of investigators to clearly distinguish developmental dyslexia from other forms of reading disabilities. Excerpts from Stanovich's recent writings (1986b) illustrate this point:

> Syntactic knowledge and awareness seem to be deficient in disabled readers. . . . Their performance is relatively low on tests of general listening comprehension and general linguistic awareness. . . . Comprehension strategies that are very general seem to be deficient . . . we seem to be uncovering a deficiency in a "specific" area that can only be labeled "language — in all its conceivable aspects." This is not the type of specific psychological disability that the originators of the idea of dyslexia had in mind. . . . It is only by isolating the true outliers that researchers can hope to obtain the evidence for specificity that the dyslexia concept requires if it is to be of scientific and practical utility. The parent groups who have pushed for ever-more-inclusive definitions of dyslexia are indirectly undermining the concept. (p. 385, 387)

Stanovich recommends the use of a stringent selection criterion in which not more than five percent of the population of children will be classified as dyslexic.

Poor readers who reportedly are deficient in both reading and listening comprehension are very likely to be learning disabled, not merely reading disabled. It is not quite correct to label these children as reading disabled since their disability is not limited to the reading process but pervades all aspects of learning. If the statistical criterion that no more than four or five percent of the population be considered dyslexic readers is valid, it can be seen that in order to obtain 40 dyslexic children from grades 4 and 5, an investigator would have to have access to a population of nearly 1,000 fourth- and fifth-grade children. This involves an investigation of nearly 20 fourth-grade and 20 fifth-grade classes. Many studies of dyslexia report having investigated more than 20 dyslexic children, but all come from a single school system. Apparently, these studies have included reading disabled children of different varieties.

Nearly 20 to 30 percent of the children in a typical classroom are said to have mild but widespread cognitive deficits, and it is not unreasonable to expect these children also to experience reading deficits. Often these children are incorrectly classified as dyslexic even though they might be poor readers of the "garden variety." The phrase *garden variety* is borrowed from Stanovich *et al.* (1986b) who, after investigating reading disability from a developmental perspective, conclude:

> If stringent definitional criteria are employed, then some reading-disabled children do display performance profiles consistent with the specific deficit model inherent in most discussions of dyslexia. . . . However, theories deriving from the study of these extremely disabled readers have been inappropriately extrapolated to the much larger population of school-labeled learning-disabled children and/or to the 10—40% of children who display reading problems in most school districts. Most of the latter are not characterized by a specific cognitive deficit. Instead, they display mild but pervasive cognitive problems. (pp. 280—281)

A major source of difficulty that has prevented researchers from reaching firm conclusions regarding developmental dyslexia can, therefore, be traced to a tendency to cast the diagnostic net too widely and to overgeneralize the concept of dyslexia. Similar overgeneralization of the description of hyperlexia is also likely to occur. Establishment of stringent criteria for the identification of the different forms of reading disabilities can be expected to avoid the problem of overgeneralization.

In this book, the terms *developmental dyslexia* and *specific reading disability* are used interchangeably. In contrast, poor readers with general cognitive deficit and an associated below-average IQ are referred to as cases of nonspecific reading disability. (NSRD) This group is similar to Rutter's backward readers.

1.2. *Reading—Language Relationship*

Another reason for a lack of clarity in the delineation of developmental dyslexia is a misunderstanding of the relationship between reading and language. Because dyslexic readers do not appear to have deficits in listening comprehension, their ability to comprehend spoken language can be used to separate them from poor readers with poor cognitive and comprehension skills. Morgan (1896), who was the first investigator to write about specific reading disability in the English language, noted that the 14-year-old boy he examined was "bright and intelligent" and reported that "the school master who taught him for some years says that he would be the smartest lad in the school if the instruction were entirely oral" (p. 1368).

Hinshelwood, in his 1917 monograph, described the unexpected form of reading disability in terms of the following characteristics. The children were bright and intelligent and their powers of observation and reasoning were quite intact; they had no difficulty in any of the subjects which could be imparted to them orally. Hinshelwood further noted that the three criteria that are useful in distinguishing this form of reading disability from other forms of learning failure are: (a) *the limitation of the disability to written language without any attendant oral language or cognitive deficits* (b) the failure to progress in reading under normal conditions of instruction, and (c) the severity of the reading problem. In short, the classification form of dyslexia, as envisaged by the early investigators, is characterized by the purity of symptoms, the lack of progress in reading, and the severity of the disability. Following this logic, when reading disorder exists as one aspect of deficits in spoken language, such a condition should appropriately be referred to as *developmental language deficit* because the disorder is neither specific to reading nor limited to the written language.

Because many researchers view developmental dyslexia from a perspective that is broader than the one adopted in this book and describe it as a form of language disability, the position taken in this book needs further clarification.

In reading disability research, phrases such as *language disability* and *language deficit* are used in a broad sense as well as in a narrow sense. The phrase *language disability* is used in a broad sense when it encompasses deficits of all aspects of symbolic communication, including reading. When used in this broad sense, reading behavior itself, with its many subprocesses can be considered as a form of language. The inability to convert the written word into its phonological representation (decoding) rapidly and effortlessly, the major symptom of dyslexia can, therefore, be considered as a form of language deficit, when the term *language disability* is used in the broad sense. In contrast, *language disability*, when used in the narrow sense, refers to a disability that is limited to the comprehension and expression of spoken language and does not include decoding skill which is unique to reading (see, for example, Crowder, 1982b). The term *language deficit* used in the narrow sense refers only to deficits in the comprehension and expression of oral language. In this book, the term *language deficit* is used in this narrow sense. Thus, when a statement such as "the dyslexic individual does not have language deficit" is made, the term *language deficit* is used in a narrow sense to mean that the subject does not have any noticeable deficit in the comprehension and expression of spoken language. He still may be found to be poor in decoding the printed word and converting it into its phonological representation.

Researchers who have advanced the linguistic deficit explanation of developmental dyslexia, in general, have used the language concept in the broad sense in order to draw a distinction between visual-perceptual deficit explanations of dyslexia and cognitive explanations of the disability. Under these circumstances the term *language deficit* is used to stress the view that the etiology of reading disability is not visuo-spatial. For example, Vellutino (1979), who is a strong advocate of the verbal deficit hypothesis of developmental dyslexia writes:

> Basing speculations largely upon clinical observations, I would estimate that the largest proportion of disabled readers are characterized by significant impairment in mapping alphabet symbols to sound, perhaps because of basic difficulty in phonetic encoding, as suggested by Liberman and Perfetti, among others. . . . Spoken language in such children is not ostensibly impaired and may even be relatively normal, at least with respect to verbal concept formation and grammatical competence. (p. 371)

He also notes that "the dyslexic typically manifests no disorder in language comprehension that can be discerned in spoken discourse" (p. 351). Thus, Vellutino appears to use the term *verbal deficit* in its broad sense and considers difficulties experienced by the dyslexic individual in the decoding of the printed word as a form of verbal linguistic deficit. To reiterate, in this book, terms such as *language disability* and *linguistic deficit* are used in the narrow sense to refer to deficiencies that are recognizable only in the comprehension and expression of oral language.

Studies described in Chapter 3 show that children who have adequate oral language skills (in the narrow sense) can have specific reading disability; conversely, those with specific reading disability can have normal ability to comprehend and generate oral language (Oaken *et al.*, 1971; Guthrie and Tyler, 1976; Torgesen *et al.*, 1985). Some studies, nevertheless, have reported a positive association between oral language and reading ability (see, for example, Fry *et al.*, 1970). These studies, however, have not limited their investigation to subjects with specific reading disability but have included NSRD children with general cognitive deficits.

A few studies which were conservative in their subject selection have reported a positive association between developmental dyslexia and deficits in some aspects of general language. The results obtained in these studies are often statistically analyzed and this tends to obscure individual differences and disregard the heterogenic nature of the reading disabled population. For instance, Davenport *et al.* (1986) reported general language deficit in children with "pure dyslexia." Using measures such as noncommunications (hesitations and fillers such as "ok," "you know"), self-corrections, and the number of communication units (independent clauses), these investigators found the dyslexic group to be statistically inferior to normal readers in narrative speech. It should be noted, however, that the noncommunication fillers used by these children may reflect a poor word retrieval skill which is related to a speed factor rather than a linguistic factor. The many self-corrections found in their speech also indicate that the dyslexic readers are capable of monitoring their own expressive language.

Furthermore, since statistical figures tend to obscure individual differences, it is not known if all 52 dyslexic children studied by Davenport *et al.* had oral language problems. It is entirely possible that the narrative speech of many dyslexic children was as good as or even better than that of some normal readers. A study by Whitehouse (1983) is illustrative of this point. She investigated 42 dyslexic adolescent boys with the aid of the Token Test and found that even though dyslexic readers, as a group, showed an impaired ability to process orally presented syntactic information, not all disabled readers had difficulty with the task. In fact, 54.7 percent of the dyslexics performed on par with the normal readers. As was noted in the previous chapter, the study which compared the phonemic, syntactic, and semantic competence of the oral language of dyslexic college students with that of normal readers also found no evidence of oral language deficits in dyslexic subjects (Aaron *et al.*, 1985). It appears, therefore, that developmental dyslexia can coexist with intact language functions. A similar conclusion was reached by Rozin and Gleitman (1977) who, after reviewing some studies that compared good and poor readers on several aspects of linguistic ability, state: "While the extraction of meaning from print is the ultimate goal of reading, decoding rather than syntactic—semantic abilities distinguish high-achieving from low-achieving beginning readers" (p. 97). More recently, after examining studies that have focused on the phonological, syntactic, and semantic abilities of disabled readers, Mann (1986) writes: "Semantic processes do not appear to be deficient among disabled beginning readers; it is, therefore, unlikely that reading disability is associated with a generalized language impairment" (pp. 146—147). Observations of these kinds indicate that it is unlikely a cause-and-effect relationship exists between developmental dyslexia and a deficit in the comprehension of spoken language (see Box 4.1.).

BOX 4.1.
Cause—effect relationship in reading disability

In science, no amount of observation of positive association between two phenomena can unequivocally establish a cause—effect relationship between them; in contrast, a single negative instance is sufficient to reject a causal relationship. This is sometimes referred to as the Popperian Principle, named after Karl Popper, who first proposed the idea. When applied to the scientific investigation of developmental dyslexia, it means that if we come across even a single case of developmental dyslexia with normal oral language comprehension, it is sufficient to reject the possibility of a cause—effect relationship between oral language deficit and developmental dyslexia. Instances of dyslexic students with adequate comprehension have been reported (Aaron *et al.*, 1985). A comment by Ellis (1984) is appropriate in this context. He writes:

> Evidence of an association between reading retardation and these other skills does not prove a causal link between the reading difficulty and the problems with object naming, verbal short-term memory, action sequencing, or whatever. Indeed, to discover, as Torgesen and Houck (1980) did, a group of dyslexic children with normal memory spans and object naming speed argues strongly against such a causal link. . . . If we discover a discrepantly poor reader whose disability cannot be put down to inadequate opportunity or teaching, and who shows normal electrical brain activity, normal lateralization, normal eye movements when not tackling print, normal short-term memory, normal visual perception, and so on, then we must acknowledge that none of those indicators is necessarily associated with dyslexia and that dyslexia can occur without abnormalities or deficiencies in any of these characteristics or abilities. (pp. 111—112)

1.3. *Dyslexia and Other Forms of Reading Disability: A Componential Differentiation*

A dissociation between comprehension and decoding is possible since these two skills constitute two independent components of reading. This can explain why the dyslexic child, in spite of his reading disability, can have normal language comprehension skill. Evidence available from different sources converges on the point that comprehension and decoding are dissociable. It was noted in Chapter 2 that Jackson and McClelland (1979) found that "the ability to comprehend spoken material and speed of accessing over-learned memory codes for visually presented letters represented two important independent correlates of reading ability," and these two factors "accounted for nearly all of the variance in reading ability" (p. 151). Investigations of neurological patients who have lost part of their once well-developed ability to read (deep dyslexics) also indicate that the ability to read words aloud can be lost without a corresponding loss of the ability to understand them (Coltheart, 1980a).

The reading performance of the hyperlexic child shows very clearly that word decoding and listening comprehension are independent skills. Though they possess extraordinary ability to decode and pronounce the written word, hyperlexic children have severe deficits in the comprehension of both written and spoken language. It is, therefore, quite possible that the converse condition — poor word recognition but adequate listening comprehension — can exist. In fact, this book is based on the premise that developmental dyslexia and hyperlexia are caused by the breakdown of different components of the reading process.

Separation of the disabled readers with poor decoding but adequate comprehension skills from disabled readers with poor comprehension ability is warranted since the former have a deficit that is specific to reading and the latter have deficits which are not limited to reading. In other words, children with specific reading disability (SRD) are qualitatively different from ones with nonspecific reading disability (NSRD) because the reading difficulties of these two groups have different etiologies. This proposition has been supported by the findings of two studies described below.

Subjects for the first study came from the pool of 98 children described in Chapter 2. All 98 children were administered a battery of tests which included the Passage Reading Comprehension subtest from the Woodcock Reading Mastery test, Form A. Form B of the Passage Comprehension subtest was administered as a test of listening comprehension by reading it to each child and requiring him/her to supply the deleted words. In addition, it was possible to administer the WISC-R intelligence test to 80 of the 98 children. Children whose reading *and* listening comprehension were one or more years below their current grade placement were considered as having nonspecific reading disability (NSRD). Twelve children were identified as having this performance profile. Next, children designated as developmental dyslexics were selected from a pool of disabled readers referred to Porter School Psychology Clinic as well as from three schools. These children have already been described in Table 3.1. of Chapter 3. It may be recalled that these twelve dyslexic children had *listening comprehension scores at about grade level* but had reading achievement scores one or more years below grade level. The twelve dyslexic children were matched for reading comprehension with the twelve children who were identified as NSRD. The matching was not perfect, but it was satisfactory. The two reading-disabled groups, therefore, differed from each other on listening comprehension but not on reading comprehension. An effort was made to match the two groups on the basis of their grades as well, but this was not always possible. A third group of twelve normal readers with grade-appropriate reading achievement scores was also selected from the original pool of 98 children and used as a control group. Children in the control group were matched with those in the two reading-disabled groups on the basis of their reading achievement scores. These data are shown in Table 4.1.

TABLE 4.1.

Psychometric data of dyslexic, NSRD, and control groups

Subject		Grade	Reading achievement	Reading comprehension	Listening comprehension	Full-scale IQ
DYS.	1	4.6	2.6	2.6	4.2	94
NSRD	1	6.0	3.0	3.2	3.7	89
CON.	1	2.6	2.9	3.3	4.3	
DYS.	2	4.6	3.5	3.6	5.4	104
NSRD	2	4.6	3.3	3.5	3.7	86
CON.	2	2.6	2.8	3.3	4.5	
DYS.	3	4.6	2.5	4.9	5.5	110
NSRD	3	6.6	4.0	4.0	4.0	82
CON.	3	4.6	4.5	4.6	4.6	
DYS.	4	4.6	2.4	3.9	4.8	110
NSRD	4	6.6	4.0	3.9	3.5	88
CON.	4	4.6	4.6	5.0	4.0	

Table 4.1. (continued)

Subject		Grade	Reading achievement	Reading comprehension	Listening comprehension	Full-scale IQ
DYS.	5	4.6	2.4	4.1	5.0	98
NSRD	5	8.0	5.3	4.2	3.4	77
CON.	5	4.6	4.8	5.0	4.6	
DYS.	6	4.6	3.0	4.0	4.5	93
NSRD	6	7.6	4.0	3.8	4.3	68
CON.	6	4.6	4.6	4.7	5.7	
DYS.	7	5.6	3.5	4.0	5.9	115
NSRD	7	6.3	4.0	4.1	4.5	91
CON.	7	4.6	4.7	4.8	4.4	
DYS.	8	5.6	4.6	5.9	8.1	120
NSRD	8	9.3	7.8	6.2	5.0	87
CON.	8	5.9	6.5	5.9	6.7	
DYS.	9	6.6	4.6	4.7	6.6	92
NSRD	9	6.6	5.3	5.0	5.3	87
CON.	9	4.9	5.0	5.1	5.9	
DYS.	10	7.6	6.2	5.7	7.2	108
NSRD	10	7.6	5.0	6.0	5.3	96
CON.	10	4.9	6.0	5.9	6.2	
DYS.	11	8.0	4.0	4.0	7.8	102
NSRD	11	8.6	6.0	4.9	4.3	86
CON.	11	4.9	5.0	5.1	4.7	
DYS.	12	9.3	6.0	6.2	9.2	119
NSRD	12	9.3	6.2	6.2	7.4	89
CON.	12	4.9	6.0	6.2	6.2	

Subsequently, the three groups were compared with each other on decoding, spelling, reading errors, reading speed, and dependency on context. A second measure of reading comprehension was also obtained with the aid of a Maze Cloze test. Data regarding reading errors, reading comprehension, and context effect were obtained from the children's performance in the reading of three versions of passages (standard, Cloze, and reversed, respectively) selected from a corpus of 36 calibrated passages and were standardized (Aquino, 1969; Miller and Coleman, 1967). Each subject read two passages from each of the three versions that corresponded to his level of reading achievement as determined by the entire battery of the Woodcock Reading Mastery Tests. The standard version was in regular printed format. Each child was asked to read the two passages aloud and the reading was taped. The number of words misread or omitted while reading aloud the standard passages provided the basic measure of reading errors. The Cloze version was in a maze format and was created by transforming every fifth word in the standard passage into three-word multiple choice. The reversed versions were created by reversing the order of words within each sentence in the standard passages and were designed to assess the reader's dependency on contextual cues. Reversing the word-order within the sentence made the sentence meaningless and thus eliminated contextual cues that could be helpful in decoding. Consequently, oral reading of the reversed version was a relatively pure measure of the reader's decoding skill. The reader who makes excessive use of contextual cues for oral reading will, therefore, be much affected by this manipulation. Context effect was determined by noting the number of reading errors committed while reading the reversed passages. Because the standard passage and the reversed passage were identical except for the arrangement of words within the sentence, additional reading errors committed while reading aloud the reversed passage would be an index of context dependency.

Because the child read passages within his ability level, it was thought that the demands of decoding would be minimal and the errors of choice committed in the Cloze test would reflect pure comprehension deficit.

Decoding skill was assessed with the aid of a list of 36 pronounceable nonwords that were based on progressively complex grapheme—phoneme relational rules (Wijk, 1966; Calfee *et al.*, 1969; Venezky, 1976). The spelling test was made up of 36 words which were also selected on the basis of the same spelling-to-sound rules on which the reading list was based. Children's reading speed was assessed by asking them to read a list of 20 highly familiar three-and-four letter function words (frequency above 500 per 5,088,721 words of running text; Carroll *et al.*, 1971). It was assumed that because these words are very common, they could be read by sight by these children. The time taken to read this list of words, therefore, provides a relatively pure measure of speed of name retrieval that is independent of decoding. Samples of these tests are shown in Appendix I.

A 3 × 8 MANOVA (three groups and eight dependent variables) was used to analyze the results. The dependent variables were: (a) reading comprehension, (b) listening comprehension, (c) reading performance on the standard passages, (d) reading performance on the reversed passages (context effect), (e) reading performance on the Cloze passages, (f) reading of nonwords, (g) spelling, and (h) high-frequency function words reading time. Statistical analysis of the data showed that there was a highly significant effect for groups. *Post hoc* analysis of the data was carried out with the aid of univariate analysis of variance, and group comparisons were made using Student—Newman—Keuls multiple-range test procedure. Analyses showed that the two groups of poor readers differed from each other on seven of the eight variables (see Table 4.2.). The only variable in which the groups did not differ was reading comprehension. This is not an unexpected finding because the three groups had been initially matched with each other on this variable. The dyslexic children did not differ from the control group in listening comprehension or in their performance on the Cloze test; the NSRD group differed from the control group in these two measures. The dyslexic group was inferior to both the control and NSRD groups in all the tasks that required decoding; the dyslexic

TABLE 4.2.

Comparison of dyslexic, NSRD, and normal readers

Dependent variable	*F*	*p*	Newman—Keuls comparisons
Reading comprehension	0.67	0.53	*Dys. Controls NSRD*
Listening comprehension	4.58	0.02	*Dys. Controls* NSRD
Reading Errors (Standard Passages)	4.24	0.02	Dys. *NSRD Controls*
Reading Errors (Reversed version)	8.20	0.001	Dys. *NSRD Controls*
Cloze test errors	7.66	0.001	*Dys. Controls* NSRD
Nonwords pronounced correctly	13.95	0.0001	Dys. *NSRD Controls*
Words spelled correctly	15.97	0.0001	Dys. *NSRD Controls*
Function word reading speed	5.33	0.009	Dys. *NSRD Controls*

df = (2, 33); italicized groups do not differ from each other.

children also committed more errors than the other two groups did when they read the reversed version indicating that the dyslexic reader is excessively dependent on context for oral reading. These findings indicate that the basic deficit of the dyslexic subjects is poor decoding skill and the basic deficit of the NSRD group is poor comprehension. It has to be mentioned that among the children in the NSRD group, a certain amount of variability existed as far as decoding skill was concerned because some of them were also poor decoders. The NSRD group also had significantly lower IQ even though two children in this group had an IQ of 90 or above. (See Appendix I for raw data.)

The second study (Aaron, 1987) involved a group of seven dyslexic college students which included the five subjects described in Chapter 3. In addition, seven college students suspected of having nonspecific reading disability because of their low IQs (1 SD below mean) and seven college students with normal reading ability were selected. The dyslexic readers had a WAIS-R full-scale IQ of 95 or above but, as assessed by the Stanford Diagnostic Reading test, read at the level of grade 9 or below. Members of the NSRD group had an IQ of 85 or below with a level of reading comprehension several grades below expectation. Both groups of disabled readers were either admitted to the University on a conditional basis or had been placed on academic probation. It was hypothesized that the etiology of developmental dyslexia is a grapheme—phoneme conversion deficit and, for this reason, the two disabled groups would differ from each other in testable skills. Seven such differences were postulated and the groups were tested. These hypothetical differences and the procedures used to obtain data are shown in Table 4.3.

A 3 × 5 ANOVA (three groups and five variables — content words, function words, two categories of nonwords, and CCC) with repeated measures showed that the dyslexic group differed from the NSRD group in reporting function words and nonwords even though the three groups did not differ from each other in the number of CCCs reported. Data collected on the remaining six differences were analyzed with the aid of Multivariate Analysis of Variance. The statistical analysis showed that members of the dyslexic group differed from those of the NSRD group in all areas except in their ability to generate syntactically correct spoken sentences. In this skill, all three groups performed equally well. The dyslexic readers were as good as the normal readers in listening comprehension and in the ability to understand syntactically complex

TABLE 4.3.
Hypothesized differences between poor readers with specific and nonspecific reading disabilities

Difference	Group		
	Dyslexic	NSRD	
1. Listening comprehension	Adequate	Poor	Listening comprehension Sub-test (Durrell, 1955)
2. On-line monitoring of reading comprehension	Adequate	Poor	Analysis of acoustic parameters of prosody (described in Ch. 3)
3. Ability to generate appropriate syntax in oral language	Adequate	Poor	Shadowing task (Ch. 3)
4. Understanding complex syntax	Adequate	Poor	"Ask—tell" and "easy to see" type questions (Ch. 3)
5. Decoding skill	Poor	Adequate	Tachistocopic report of words, nonwords, and CCC
6. Decoding-comprehension relationship	Poor decoding limits comprehension	Poor comprehension limits decoding	Rate when reading Cloze test vs. standard passages
7. Reliance on top-down or bottom-up processes	Top-down	Bottom-up	Analysis of reading errors

sentences. It was concluded that the dyslexic readers were significantly worse than the poor readers with nonspecific reading disability in decoding of function words and pronounceable nonwords. The NSRD group was significantly worse than the dyslexic group in on-line monitoring of reading comprehension, listening comprehension, and the understanding of syntactically complex sentences. They made many more contextually inappropriate oral reading errors than the dyslexic readers did and were also much affected in their rate of reading when comprehension was made obligatory. In addition to the fact that all these differences were statistically significant, there was very little overlap of scores between the two groups. The findings of these two studies suggest that the dyslexic group and the nonspecific reading-disabled group are two distinct populations of poor readers, separated by deficits associated with the two components of reading, decoding and comprehension.

In view of the fact that members of the NSRD group had below average IQs, these results may not come as a surprise. But several investigators have argued that there are no qualitative differences between dyslexic readers and other types of poor readers (Taylor *et al.*, 1979; Bloom *et al.*, 1980). A way out of this impasse has been suggested by Davis and Cashdon (1963) who propose that, in order for developmental dyslexia to be considered a unique form of reading defect, it should differ from other forms of reading disabilities in one or more of the following criteria: prognosis, response to treatment, or etiology. Studies discussed in this book show that dyslexia differs from nonspecific reading disability in its etiology: Dyslexia is associated with poor phoneme—grapheme-conversion skill, and NSRD is part of a generalized cognitive deficit. In addition to satisfying the Davis—Cashdon requirement, these differences provide a basis for delineating developmental dyslexia from other forms of reading disability.

1.4. *An Operational Definition*

In this book, the term *developmental dyslexia* is applied to the form of "classical dyslexia" found in children similar to the ones described by Morgan, Hinshelwood, and Orton. In terms of prevalence and characteristics, the view of developmental dyslexia presented here also matches that of "specific reading retardation" reported by Rutter (1978). The term *specific reading disability* can also be considered a synonym of dyslexia because the term implies that the disability is specific and limited to written language. As was noted earlier, the identifiable etiology of developmental dyslexia is a grapheme—phoneme-conversion deficit which affects all aspects of the written language. All the disabled readers who have been diagnosed as dyslexic, studied, and described in this book had average or above average intelligence (full-scale IQ of 90 or above on Wechsler Intelligence Scales), were noticeably free from listening comprehension deficit, but were retarded one year or more in reading. It is believed that the exclusion of poor readers with generalized cognitive deficit as indicated by sub-average IQs and poor listening comprehension makes it possible to delineate the syndrome of developmental dyslexia with reasonable rigor and to study the relatively pure form of the disability. The following operational definition of developmental dyslexia is based on this rationale: *Developmental dyslexia* is defined in this book as a form of reading disorder found in individuals who have average or superior listening comprehension but whose reading performance is compromised by deficient phonological skills.

2. HYPERLEXIA

2.1. *Overgeneralization of the Concept*

It was noted in Chapter 1 that introduction of the term *hyperlexia* by Silberberg and Silberberg (1967) was followed by a tendency to overgeneralize the concept resulting in the inclusion of normal and even superior readers in the hyperlexia category. Niensted (1968), for instance, suspecting that something in the teaching methods employed by the schools (i.e., the phonics approach) might account for hyperlexia, tested 45 pupils in one school and 45 in another and identified 26 children in the first school and 10 children in the second school as exhibiting the syndrome of hyperlexia. Thus, the loose application of the concept of hyperlexia led to labeling nearly 40 percent of children as hyperlexic. Undoubtedly, many normal readers were labeled as hyperlexics in this study. It was also noted in Chapter 1 that Silberberg and Silberberg (1968), in their presentation of case histories of hyperlexia, included three children with IQs above 100.

Even though the dilution of the definition of *hyperlexia* can be attributed to the initial conceptualization which did not carry the implication that hyperlexia is a form of reading disability, the practice of identifying children as hyperlexic solely on the basis of superior decoding skill continued even after 1971 when many investigators started using the term in the context of reading disability. For instance, Elliott and Needleman (1976) suggested that "the term hyperlexia be redefined as a remarkably accelerated ability to recognize written words, which may or may not occur along with truly pathological conditions" (p. 340). In selecting the ten hyperlexic children for their study, Richman and Kitchell (1981) followed the criterion proposed by Silberberg and Silberberg (1968) which was based on the child's expected decoding skill, as derived from IQ, and the actual decoding performance. By this criterion, children were considered to be hyperlexic if their word decoding score on the WRAT was at least two years above their expected level of decoding. This selection criterion did not include any measures of comprehension.

Fontenelle and Alarcon (1982) studied eight children whom they considered hyperlexic. Even though this group included some mentally retarded children, there were some children whose IQs were as high as 118. Similar range in intelligence can be seen in the 20 autistic boys indentified as hyperlexic by Whitehouse and Harris (1984). The mental ability of these boys ranged from severe mental retardation to very superior intelligence. In fact, five of the 20 children had IQs above 90 with one having an IQ of 112 and another 144. When tested during the study, one boy was found to have age-appropriate reading comprehension and two had reading comprehension above age level. These authors stated that "the majority possesses an excellent stored vocabulary that could be used with written words despite the poverty of their expressive language" (p. 281). The "poverty of expressive language" of at least some children studied by Whitehouse and Harris might have been due to infantile autism. Identifying hyperlexia solely on the basis of superior decoding skill could lead to erroneously labeling some normal readers as hyperlexic. The psychometric profile of such a precocious but talented superior reader was presented in Chapter 1 (Pennington *et al.*, 1987a).

As has happened in investigations of developmental dyslexia, there also appears to be a tendency to overextend the concept of hyperlexia to include borderline and even normal readers within the category. It will be prudent to avoid further dilution of the concept by reserving the term *hyperlexia* to denote a form of reading pathology and by strictly adhering to the criteria of the syndrome such as those proposed by Healy *et al.* (1982; see Chapter 1).

2.2. *Hyperlexia and Dyslexia: Differentiation of the Syndromes*

It is logical to expect investigators of reading disabilities to try to compare hyperlexia with dyslexia because both disabilities defy ordinary explanations. And they have. Even as Silberberg and Silberberg coined the term *hyperlexia* (1967), they hypothesized that the concept of hyperlexia suggests a continuum of word-recognition skills. In their 1968 paper, they were more explicit when they wrote:

> At the end of the continuum are the children usually labeled dyslexic . . . whose word recognition skills are significantly below their expected ability to comprehend. . . . Next on the continuum are the majority of children, who learn to read normally. At the other end of the continuum is the group under consideration in this paper. (p. 3)

Other investigators, however, have been less certain about such a formulation of the relationship between hyperlexia and dyslexia. For example, de Hirsch (1971) stated that "hyperlexics, no matter how good their word-recognition skills, *are* dyslexics" (p. 243). She continued: "This writer does not believe that dyslexia and hyperlexia occur at opposite extremes of the reading continuum" (p. 245). The difference between the views of de Hirsch and those of the Silberbergs' appears to stem from de Hirsch's conception of hyperlexia as a reading disability and her possible interpretation of the Silberbergs' view that it is not. Healy *et al.* (1982) also seem to have this larger conceptualization that both hyperlexia and dyslexia are reading disabilities when they write that the disordered symbolic relationship is considered to be integral to the dyslexic condition as well as to hyperlexia.

Benton (1978) viewing dyslexia from a different perspective expressed a similar opinion when he wrote:

> There are also dyslexic children who, like another type of aphasic patient, read aloud with fair accuracy and fluency, but show a striking disability in apprehending the semantic aspects of the message. . . . An extreme example of this state of affairs . . . is the so-called "hyperlexic" child who shows exceptionally good ability to read aloud . . . without, however, a comparably good understanding of the meaning of the material which he reads so fluently. . . . I once called this condition the opposite of dyslexia . . . I now would tend to view it as a particular form of dyslexia (p. 457).

Benton's view that hyperlexia is a form of dyslexia can be traced to his willingness to accept those children who can read aloud the printed language fluently and accurately but without comprehension as dyslexic.

This description of dyslexia is different from the one proposed in this book. Individuals who can decode well but cannot understand what they have read are considered in this book as exhibiting hyperlexia-like syndrome and not dyslexia.

In a recent family study of hyperlexia and dyslexia, Healy and Aram

(1986) compared the two disorders from the perspective of family history. After tracing the family history of the twelve hyperlexic children mentioned earlier, they discovered a high incidence of nonrighthandedness, delayed speech, delayed writing, and deficient reading comprehension in members of the families of these children. Eight of the twelve fathers also reported dyslexia symptomatology. Healy and Aram concluded that "qualitative evaluation of these family learning histories strongly points to a link with dyslexia, although the relationship remains tantalizingly speculative" (p. 248). If the genetic link between dyslexia and hyperlexia turns out to be a reliable phenomenon, it will be one of the most exciting discoveries made in regard to reading disabilities. Studies of this nature, however, call for the exercising of a considerable degree of caution in interpreting the data. For instance, the presence of learning disorders in family members does not by itself mean that they have dyslexia. The term *dyslexia* is frequently used by lay people to describe any kind of reading and learning problem, including those associated with subaverage intelligence. Healy and Aram (Healy, personal communication), however, consider the dyslexia symptomatology reported for the fathers of the hyperlexic children they studied to be clinically reliable, which leaves open the possibility that at the molecular level the two forms of deficits may be related to each other even though phenotypically they are expressed in divergent forms, an instance of pleiotropy, perhaps.

Much of the controversy surrounding the relationship between hyperlexia and dyslexia can be attributed to the process—product difference at which the comparison is made. The two forms of reading disabilities, dyslexia and hyperlexia, can be compared with each other at the process level or at the product level. As products both hyperlexia and dyslexia are reading disabilities; from this point of view, they are similar. From the process perspective, however, they are different because hyperlexia is related to poor comprehension and dyslexia is associated with poor decoding ability. It is reasonable to assume that advanced decoding is not the etiology of hyperlexia, but extremely deficient comprehension is; conversely, it is not poor comprehension, but poor decoding that is associated with dyslexia.

In terms of the processes that lead to reading difficulty, the two forms of reading disabilities differ from each other and, as Silberberg and Silberberg (1968) proposed, occupy opposite positions in a continuum of decoding skills. An analogy can make this relationship more explicit. Impaired motor skills affect movement. Movement disorders can be caused by damage either to the motor cortex of the brain or to the muscles. Even though the outcome of the two forms of damage is the same, namely impaired motor skill, neuropathology is different from myopathology. Similarly, even though hyperlexia and dyslexia result in reading disability, they represent two distinct forms of reading disorders with roots in two distinct etiologies. Some of the differences between hyperlexia and dyslexia are summarized in Table 4.4..

TABLE 4.4.
Differences between hyperlexia and developmental dyslexia

Hyperlexia	Dyslexia
Good decoding	Poor decoding
Poor listening comprehension	Adequate listening comprehension
Reading comprehension inferior to decoding	Reading Comprehension superior to decoding
Spelling, above average	Spelling, below average
Below average IQ	Average or above average IQ
Bottom-up processing, data driven	Top-down processing, concept driven
Use of grapheme—phoneme-relational rules and word-specific addressing of pronunciation	Use of print-to-meaning; direct access and word-specific addressing of pronunciation
Clinical neurological symptoms often present	Clinical neurological symptoms usually absent

2.3. *An Operational Definition of Hyperlexia*

In this book, hyperlexia is viewed as a form of reading disability, and in defining it, the cause of the reading disability is given precedence over the symptomatology. For instance, the hyperlexic child's comprehension deficit is considered to be more important than other symptoms. By taking etiological factors into consideration, hyperlexia can be differentiated from other forms of reading disabilities. Aram and Healy (1987) have maintained that abnormal or deficient development in areas other than word decoding is part of the phenomenon of hyperlexia. Healy *et al.* (1982) suggest that the term *hyperlexia* be reserved for the syndrome characterized by spontaneous and intense early interest in letters and words which results in the development of extensive word recognition prior to age 5, coupled with significantly disordered language and cognitive development. Healy (1982) also cautioned that *hyperlexia* not be defined solely on the basis of a discrepancy between word recognition and comprehension skills. Similarly, Snowling and Frith (1986) have described hyperlexia as a reading disorder that is manifested in terms of surprising decoding ability and surprising comprehension failure.

In this book, *hyperlexia* is operationally defined as a reading disorder caused by severe deficiencies in comprehension accompanied by extraordinary facility in decoding that has developed spontaneously and at a very young age.

3. A MODEL OF READING AND READING DISABILITIES

The three groups of poor readers, that is, dyslexic, hyperlexic, and nonspecific reading disabled, as envisaged in the previous discussion are diagrammatically represented in Figure 4.1. The dyslexic reader of the classic type is portrayed as having poor decoding skill. Since language comprehension remains unaffected in dyslexia, disordered oral language skills are not considered as contributing factors to the reading disability. On the other hand, the hyperlexic reader has superior decoding skill; his extremely poor language comprehension is the factor that limits his general reading ability. The individual with nonspecific reading disability — the poor reader of the "garden variety" — has both word decoding and language comprehension deficits, but in varying degrees of combination. It is the degree of the ability to decode print and to comprehend language that separates the subgroups of poor readers from one another. A similar model of reading disability has recently been proposed by Gough and Tunmer (1986). According to their model, there are "three types of reading disability, resulting from an inability to decode, an inability to comprehend, or both. It is argued that the first is dyslexia, the second hyperlexia, and the third common, or garden variety reading disability" (p. 6).

Because hyperlexia does not exist in an "all or none" form but is present in degrees, it is quite possible to encounter poor readers who have moderate age-appropriate ability to decode but have poor

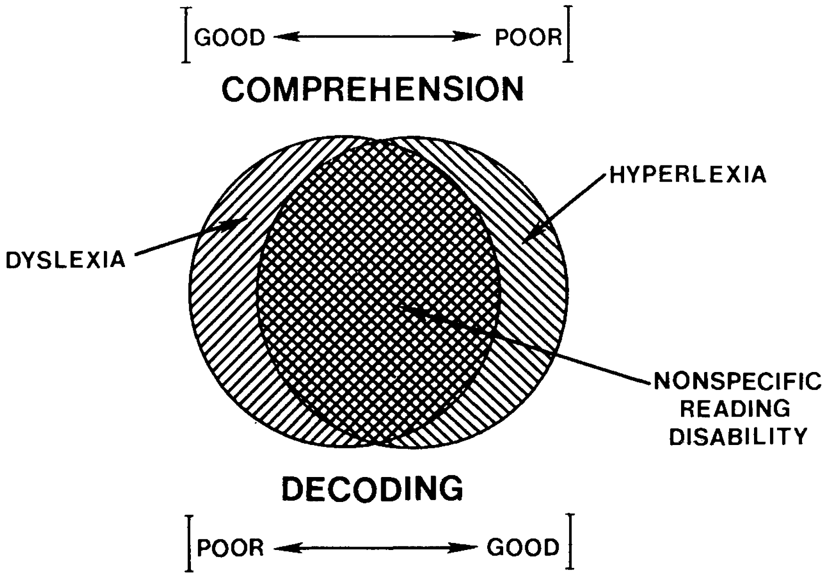


Fig. 4.1. A model depicting the relationship among the three forms of reading disabilities.

comprehension skill. In addition, these readers may not manifest precocity in the acquisition of decoding skill. These children have been traditionally referred to as *word-callers*. In this book, this type of reader is described as exhibiting *hyperlexia-like* symptom. It is important to distinguish readers who manifest hyperlexia-like symptoms from those placed in the NSRD category. Readers belonging to the NSRD category are deficient in *both* decoding and comprehension; those who exhibit hyperlexia-like symptoms have adequate decoding skill but poor comprehension.

The two major components of reading ability, namely decoding and comprehension, can be used as two axes to represent these forms of reading disabilities as well as normal reading performance. A model based on this conceptualization is shown in Figure 4.2. In addition to representing the two major components of reading, this model also can accommodate the fact that reading ability and disability are not discrete entities but represent a range of positions on a continuum.

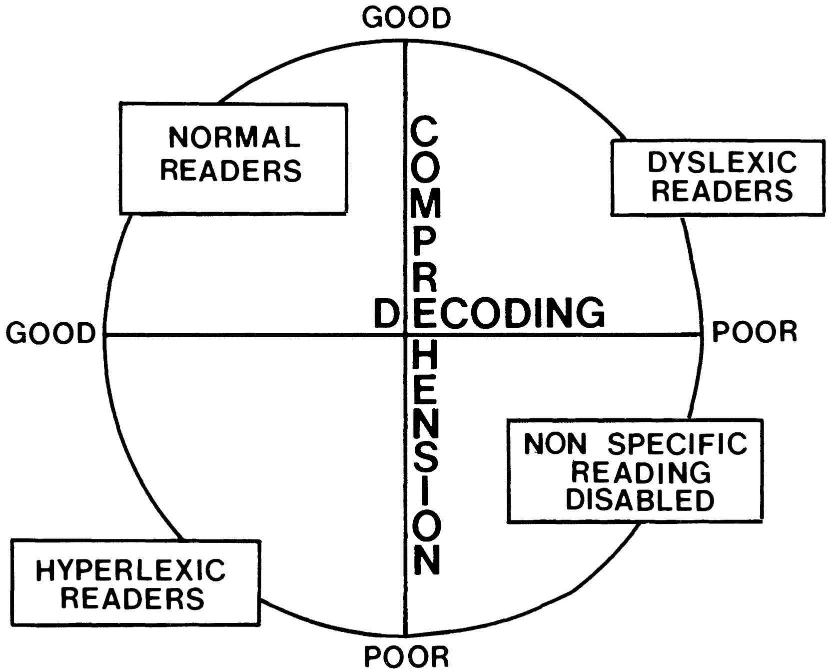


Fig. 4.2. A model depicting the four kinds of readers. (In the general population, the number of dyslexics and hyperlexics is much smaller than that of normal readers and NSRD readers.)

OUTLINE OF CHAPTER 5
['THE "SYNDROMES" OF DEVELOPMENTAL DYSLEXIA AND HYPERLEXIA']

1. The Syndrome of Developmental Dyslexia
   - 1.1. Invariant Symptoms
     - 1.1.1. Slow Reading Speed
     - 1.1.2. Errors in Oral Reading
     - 1.1.3. Poor Spelling
     - 1.1.4. Errors of Syntax in Written Language
     - 1.1.5. Excessive Reliance on Context for Word Recognition
   - 1.2. Variant Symptoms
     - 1.2.1. Reversals in Writing
     - 1.2.2. Neurological Soft Signs
   - 1.3. Two Issues Regarding the Syndrome of Developmental Dyslexia
     - 1.3.1. Is Dyslexia a Heterogeneous Disorder?
     - 1.3.2. Is Dyslexia Orthography-Specific?
2. The Syndrome of Hyperlexia
   - 2.1. Invariant Symptoms
     - 2.1.1. Severely Deficient Comprehension
     - 2.1.2. Developmentally Far Advanced Decoding Skill
     - 2.1.3. Spontaneous Acquisition of Decoding Skill
   - 2.2. Variant Symptoms
     - 2.2.1. Autism
     - 2.2.2. Neurological Impairment

CHAPTER 5

THE "SYNDROMES[1]" OF DEVELOPMENTAL DYSLEXIA AND HYPERLEXIA

1. THE SYNDROME OF DEVELOPMENTAL DYSLEXIA

1.1. *Invariant Symptoms*

Evidence presented in the previous chapters indicates that developmental dyslexia is caused by a difficulty in efficiently processing the phonological features of written language. Such a phonological deficit is manifested in more than one symptom including slow reading, erratic oral reading, spelling errors, and incorrect use of suffixes and other "grammar" errors of written language.

In addition to presenting the symptoms of poor phonological skill, the dyslexic reader tends to compensate for poor phonological skills by relying on other strategies for reading. It is generally accepted that a deficit in any particular process of reading will result in greater reliance on other knowledge sources. Stanovich (1980) has presented this view in the form of the "interactive compensatory model of reading" and has provided substantial evidence to show that higher-level processes compensate for deficiencies in lower-level processes. Stanovich has also shown that poor readers with poor decoding skills rely on semantic context for word recognition more than good readers do. Poor decoding skill, in combination with an excessive dependence on context for word recognition, invariably results in imperfect word recognition. Because the dyslexic reader tends to compensate for poor phonological skills by relying on context for reading, he tends to show evidence of context dependency for word recognition. Reading errors that can be attributed to excessive reliance on context are, therefore, considered as another symptom of the dyslexia syndrome.

Because it is made up of many symptoms, dyslexia is considered a syndrome. Substandard reading skill, the cardinal defect of dyslexia is, therefore, only part of the syndrome. Any viable explanation of the etiology of dyslexia should, therefore, be able to account for the syndrome, not just one symptom or another. Single symptom explanations of dyslexia such as the one based on visual processing defect

(Geiger and Lettvin, 1987) fail to account for the dyslexic reader's other defects such as poor spelling and suffix dropping and, therefore, cannot be satisfactory explanations of the reading disorder.

In sections 1.1.1—1.1.5, the five symptoms that constitute the syndrome of developmental dyslexia are described.

1.1.1. *Slow Reading Speed*

A number of studies show that the speed with which words can be recognized is a major factor that contributes to individual differences in reading fluency (Lesgold and Perfetti, 1978; Mason, 1978; Jackson and McClelland, 1979). Even though some authorities consider speed of word recognition to be separate from the ability to recode items into phonological form (Stanovich, 1980), it is this author's impression that poor readers are held back when they encounter unfamiliar words which must be decoded in order to be understood. A timed reading test prevents the dyslexic reader from attempting to answer all the questions in the test. For this reason, slow rate of reading is considered to be one of the symptoms of dyslexia. In a study described earlier (Aaron and Phillips, 1986), data regarding the reading speed and comprehension of 20 college students were compared. Information regarding reading speed and comprehension was collected by administering the Stanford Diagnostic Reading Test. It was found that the mean reading comprehension scores (grade equivalent) of 18 of the 20 subjects were higher than their reading speed; and the remaining two subjects had equivalent scores. This study also shows that dyslexic subjects continue to remain slow readers in spite of years of educational experience.

It appears that while all dyslexic subjects are slow readers, not all poor readers are slow in reading. A comparison of the reading speed of the twelve dyslexic children described in the previous chapter (Table 4.2., Chapter 4) with those of the twelve NSRD poor readers and twelve normal readers illustrates this point. The reading speeds of these three groups of children were computed from their reading of a list of 20 function words. Isolated words were used to minimize context effect, and function words were used because they occur with such high frequency that even children in primary grades are familiar with them. Analysis of data showed that the dyslexic children took 24.25 seconds to read the list of 20 words, whereas the NSRD children took 12.58 seconds and the control group took 16.75 seconds to read it.

There is also a possibility that the reading speed of the dyslexic reader and that of the NSRD reader can be affected by different factors. This is suggested by the findings of the study in which seven dyslexic college students were compared with seven NSRD and seven normal readers (Aaron, 1987). The reading speeds of the subjects were assessed under two conditions. Under one condition, subjects were administered a Cloze test which made comprehension obligatory. Under the second condition comprehension was not made a requirement; the subjects were asked to read a standard passage and were told that no questions would be asked after they had read the passage. Analysis of the data showed that requiring comprehension depressed the reading speed of the NSRD group more than it affected the reading speed of the dyslexic readers.

1.1.2. *Errors in Oral Reading*

Poor decoding skill leads to a dependency on the sight-word reading strategy. Such a combination of a deficit and a compensatory strategy results in erratic oral reading. Oral reading errors committed by dyslexic subjects involve misreading and omission of both content and function words. It is known that normal readers also tend to commit reading errors which involve function words, but the magnitude of such errors committed by dyslexic readers exceeds normal bounds. Dyslexic readers also tend to commit more reading errors than NSRD readers do. This was true of the dyslexic college students as well as the twelve dyslexic children both described in Chapter 4. Omission and substitution of suffixes are also frequently seen in the oral reading of the dyslexic individual. The substituted function word invariably belongs to the same grammatical category as the target word. For example, the article *a* may be substituted for *the*, the verb *is* for *was*, and the preposition *on* for *above*. This indicates that despite the oral reading errors, the dyslexic reader is monitoring his comprehension. Furthermore, because the target word and the substituted word do not visually resemble each other, defective visual perception cannot explain such misreading nor can lack of familiarity, since these morphemes occur more frequently in text than content words do. These observations are in agreement with the findings of Blank and Bruskin (1984) that beginning readers and dyslexic subjects find it more difficult to process function words than content words. The fact that function words are semantically empty may have something to do with this difficulty, and we can only speculate that morphemes which are to be stored in the working-memory in a phonological form present special problems to the dyslexic reader. The same hypothesis can be advanced to explain the frequent omissions of inflectional morphemes in reading. Even though these errors appear to be instances of agrammatism, on the basis of her observation of Broca's aphasics, Kean (1977) has argued that such errors actually are phonological in nature.

Generally, misreading of content words results in contextually appropriate substitutions. In contrast to the processing of function words, however, the dyslexic subject appears to depend on partial visual cues to process content words, since the target word and the substituted word often have the same initial letters. These visual errors occur because the dyslexic reader does not carry out a phoneme analysis of all the letters in the word. Furthermore, these errors are as prevalent in the reading of isolated words as they are in the reading of sentences. The fact that mature dyslexic subjects commit a substantial number of errors in reading isolated words indicates that the reading problem can be traced down to the level of individual words. The seven dyslexic college students described in Chapter 4 misread nearly one fourth of the words in the list. They also made an equal number of errors when they read lists of "regular" and "irregular" words constructed by Coltheart (1978). Examples of misreading were: *sort* as *sport* or *short*; *cult* as *cute* or *cut*; *spade* as *spare*, *shade*, or *shape*; *pint* as *pin*, *paint*, or *print*. Because good decoding skill is expected to provide an advantage in the oral reading of "regular" words over "irregular" words, an absence of differences in the dyslexic subjects' reading of both lists of words indicates that they used the same strategy in reading both lists. This strategy, probably, is whole-word reading because grapheme—phoneme regularity of the word has little effect on the dyslexic subjects' reading. In spite of their poor reading of non-words and function words, the twelve dyslexic children described in Chapter 4 made few errors in reading the list of highly familiar content words. This discrepant word-reading performance can be explained by postulating a hypothesis that dyslexic subjects use whole-word reading strategy and try to access meaning directly. This strategy can be used successfully in reading familiar content words but not function words which are semantically empty. Dyslexic readers also produce significantly fewer nonsense words during oral reading as compared with

NSRD readers (Aaron, 1987) indicating that they rely on top-down process for reading.

1.1.3. *Poor Spelling*

Many studies of developmental dyslexia suggest that poor spelling is a concomitant of poor reading (Nelson and Warrington, 1976; Cook, 1981; Gerber, 1984). This should come as no surprise since it appears that spelling-to-sound relational rules are used both in reading and spelling (Barron *et al.*, 1980) and that dyslexic readers are deficient in grapheme–phoneme-conversion skills. A recent study by Waters, Bruck, and Siedenberg (1985), which specifically examined the question of whether children use similar processes to read and spell words, found that third-grade children, regardless of their ability level, used spelling–sound correspondences in both reading and spelling. (This statement, however, may not apply to beginning readers and preschoolers; see, for example, Bryant and Bradley, 1980.) For these reasons, it is not surprising that dyslexic readers are poor spellers. Without exception, all the dyslexic readers, including dyslexic college students studied by this author were poor spellers. Even though, probably by using a whole-word reading strategy and by building up a sizeable sight vocabulary, some adults with specific reading disability manage to acquire adequate reading skill, they fail to make similar progress in spelling. Careful testing of these poor spellers who appear to be normal readers reveals residual reading deficits. This point will be discussed below.

The relationship between spelling and reading is so strong that some diagnostic tests of reading disability have incorporated an analysis of spelling performance as part of reading assessment. The classification of dyslexic readers into the dyseidetic and dysphonetic categories developed by Boder (1973) and by Boder and Jarrico (1982) is, perhaps, the most widely-known diagnostic procedure of its kind. According to this system of taxonomy, poor readers, on the basis of the nature of their performance on reading and spelling tasks, are classified into three categories: dysphonetic, dyseidetic, and mixed. The dysphonetic poor reader is said to have poor phonetic skill and tends to process the written word in a global, simultaneous fashion. He depends more on visual memory than on phonological cues to spell the word. Spelling errors produced by the dysphonetic reader are not phonologically acceptable and the target word usually cannot be guessed by sounding out the misspelled word produced by the dysphonetic reader (e.g., *stop* as *ptos*, and *girl* as *gril*). The dyseidetic reader employs the opposite form of strategy and tends to produce phonologically acceptable misspellings (e.g., *girl* as *gal*, and *blue* as *bloo*). A majority of the spelling errors committed by dyslexic readers, particularly the mature ones, appear to be of the dyseidetic type. That is, the spelling errors appear to suggest a weakness of visual memory and a compensatory reliance on phonetic features. Examples of such errors are *city* as *sity*, *duel* as *dul*, *treat* as *treet*, *circuit* as *sercut*, and *gone* as *goan*. The phonology deficit hypothesis of dyslexia which suggests weakness in the use of phonology, therefore, is incongruent with this explanation of dyslexics' spelling patterns. This necessitates a close examination of the nature of spelling defect of the dyslexic reader. Even though at the outset the apparent "incongruence" between the origin of reading errors (poor phonology) and spelling errors (dependency on phonology) seems to be paradoxical, both errors can be traced to poor mastery of grapheme–phoneme-conversion rules (GPC rules) and accommodated within the phonology deficit hypothesis of dyslexia.

A number of investigators have observed that the orthographic rules are progressively acquired by children as they grow older. For instance, one study by Venezky (1976) showed that the pronunciation of *c* as /k/ in initial position before *a*, *o*, or *u* (as in *cat*) is acquired by nearly 88 percent of fourth graders, but *c* as /s/ in initial position before *i*, *e*, or *y* (as in *city*) is learned by only about 40 percent of these children. This study also found that many children learn to pronounce *g* as /g/ (as in *game*) before they learn to pronounce *g* as /dj/ (as in *gem*). Thus, a child who spells *city* as *sity* has not progressed beyond the "one letter = one sound" rule; for him, *c* has one sound, /k/, and *s* has only one sound, /s/. Consequently *city* is spelled with the letter *s*. These spelling errors, therefore, reflect an immaturity in the acquisition of GPC rules rather than an overuse of such rules. For this reason, even though these spelling errors may appear to be "phonetic" they really reflect a poor mastery of phonology.

The progressive mastery of the spelling rules and their relationship to reading was demonstrated in a pilot study conducted by Phillips *et al.* (1985). As a first step in this investigation a spelling test that comprised of 38 words was developed. The 38 words selected were intended to test the proper use of a specific phoneme–grapheme-relational rule (see Appendix I, Tables II and III). The list is based on thirteen such spelling—pronunciation rules. The spelling test was administered to 41 normal readers and 26 poor readers from grades 2 through 6. The poor readers were achieving one or more years below grade level as determined by the Iowa Test of Basic Skills and the Metropolitan Reading Test. Written spelling errors committed by the children were analyzed in two ways. First, using the criterion recommended by Boder (1973) each misspelled word was categorized as either dysphonetic, dyseidetic, or mixed error. For example, spelling the word *girl* as *gal* was considered a dyseidetic error; spelling it as *gril* was considered a dysphonetic error. Errors that could not be classified either as dysphonetic or dyseidetic were considered as mixed errors.

The second analysis was carried out by evaluating each spelling error as correct or incorrect with reference to the particular phoneme—grapheme rule the word was intended to test. For example, in the spelling list, the word *city* is used to test the child's mastery of the *c* as /s/ rule. Misspelling the word as *sity* was considered as an indication that the subject had not acquired this particular rule; misspelling the word as *cite*, even though incorrect, indicated that the child had acquired the *c* as /s/ rule and, therefore, was not counted as an error.

Analysis of spelling errors showed that normal readers committed fewer spelling errors than poor readers did. There was also a gradual increase in the number of words spelled correctly as age increased (Table 5.1.). Poor readers also made some progress but, more importantly, the types of errors they committed changed from being predominantly dysphonetic at second and third grades to being mostly dyseidetic by fourth grade. Analysis of the spelling errors of normal readers with reference to the GPC rules revealed a progressive acquisition of these rules. The *c* as /k/ and *g* as /g/ rules were mastered by almost all the second-grade normal readers. However, rules *c* as /s/ and *g* as /dj/ were mastered only by 65.8 percent of all children. Spelling based on vowel digraphs were correctly reproduced only by 31.5 percent of all children. In terms of patterns of errors, the performance of sixth-grade dyslexic readers was similar to that of second-grade normal readers, suggesting a failure to progress in the acquisition of GPC rules. The abrupt change in the proportion of dysphonetic and dyseidetic spellers from lower to higher grades suggests that developmental cognitive factors are in operation. That is, many poor readers in grades two and three manage to acquire the initial GPC rules by the

TABLE 5.1.

Mean number of words misspelled by normal and poor readers (total number of words = 38)

	Normal Readers			Poor Readers	
	Mean number of words misspelled				
	Dysphonetic	Dyseidetic		Dysphonetic	Dyseidetic
Grades 2 and 3 (n = 18)	4.33	4.84	(n = 9)	15.83	6.67
Grades 4 and 5 (n = 14)	3.64	4.43	(n = 11)	4.60	6.63
Grade 6 (n = 9)	1.33	1.89	(n = 6)	4.60	5.67

time they reach fourth grade. Beyond learning the most elementary rules, however, they fail to master the more complex GPC rules. This interpretation may also explain why almost all the dyslexic college students commit the dyseidetic type of spelling errors.

Pennington *et al.* (1986) studied dyslexic adults, their normal adult relatives, and spelling-age matched normal controls. These authors assumed that producing accurate spelling depends on two strategies: phonological and orthographic. While the phonological strategy may be viewed as involving GPC relational skills, orthographic strategy involves a knowledge of the sequence in which letters occur in written English words. Thus, misspelling the word *anxiety* as *angziaty* is an orthographic error because the sequence of the three letters *ngz* does not occur in written English. Analysis of the spelling errors committed by the dyslexic adults showed that in the group of dyslexics, the development of phonological accuracy but not orthographic accuracy had become delayed or even arrested at about the fifth- or sixth-grade level. These authors also did not find a consistent qualitative difference in phonological accuracy between dyslexics and younger normals. Finucci *et al.* (1983) tested groups of children from grades 3 through 12, including dyslexic children. They found that the type of spelling error varied with the severity of the reading disability. Severely disabled readers produced words which could not be pronounced readily (i.e., dysphonetic errors), whereas mildly disabled readers produced phonologically acceptable errors. Thus, differences among the spelling errors committed by dyslexic readers seem due to a combination of the severity of the reading disability and the level of reading achievement of the subject rather than some intrinsic qualitative differences among dyslexic readers.

Classification of spelling errors is a difficult undertaking because it is not possible to adequately control the subjects' familiarity with the words on the test list. Consequently, it is difficult to decide whether an error of spelling reflects the subject's poor mastery of the spelling skill or a lack of acquaintance with the word. For this reason, it is difficult to examine if qualitative differences exist between spelling errors of dyslexic and NSRD readers even though the former tend to make more errors than the latter. The twelve dyslexic children and the twelve NSRD readers described in the previous chapter were administered the 38-word spelling test (Phillips *et al.*, 1985). As a group, the dyslexic subjects made significantly more errors than did the NSRD and control groups (see Appendix I, Table I). When the performances were inspected individually, it was found one subject from the NSRD group also made as many spelling errors as his matched dyslexic counterpart did. This is because this child may have phonological deficit in addition to comprehension deficit.

At the beginning of this section, it was noted that poor readers are invariably poor spellers. Is the converse statement true? That is, are poor spellers also poor readers? Some investigators have argued that poor spelling need not always be accompanied by poor reading. Spelling disability that reportedly exists along with normal reading ability is referred to as "developmental spelling retardation" (Nelson and Warrington, 1974), "unexpected spelling problems" (Frith, 1980), "spelling only retardation" (Jorm, 1983b), and "specific spelling problems" (Frith, 1984). If GPC rules are essential for both reading and spelling, the existence of "poor speller but good reader" cannot be easily explained. A possible resolution to this controversy can be found in a comment made by Bryant and Bradley (1980) that they had encountered children of 11 and 12 years of age who read well but spelled appallingly but who, around the age of 13, experienced serious reading difficulties because they were unable to use phonological strategy to meet the increased demands of reading. These poor spellers, apparently, use a whole-word strategy for reading, which fails when they encounter unfamiliar and multisyllabic words. It may, therefore, be suspected that the so-called "poor speller—good reader" may be using a whole-word strategy for reading which conceals his decoding deficits.

This possibility was tested by studying three college students who claimed to be poor spellers but good readers (Joshi and Aaron, in press). When the Stanford Diagnostic Reading Test was administered to these three subjects without time restriction, they all obtained comprehension scores at the thirteenth-grade level. However, when the alternate form of the test was administered following the standard time restrictions, their reading scores declined to grade levels, 11.1, 10.5, and 9.1, indicating they were slow readers. When their reading speed was computed, it was found that they read 139, 123, and 81 words per minute. Compared with the reading speed of normal college students, which ranges from 250 to 300 words per minute (Sticht, 1984), this is decidedly slow. In an oral reading task, they also misread many words. They had a tendency to misread more function words than content words. The number of their reading errors is rather high when compared to that usually committed by normal readers. The three subjects were also required to read a list of 50 nonwords made up of the same GPC rules described in the previous spelling study (Phillips *et al.*, 1985). They misread 14, 11, and 20 nonwords, respectively. A matched group of three normal readers misread 2, 4, and 5 nonwords. All three subjects were also administered a list of 75 low-frequency words and another list of 75 high-frequency words. The low-frequency words had a frequency below 90 words per 5,088,721 words of running text and the high-frequency words had a frequency above 90 (Carroll *et al.*, 1971). A frequency effect was found in the sense that all three subjects misread more low-frequency words than high-frequency words. The numbers of low-frequency words read incorrectly were 3, 5, and 11; the corresponding figures for high-frequency words were 1, 0, and 1. Thus, the three "poor spellers but good readers" resemble normal readers in reading high-frequency words but are like dyslexic readers in reading low-frequency words. The "word frequency effect" suggests that they probably depend on sight vocabulary rather than decoding strategy and, therefore, have difficulty reading unfamiliar words. This limited study does not prove that all poor spellers are also poor readers. It does, however, suggest that the notion of the existence of the so-called "poor spellers—good readers" can be accepted only after careful testing because it is likely that they do have residual reading deficits.

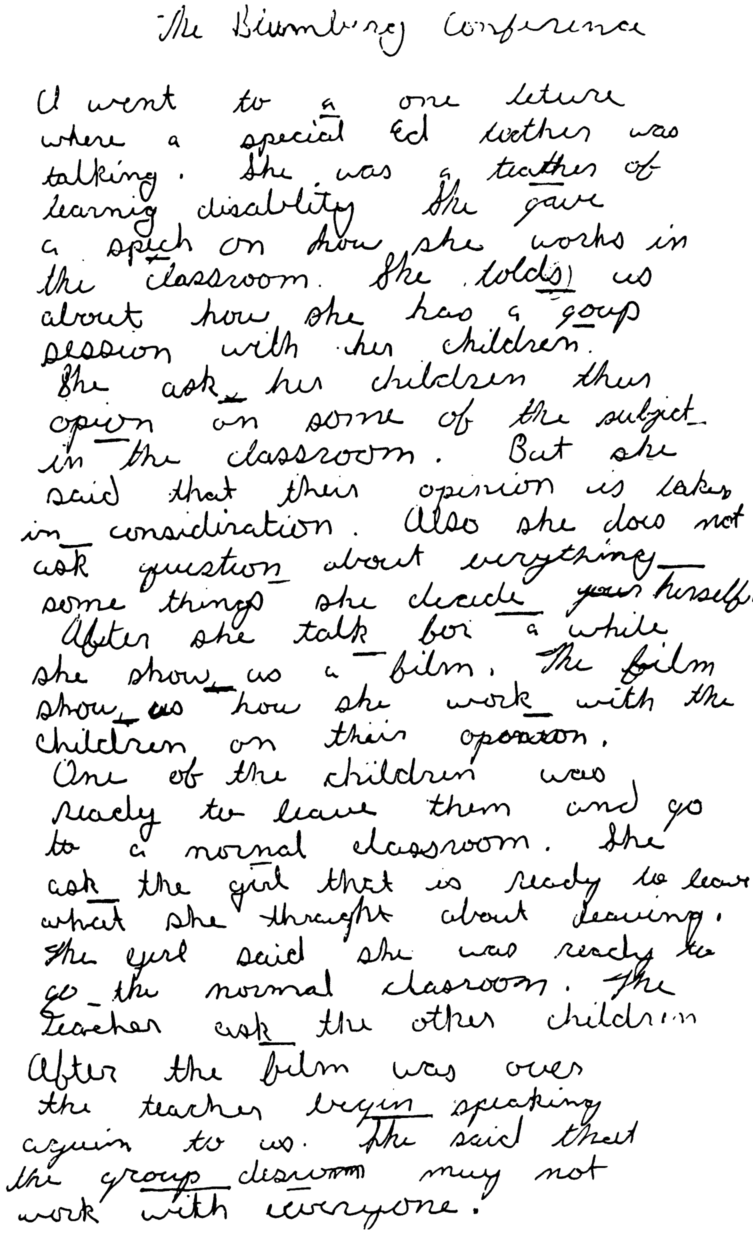
1.1.4. *Errors of Syntax in Written Language*

The written work of dyslexic readers contains errors of grammar even though there is a considerable amount of intersubject variation in the quantity of such errors. These errors are primarily caused by the omission of suffixes of words. Confusion of homophonic words (*were* for *where*, *there* for *their*, *one* for *won*) also result in errors of grammar. By and large, the written language errors reflect oral reading errors. A sample of one dyslexic college student's spontaneous writing which contains written syntactic errors is shown in Figure 5.1. At the outset, these omissions and substitutions would appear to be errors of grammar and give an impression that the dyslexic subject has difficulty in dealing with certain syntactical aspects of language. There is reason to doubt the validity of such an interpretation because the spoken language of these subjects is free from similar errors. An alternate hypothesis of the written errors of syntax would be that, in both reading and writing, the dyslexic subject tends to bypass the phonological code and rely on a direct semantic route. Consequently morphemic units that are semantically empty and have to be processed in some phonological form are likely to be poorly handled and stored in working-memory or not efficiently retrieved.

Experiments conducted by Gibson and Guinet (1971) and by Bock (1982) show that the root morpheme and the suffix of a word are processed separately and by different mechanisms. When the models of lexicons were discussed in Chapter 2, it was seen that during the reading process, suffixes are stripped off the root word and are handled separately. Neuropsychological observations also support this view. For instance, Kean (1977) observes that Broca's aphasics may read *rewind* as *wind* but not *remit* as *mit*. For this reason, errors of reading and writing which appear to be grammatical in nature can be considered as yet another manifestation of poor phonological skill.

1.1.5. *Excessive Reliance on Context for Word Recognition*

Consider the sentence: 'Basketball is a game played by many in America.' When asked to read this sentence, suppose a child reads it as 'Baseball is a game played by men in America.' The reading errors suggest that he probably cannot decode the word *basketball* but can recognize familiar words such as *game* and *play* from context, and guesses the words he cannot decode. Accurate reading of the sentence



The Blumberg Conference

I went to a one leture
where a special Ed tecther was
talking. She was a teather of
learnig disablity She gave
a spech on how she works in
the classroom. She tolds) us
about how she has a goup
session with her children.
She ask_ her children thier
opion on some of the subject_
in the classroom. But she
said that their opinion is taken
in_ consideration. Also she does not
ask question about everything_
some things she decide_ your herself.
After she talk for a while
she show_ us a film. The film
show_ us how she work_ with the
children on their oporaton.
One of the children was
ready to leave them and go
to a normal classroom. She
ask_ the girl that is ready to leave
what she thraght about leaving.
The girl said she was ready to
go_ the normal classroom. The
Teacher ask the other children
After the film was over
the teacher begin speaking
again to us. She said that
the group classroom may not
work with everyone.

Fig. 5.1. Written syntactic errors committed by a dyslexic college student.

apparently starts with the correct recognition of the printed word *basketball.* This initial operation is, therefore, considered as "text driven" or "data driven." Since this operation represents the first step in reading, it is also referred to as the "bottom-up" process. Substitution of the word *baseball* for *basketball* is not an accident but is the result of the reader's previous experience because the child uses context as well as his stored concepts in making this response. This aspect of reading is, therefore, referred to as "context-driven" process. Other terms that are used to describe this aspect of reading are *concept-driven* and *top-down* processing. Accurate and skilled reading cannot be accomplished by either *top-down* or *bottom-up* processing alone. The above example also illustrates that when the *bottom-up* process is blocked, the reader tends to rely more on context to decode print. It is also conceivable that the converse condition can exist. That is, if top-down processing is impeded, the reader is likely to rely on print. The dyslexic reader, being weak in decoding, is likely to depend excessively on context; the hyperlexic reader, being deficient in general knowledge, is likely to depend excessively on print.

There is some controversy about the extent good and poor readers make use of context. Some experts have claimed that good readers make use of context and poor readers are unable to make optimum use of context. But a substantial body of research indicates the opposite to be true (see, for example, Mitchell, 1982). One of the reasons for this controversy is a misunderstanding regarding the stage of reading in which context is thought to play a role. The two stages in which context can play an important role are word recognition and sentence comprehension. There is little doubt that context is important for proper comprehension of sentences. For instance, in the following pair of sentences whether the girl or the dog was fed dog biscuits depends on the context in which it occurs.

(a) Jane's parents were very poor. They always fed her dog biscuits.

(b) Mary's parents were very rich. They always fed her dog biscuits.

In contrast to sentence comprehension, word recognition in the course of normal reading is thought to be less dependent on context because reading is accomplished at too fast a rate to make use of contextual clues. Mitchell (1982), after reviewing relevant literature, concludes that "word recognition is not guided or influenced in any way by the contextual information. . . . Fluent word recognition can be characterized as a bottom-up process" (p. 116). Research also indicates that poor readers with word recognition difficulties depend more on context than on print. The present discussion is limited to the role of context in word recognition.

Juel (1980) compared the errors committed by second- and third-grade children of differing reading ability when they read sentences which contained words of different frequencies. Some of the sentences were constructed in such a way that recognition of the critical word was facilitated by context. She found that poor readers committed fewer errors when word recognition was facilitated by context. Allington and Strange (1977) asked good and poor readers from fourth grade to read sentences in which a single letter in a word was altered (e.g., 'He leaned too fan over the edge'). If the word *fan* was read as *far*, it would indicate reliance on context; if it was read as *fan*, it would indicate the use of reliance on print and the *bottom-up* process. These investigators found that readers from both ability groups tended to substitute the target word with a contextually appropriate word but good readers pronounced the actual target word more often than poor readers did. In another study, Allington and Fleming (1978) required fourth-grade children of two reading ability levels to read 37 words in isolation and the same set of words embedded in sentences. Poor readers misread more words when presented in an isolated list than when presented as part of sentences.

The studies discussed so far have investigated the use of context by good and poor readers but have not distinguished between different types of poor readers. The study of the twelve dyslexic children described in Chapter 4 examined the context dependency of different types of poor readers. It may be recalled that the effect of context was assessed by asking these children to read two standard passages and a transformed version of these two passages in which the order of the words within each sentence was reversed. The data (see Appendix I, Table I) showed that all three groups (dyslexic, NSRD, and normal readers) committed more errors when they read the reversed passages indicating the use of context by all children. The dyslexic group committed the greatest number of errors when they read the transformed text; the control group committed the fewest errors. The NSRD group's performance fell between these two extremes. This study suggests that dyslexic readers depend excessively on context for word recognition.

The five symptoms described above are usually found in all dyslexic readers. Because factors such as severity of the deficit, number of years of reading experience, and the type of remediation received vary among dyslexic readers, quantitative differences among these symptoms may be seen. For this reason, symptoms such as errors of syntax in written language may not, in some dyslexic readers, exist to a clinically recognizable degree. Careful testing of the dyslexic reader, however, reveals evidence of the presence of most of these symptoms. In contrast to these invariant symptoms, there are some other characteristics which are inconsistently related to developmental dyslexia. Two of these variant symptoms are described in the following section.

1.2. *Variant Symptoms*

1.2.1. *Reversals in Writing*

Many individuals who are concerned with children's education, including some elementary school teachers, associate dyslexia exclusively with letter and word reversals in writing. Many parents become alarmed when they see reversals in their young children's writings. We saw in Chapter 1 that Orton was one of the earliest investigators to draw attention to dyslexic readers' tendency to reverse letters and words. Orton (1937) pointed out that a tendency to produce reversals in writing was by no means a reliable and constant symptom of specific reading disability. Systematic investigations undertaken since that time have indicated that Orton was essentially correct in noting the variability of reversal errors in poor readers.

One of the earlier studies to investigate reversal tendencies in children was undertaken by Davidson (1935) who required kindergarten and first-grade children to look at a letter (such as *b*, *d*, *g*, *p*, *n*, *h*) and select from among an array of four letters the one that looked exactly like the target letter. Davidson found that at the first-grade level, significantly more boys than girls made confusion errors. There was no sex difference among kindergarten children. A factor-analytic study by Lyle (1969) found that one of the two factors with the highest loading on reading achievement was letter and sequence reversals in reading and letter reversals in writing. A direct investigation of reversal errors, particularly in oral reading, was undertaken by Fischer *et al.* (1978). These researchers found that reversals in reading represented only a small proportion of the total number of reading errors. Thus, although some investigators have suggested that dyslexic children commit more errors of reversals in reading and writing, others have shown that not all dyslexic readers make reversal errors and that even those who commit such errors are inconsistent in their performance and do not systematically reverse everything they write.

The inconsistent way dyslexic children reverse letters and words probably reflects their tendency to process words as though they are pictures (or logographs) by using a "simultaneous strategy." Several studies show that adult humans can recognize a picture or a geometrical shape as familiar, even if it is the mirror image of the one seen before. Furthermore, they cannot tell whether the test stimulus was the same or a mirror-reversed version of the target stimulus (Rock, 1973; Standing *et al.*, 1970). It appears that stimuli which can be described as spatial or gestalt in nature are processed without regard to their orientation along the horizontal axis. For this reason, it can be argued that readers who process letters and words as though they are gestalts will also tend to disregard the sequential–directional orientation of such stimuli. Such a disregard for directional orientation of stimuli can result in reversals half of the time. Thus, reversals occur in an almost random fashion. Letter and word reversal in written language is, therefore, not a reliable symptom of dyslexia. Furthermore, the tendency to reverse disappears with age. Over a period of ten years, the author has not seen any instance of reversals in the writings of the more than 20 dyslexic college students investigated.

1.2.2. *Neurological Soft Signs*

It is no surprise that individuals with organic brain damage experience reading difficulties. This does not mean that the converse situation has to be true. That is, it cannot be asserted with equal force that those who have reading difficulty have neurological impairment. Rourke (1978) who has discussed this issue notes that "the presence of prenatal, perinatal, and neonatal complications of neurological significance is neither a necessary nor a sufficient explanation for reading disorders in children" (p. 144). Nevertheless, because some dyslexic children have been found to have abnormal EEG patterns and because the difficulties experienced by some dyslexic children in performing temporal—sequential operations resemble those of neurologically impaired children, it is proposed by some neuropsychologists that even though hard neurological signs are not apparent in reading-disabled children, these children may have subtle neurological impairment. The presence of neurological soft signs in some reading-disabled children is taken as evidence of such a subtle neurological impairment. The question is: Do neurological soft signs occur with enough regularity and consistency in dyslexic individuals to be considered as part of the dyslexia syndrome?

Neurological soft sign is defined as "non-normative performance on a motor or sensory test . . . that is elicited from an individual who shows none of the features of a fixed or transient localizable neurological disorder" (Shaffer *et al.*, 1983, p. 144). Neurological soft signs are not symptoms that follow neurological insult such as head injury, infection, or tumor. Clinically, soft signs include finger agnosia (inability to recognize or name the finger that has been touched by the examiner while the subject is blindfolded), inability to recognize if one or more points of the back were touched, inability to move right arm or fingers without making similar movements on the left side of the body, and inability to make smooth and continuous movements with one arm.

Findings of the few studies which looked for specific association between developmental dyslexia and neurological soft signs are inconclusive. Owen *et al.* (1971) compared learning-disabled children with their non-LD siblings and a matched control group. The learning-disabled group differed from the control group in having a few soft signs, but not many. Children in the LD group did not differ from their non-LD siblings in the number of soft signs evidenced. Adams *et al.* (1974) conducted a large scale study of 10-year-old children who had IQs above 85. Even though children with learning disability in this group showed more soft signs than did normal children, the overlap between the two groups was so great that the authors concluded that the signs could not be used reliably for clinical purposes.

Shaffer *et al.* (1983) report a study of 456 seven-year-old children. As part of Collaborative Perinatal Project, measures of soft signs were compared with intelligence and with reading and spelling achievement scores. The investigators found that there was a significant association between soft signs and achievement scores. This association, however, disappeared when IQ was partialled out, indicating that neurological soft signs were positively associated with IQ rather than with reading and spelling scores. This finding underscores the problems in determining correctly the origins of neurological soft signs. Shafer *et al.* (1983) point out that in most studies, the intelligence factor had not been controlled except for the exclusion of retarded children. Studies which have included measures of intelligence show that, in general, subjects with lower IQs show more soft signs than do individuals with average or above average IQs.

There are also other confounding factors which introduce elements of uncertainty in the interpretation of the significance of neurological soft signs. Maturation, genetics, and experience are examples. Shaffer *et al.* (1983) conclude that the clinical value of neurological soft signs is limited by the fact that many apparently normal children, who do not have learning or other problems, also present soft signs. Because neurological soft signs are not seen exclusively in reading-disabled children, these signs cannot be considered reliable symptoms of the syndrome of developmental dyslexia.

The expectation that dyslexic children have neurological soft signs is based on the assumption that something has to be wrong with the neurological equipment of these children. This form of reasoning is based on the *deficit model* of dyslexia. The fact that no consistent differences in overt neurological symptoms between dyslexic and normal readers have been established may be due to a possibility that dyslexic individuals do not have neurological deficits but have come to depend on certain brain functions (or strategies) more than normal readers do. The dependency on such strategies may be so excessive that they occupy an extreme position, even though they could still be considered to be within the normal range of human variation. This explanation is derived from the *difference model* of developmental dyslexia. The view that developmental dyslexia is not caused by brain dysfunction of traumatic origin is supported by the observation that dyslexics, unlike those who are neurologically impaired, frequently possess complementary skills. A statement by Geschwind (1985) illustrates this notion:

> If you have a simple method of preventing the existence of dyslexia, if we just put that into play tomorrow, society might be worse off because we might get rid of five million dyslexics and we might (also) get rid of . . . highly talented people who are superb artists, metal smiths, engineers, and so on. (p. 17)

The difference model of developmental dyslexia fits rather nicely with the componential structure of the reading process. That is, decoding and comprehension abilities are separate and independent components of reading, and decoding skill is an autonomous, specific ability that is independent of the "g" factor of intelligence. A study by the author (Aaron, 1985) in which the performances of 15 dyslexic college students were analyzed found that the correlation coefficient between decoding (as determined by a nonword reading task) and WAIS Full-scale IQ was insignificant. It appears that the decoding operation is carried out by a relatively autonomous system. In this respect, decoding may be considered an automatized subroutine that is modular in nature. In his book *Modularity of Mind*, Fodor (1983) considers modular abilities as input systems and describes them as being domain-specific, mandatory, fast, informationally encapsulated, less subject to influence from top-down, and associated with fixed neuronal architecture. Decoding skill matches these descriptions and its neuronal and cognitive specificity is demonstrated by cases of acquired deep and phonological dyslexia as well as by hyperlexia.

Before concluding the developmental dyslexia section of this chapter, two issues that are frequently raised in conjunction with developmental dyslexia will be addressed. These are the heterogeneity of the dyslexia syndrome and the relationship between dyslexia and orthography.

1.3. *Two Issues Regarding the Syndrome of Developmental Dyslexia*

1.3.1. *Is Dyslexia a Heterogeneous Disorder?*

Many investigators have considered seriously the possibility that developmental dyslexia is not a homogeneous disorder and that there are dyslexia subtypes. It is true that there are different varieties of reading disorders. For example, the three varieties of reading disorders, namely dyslexia, hyperlexia, and NSRD, presented in this book can be considered as reading disability subtypes. It has to be noted that in this book, developmental dyslexia is presented as one of the three reading disability subtypes. The question is whether dyslexia itself has its own clearly identifiable subtypes. The answer depends on the crucial distinction between dyslexia in particular and reading disabilities in general. Many investigations of reading-disability subtypes have treated dyslexia, reading disability, reading disorder, and learning disability as synonyms. It is not surprising that, when a group of learning-disabled children with a variety of cognitive deficits is studied, differences among them emerge. A comprehensive review of reading-disability subtype studies is provided by Malatesha and Dougan (1982). In a recent article, Siegel *et al.* (1985) have critically examined this issue.

Satz *et al.* (1985) note that the two critical issues which subtype studies face are subtype stability and subtype interpretation. It is likely that the reading level of poor readers, unless controlled, could, as a developmental factor create a false impression of subtypes. Earlier in this chapter, the subtype classification of dyslexia proposed by Boder (1973) and Boder and Jarrico (1982) was briefly discussed. It was also noted that the subtypes based on reading—spelling performance pattern may be artifacts representing stages of reading acquisition rather than differences in cognitive skills. One of the reasons for such a conclusion is that the proportion of dyseidetic to dysphonetic readers changes with age and at the college level, the dysphonetic subtype disappears altogether. As noted earlier (Table 5.1.) the spelling pattern of fifth-grade poor readers resembled those of second-grade normal readers, and among poor readers, the ratio of dyseidetic to dysphonetic subtypes did not remain constant over the grades. These findings suggest that these subtypes may actually represent substages of reading skill acquisition. The study by van den Bos (1984) mentioned earlier also failed to find differences between dysphonetic and dyseidetic poor readers. In his study, van den Bos classified 9- and 10-year-old Dutch children as dysphonetic and dyseidetic and tested their performance on auditory and visual information processing tasks. He found that dyseidetic children were as poor as dysphonetics in both the auditory and visual tasks. Satz *et al.* (1985) report the existence of a group of disabled readers who do not have any cognitive or linguistic deficits. They estimate that this "unexpected" subtype may constitute as much as 25 percent of the population of poor readers. More importantly, Satz and his co-workers found that the test performance of this group improved over a period of six years and the pattern changed. This group appears to be similar to the 20 dyslexic college students described earlier who comprised a homogeneous group (Aaron and Phillips, 1986).

As to the difficulty in interpreting the "subtypes," it appears that despite claims of differences among subtypes, some form of phonology related deficit underlies the difficulties of all the subtypes described. In order to identify possible reading-disability subtypes, Doehring and Hoshko (1977) and Doehring *et al.* (1981) administered a large number of tests to poor and normal readers. After analyzing the data for factors, they identified three major subtypes of reading disability and labeled them as oral reading deficit subgroup, intermodal-associative deficit subgroup, and sequential relations deficit subgroup. Their description of each of the subtypes indicates that children in all three subgroups had word recognition and pronunciation problems which suggests that the subgroups are more similar to each other in certain respects than they are dissimilar. Doehring (1984) himself has noted that "the most profound reading disabilities involve difficulty in acquiring lower-level coding and word-recognition skills" (p. 211).

Petrauskas and Rourke (1979; also see Rourke and Strang, 1983) administered a battery of tests to 160 seven- and eight-year-old children, of whom 133 were retarded in reading. They obtained 44 dependent measures, and factor analysis of this data yielded evidence for three subtypes. Subjects placed in subtype 1 had marked difficulties on tests that were primarily verbal in nature. They also had auditory—verbal and language-related problems and their verbal IQ was lower than their performance IQ. Subjects in subtype 2 had auditory—verbal and language-related problems to a lesser degree than those in subtype 1. These children, in addition, performed very poorly on tests of finger agnosia. Subtype 3, which constituted the smallest category consisted of children with adequate visuo-spatial skills. These children performed poorly on tasks of verbal information and verbal coding and had lower verbal than performance IQs. Here again, some language-related deficit seems to be a common denominator of all three subtypes which raises the question whether the subtypes are psychologically real or artifacts of the statistical procedures adopted in the analysis of data.

Even though some studies have reached conclusions favoring the notion of dyslexia subtypes, review articles are uncertain about the validity of these subtypes. For example, Doehring (1984) noted that there does not seem to be general agreement as to the number of different subtypes and their distinguishing characteristics. Satz *et al.* (1985), in their discussion of subtypes, note that homogeneity within any given subtype has not been demonstrated and that existing studies have failed to show if subtypes differ in their etiology and the nature of the cognitive and neurological substrates. In a discussion of the issue of dyslexia subtypes, Siegel *et al.* (1985) have classified the studies of subtyping into the following four broad categories: subtyping based on (i) achievement tests, (ii) patterns of responses on reading tests, (iii) neuropsychological measures, and (iv) multivariate statistical procedures. After reviewing some important studies from each one of these categories, these authors concluded that "conclusive and convincing evidence of subtypes of reading disability has not emerged. . . . Apparent heterogeneity is a function of the definition used. . . . If a logically consistent definition of dyslexia is used, all dyslexic children have problems with language" (p. 186).

Mention must be made of the fact that in many reading subtype studies, a visual—perceptual deficit group has emerged as a separate entity. Can there be a visual—perceptual deficit dyslexia group? This problem was discussed in Chapter 3 and evidence was presented to show that dyslexia is not associated with visual—perceptual deficits although it is possible that poor visual perception may be associated with other forms of reading disability. Two of the twelve NSRD children (see Appendix I) have performance IQ scores that are 1 SD below mean. These children, however, have low full-scale IQs and are also poor in listening comprehension and, therefore, cannot be considered dyslexic. It appears that if IQ and comprehension requirements are relaxed, a visual—perceptual-deficient reading-disability subtype will emerge. This group, however, does not fit the criteria established in this book for developmental dyslexia.

In order to show that subtypes of dyslexia other than phonology-deficient dyslexia exist, it would be necessary to demonstrate the existence of poor readers with normal intelligence and normal phonological ability, who are deficient in some other reading-related operation. This might be difficult to accomplish because the only other major component that is a potential causative factor of reading disability is poor comprehension. Because poor readers with subnormal comprehension also tend to have below average IQs, they cannot be considered as dyslexic. In this book they are described as having nonspecific reading disability (NSRD).

1.3.2. *Is Dyslexia Orthography-Specific?*

If phonological deficit and an associated poor GPC skill are responsible for the reading difficulties of the dyslexic child, then a writing system with a one-to-one correspondence between spelling and pronunciation that does not require the use of complex GPC skills for reading can be expected to minimize the decoding problem. The incidence of developmental dyslexia, therefore, can be expected to be very low in users of such an orthography. To take the reverse of this, it can be argued that poor phonological skill is a problem intrinsic to the reader and is only incidentally related to the script, which is extrinsic to the reader. Furthermore, other symptoms of dyslexia such as suffix and function word errors in writing and reading can also be expected to be seen in users of languages with shallow orthographies. Thus, a controversy exists regarding the relationship between orthography and reading. It is not surprising, therefore, that reports of the absence of reading disability and reading retardation in the Japanese language (see, for example, Makita, 1968) have aroused a great deal of interest. A claim that reading disabilities do not exist among Chinese children has also been made by Kuo, a Chinese psychologist (Stevenson *et al.*, 1982). Examination of this issue requires a knowledge of the nature of Japanese orthography.

The Japanese writing system is made up of three different kinds of symbols: *katakana*, *hiragana*, and *kanji*. Both *katakana* and *hiragana* are written in syllabic form. *Katakana* is used primarily to represent borrowed words and is not of much relevance to the present discussion. Each of the nearly 71 *hiragana* characters represents a single syllable and is associated with a single pronunciation. In this respect, *hiragana* syllables differ from English syllables which can represent more than a single sound pattern (e.g., *ra*pid, *ra*dio, *ra*ucous). *Kanji*, which has been borrowed from the Chinese language, is in logographic form. Each Japanese word is made up of one or more *kanji* characters, and a single *kanji* character may have more than one pronunciation, depending on the context. Content words such as nouns, verbs, and adjectives are written in *kanji* whereas function words are represented in *hiragana*. By the end of middle school, Japanese children are expected to have learned to read 1,850 *kanji* characters (Stevenson *et al.*, 1982). Because each *hiragana* character is pronounced one way only and each *kanji* character can be pronounced by associating the logograph with sound, the need for the use of phonological analysis of the written character is minimal. In other words, the pronunciation of these characters need not be assembled but can be addressed. In addition, because the syllable appears to be a natural unit of speech perception (Rozin and Gleitman, 1977), syllable-based orthographies have an advantage over alphabetic scripts. For these reasons, it is reasonable to expect the incidence of specific reading disability to be minimal or even nonexistent in languages such as Japanese and Chinese.

Reports that reading disability does not exist among Japanese children are not based on systematic research but are based primarily on teacher judgments. It is quite possible that Japanese teachers consider poor readers of the NSRD type as poor achievers in subject matter areas and, therefore, may not report them as cases of reading disability. One exception to this statement is a study conducted by Stevenson *et al.* (1982). These investigators constructed reading tests in English, Japanese, and Chinese languages and administered them to large samples of fifth-grade children in Japan, Taiwan, and the U.S. In addition to assessing the children's ability to read aloud isolated words and reading comprehension, they also administered a battery of verbal and nonverbal cognitive tasks. These children were also administered Raven's Progressive Matrices Test, and those who obtained IQ scores below 70 were not included in the data analysis. Analysis of the scores of children whose *z* scores in the cognitive tests were greater than 1 SD below mean showed that, contrary to the generally held belief, 5.4 percent of the Japanese children and 7.5 percent of the Chinese children were reading more than two grades below their grade placement. The corresponding figure for American children was 6.3 percent. The authors concluded that these findings offer no support to the hypothesis that the orthographic systems of Japanese and Chinese languages preclude the development of disabilities in reading.

In spite of this conclusion, inspection of data provided by these investigators suggests there is reason to believe that orthography might have contributed to the difficulties of *some* children from the U.S. When Stevenson *et al.* analyzed the data to see what contributed to the reading retardation of the poor readers, they found that among Japanese children who were two years behind in reading, 2 percent had poor word-reading skill, 64 percent had poor comprehension, and 34 percent had a combination of the two. The corresponding figures for American children were 5 percent, 52 percent, and 44 percent. This means that 5 percent of American children had word-reading difficulty but adequate comprehension, whereas, only 2 percent of the Japanese children and 1 percent of Chinese children were poor readers because of word-reading deficit. Thus, more American children were found to be poor readers because of word-reading difficulty. The 3 and 4 percent excess of American children with word-reading difficulty may, therefore, be attributed to the nature of English orthography. The investigators themselves concluded: "The causes of failure to meet the criteria for satisfactory reading tend to differ according to the severity of the problem and the language being used." (p. 1173). The 5, 2, and 1 percent English, Japanese, and Chinese poor readers with word-reading difficulty can be considered dyslexic because they had adequate comprehension.

It was noted earlier that even though oral reading errors may be influenced by orthography, other symptoms of dyslexia may not be affected by it to the same extent. A study of an Italian dyslexic boy by Sartori (1987) illustrates this point. Unlike English, Italian orthography is shallow in the sense that no complex rules are involved in grapheme—phoneme conversion and words are spelled the way they are pronounced. Such a highly regular orthography, therefore, minimizes the opportunity for committing spelling errors. There exists, however, a possibility for committing errors of parsing, segmentation, and blending in written Italian. For example *la radio* could be incorrectly parsed and written as *l aradio* or blended as *laradio.* In addition, spelling errors can also occur as a result of consonant doubling (e.g., *casa* as *ccasa*), letter substitutions (e.g., *ipocrito* as *ipoclito*), letter additions (e.g., *queqlj* as *quelqlj*), and letter deletions (e.g., *contrastare* as *contastare*). A sample of written spelling errors committed by the 15-year-old boy reported by Sartori are: *l'anno scorso* as *lanno scorso*, *Ad ogni* as *a dogni*, *inizio* as *i nizio*, *la mamma* as *lamamma*, *taccuini* as *tacguini*, and *sogguadro* as *socguadro.* Spelling errors of certain types can, therefore, occur in shallow orthographies.

An investigation of limited scope which compared the reading performance of children in two languages with orthographies of varying depths was conducted by the author (Aaron, 1982). This study involved forty children from grades 8, 9, and 10 whose mother tongue was Tamil, which is one of the four principal Dravidian languages. It is spoken by more than 30 million people in South India, parts of Sri Lanka, Malaysia, and a few other places. It is a highly inflected language with grammatical markers such as tense, number, and case represented by the suffixes. Furthermore, it is an agglutinative language in the sense that separate formal morphemic units are blended and incorporated into a single word. The Tamil script is almost entirely alphabetical, with each character pronounced one way only. Formal instruction in English for these children starts when they reach 5th grade and the language is taught for no less than five hours a week. The alphabet is introduced first, and the method of reading instruction is essentially phonetic. These forty children were asked to read passages in Tamil and English, and their performance was taped, transcribed, and analyzed. Each passage contained five paragraphs from their Tamil textbook. The passage chosen was from the textbook used in their classrooms but the material had not been introduced as a lesson. Subsequently, each child was asked to read three passages from Durrell's reading test. The eighth-grade boys read passages from Durrell's level two, the ninth graders read level three, and the tenth graders read level four.

Analysis of reading errors showed that very few errors of mispronunciation were committed in the reading of Tamil. Omission and substitution of suffixes, however, were common in the reading of Tamil. Mispronunciation, literal decoding of words, and omission of words and suffixes occurred with higher frequency in the reading of English than in the reading of Tamil. However, the correlation coefficient obtained between the mean number of agrammatic errors committed in Tamil and English was 0.92. The five boys who committed the highest number of errors in reading English also committed the highest number of errors in Tamil. This study reveals that poor readers are poor readers regardless of the language even though the intensity of symptoms may vary according to the orthography.

These studies show that the neurological substrata responsible for developmental dyslexia is present in children from different countries. Dyslexia is not limited to certain orthographies even though some of the symptoms can be exacerbated by some writing systems.

This section on developmental dyslexia can be concluded by stating that the syndrome of developmental dyslexia is made up of five major symptoms: slow reading, incorrect oral reading, defective spelling, syntax errors in writing, and excessive reliance on context for word recognition. Because these symptoms are influenced by variables such as severity of the reading disability, educational experience, and the nature of orthography, the degree of the expressivity of these symptoms may vary from individual to individual. These symptoms, however, collectively can be used for diagnostic purposes.

2. THE SYNDROME OF HYPERLEXIA

The syndromic nature of hyperlexia was discussed briefly in Chapter 4. The symptoms of hyperlexia can also be classified into two categories: invariant symptoms that are seen in all cases of hyperlexia and variant symptoms seen in many but not all cases of hyperlexia. In order to be identified unequivocally as hyperlexic, an individual should show signs of the presence of the three invariant symptoms. Variant symptoms, when present along with the invariant symptoms, provide further confirmation of the diagnosis of hyperlexia.

The three invariant symptoms that constitute the core of the syndrome of hyperlexia are: (1) severely deficient comprehension, (2) developmentally far advanced decoding skills, and (3) spontaneous acquisition of the decoding skills.

2.1. *Invariant Symptoms*

2.1.1. *Severely Deficient Comprehension*

Research relating to hyperlexic children's performance in comprehending words, sentences, and text was presented in Chapter 3. It was noted that hyperlexic children were found to be uniformly poor in comprehending text-level material even though there was some variability in their ability to comprehend words and simple sentences. In general, hyperlexic readers may be able to associate isolated single words and sentences with their meanings in a rote fashion. However, when comprehension depends on the cohesion of sentences, organization of ideas, and making of inferences when information is not explicit, they perform poorly. The comprehension deficit includes both written and spoken language. Aram and Healy (1987), who have reviewed the important literature available on hyperlexia, concluded that a significant disorder of language comprehension is fundamentally associated with hyperlexia.

2.1.2. *Developmentally Far Advanced Decoding Skill*

Not only do hyperlexic children begin decoding words earlier than most normal children, they also become quite proficient in this skill within a very short time. For instance, one of the children described by

Huttenlocher and Huttenlocher (1973) read aloud fluently a third-grade reading paragraph at the age of 4 years and 10 months; another child read aloud the newspaper at the age of 3 years. A majority of the twelve children described by Healy *et al.* (1982) was far advanced in word decoding as determined by the Wide Range Achievement Test. Some of the 7-year-old children from this group were decoding words at the seventh- and ninth-grade levels even though a few children were advanced by only one or two years. It is not known how advanced a decoding skill a disabled reader should have before being considered as hyperlexic. It is, however, to be noted that decoding skill, by itself, cannot be used as the sole criterion for identifying hyperlexia; rather, exceptional decoding skill should be treated as part of the symptom complex of hyperlexia and should occur in conjunction with subnormal comprehension ability. According to Snowling and Frith (1986), "true hyperlexia is manifested in terms of both surprising decoding success and surprising comprehension failure" (p. 410). Rispens and Berckelaer (in press) stress this concept of double discrepancy in defining hyperlexia. After discussing the problems in defining hyperlexia, these authors cite their own study of hyperlexic children and conclude that defining hyperlexia in terms of a single discrepancy misses an important point. According to Rispens and Berchelaer, hyperlexia should be defined in terms of this double discrepancy of above-normal decoding and subnormal comprehension.

Developmental dyslexia can be considered to represent a converse condition and be defined in terms of double discrepancy also, that is, normal comprehension and subnormal decoding abilities.

2.1.3. *Spontaneous Acquisition of Decoding Skill*

Even though some precocious children who eventually become proficient readers acquire reading skills without formal instruction during their preschool years, a majority of children learns to decode the printed word only after they enter kindergarten or first grade. Many children who learn to read during preschool years are academically talented and eventually turn out to be excellent readers. This, of course, is not the case with the hyperlexic child who remains a poor comprehender in spite of his precocious decoding performance. In the hyperlexic child, decoding remains as a splinter skill.

Almost all the published reports on hyperlexia make remarks about the spontaneous early development of decoding skill. In fact, some children seem to have started reading aloud even before they began to talk. Parents reportedly provided assistance only after making the startling discovery that their child could read. Aram and Healy (1987) have tabulated information regarding the age of onset of word decoding in 62 children for whom information about early history was available. These data show that in some children, the decoding ability manifested itself as early as one year of age. All 62 children had started reading words aloud before the age of 5 years. Spontaneous, early acquisition of decoding skill, therefore, constitutes an important component of hyperlexia.

2.2. *Variant Symptoms*

The two symptoms that are reportedly seen in many but not all hyperlexic children are autism and signs indicative of neurological impairment.

2.2.1. *Autism*

Even though a large number of hyperlexic children manifest autistic symptoms, not all of them do. It was noted in the earlier section that some of the autistic children studied by Whitehouse and Harris (1984) cannot be considered as hyperlexic because they had superior intelligence. In a recent study, Burd *et al.* (1985) examined a group of 68 children with developmental disorders or with autistic or autistic-like behavior. Of the 68 children, 21 were identified as autistic according to the DSM III criteria. However, only four children were diagnosed as hyperlexic. This indicates that a majority of children identified as autistic were not hyperlexic. Snowling and Frith (1986), who studied autistic and mentally retarded children with hyperlexia, found that the performance of autistic-hyperlexic readers was indistinguishable from that of mildly retarded-hyperlexic children. This led the researchers to conclude that hyperlexia is not an autism-specific syndrome. Rispens and Berckelaer (in press) studied 32 autistic children and found that when the double discrepancy criterion (i.e., subnormal comprehension, above-normal decoding) was applied, only four children could be unequivocally diagnosed as hyperlexic.

2.2.2. *Neurological Impairment*

Even though many investigators have described the health history of hyperlexic children, no consistent picture regarding the neurological status of these children has emerged. Aram and Healy (1987), in their review, conclude that clinical neurological findings have been highly variable ranging from overt seizure disorders to completely negative results. They add that conventional neurological laboratory findings have also been equally unproductive. Thus, neither neurological history nor neurological examinations have contributed to the understanding of the etiology of hyperlexia.

NOTE

[1] According to *The American Heritage Dictionary* (Houghton Mifflin, 1976), "a *syndrome* is a group of signs and symptoms that collectively indicate or characterize a disease, psychological disorder, or other abnormal condition." Because reading performance is subject to the influence of various factors such as age of the reader, his learning experience, and severity of the reading disability, symptoms described in this chapter may not clinically manifest themselves to the same degree in all subjects. Consequently, some of the symptoms of dyslexia may be present in too mild a form to be clinically recognizable. For the same reason, all the invariant symptoms of dyslexia need not be present for a diagnosis of dyslexia to be made. I wish to thank Michel Paradis for drawing my attention to this fact.

OUTLINE OF CHAPTER 6
['DIFFERENTIAL DIAGNOSIS OF READING DISABILITIES']

CHAPTER 6

DIFFERENTIAL DIAGNOSIS OF READING DISABILITIES

1. INTRODUCTION

The traditional method of diagnosing developmental dyslexia is based on the exclusionary definition which includes the proviso that developmental dyslexia is not caused by intellectual deficiency. Thus, an important criterion used in the identification of developmental dyslexia is the discrepancy between the reader's potential to read and his actual reading achievement.

In the U.S., this view is given official status by Public Law 94—142, part of which states "when a severe discrepancy between ability and achievement exists which cannot be explained by the presence of other known factors that lead to such a discrepancy, the cause is believed to be a specific learning disability" (Federal Register 42, no. 250, December 29, 1977, p. 65085). Even though this statement is intended for the diagnosis of learning disability in general, the academic achievement of learning-disabled children is almost always assessed with the aid of some standardized test of reading ability or an achievement test of which reading is a major component (Artley, 1980; Gaskins, 1982; German *et al.*, 1985). For this reason, a substantial number of children identified as learning disabled are in actuality reading disabled. It is not even certain, with the exception of a few children who may have specific difficulty in arithmetic, if there exists any learning disability other than specific reading disability. Conditions such as attention deficit disorder and perceptual deficit refer to putative causal factors that may affect reading and arithmetic learning but are not learning disabilities *per se*. At any rate, the discrepancy concept, often expressed in quantitative terms in the form of discrepancy formulas, is generally used in the identification of the reading-disabled child. The individually administered intelligence test, particularly the WISC-R, is the most widely-used instrument for estimating the child's potential to achieve in school. The use of intelligence tests, in essence, is meant to separate the dyslexic child from the NSRD child. Reading specialists sometimes refer to NSRD children as *slow learners* and distinguish them from the dyslexic child by reading achievement which, although below their chronological age, falls in line with their mental age (Harris and Sipay, 1985). The use of IQ tests to differentiate between the dyslexic and the NSRD reader is, however, fraught with several problems.

There exists no consensus about how much of a discrepancy between reading potential and achievement indicates specific reading disability. There is also disagreement as to which is the best statistic to use (MA or IQ, regression formulas or reading expectancy formulas) to separate the two groups of poor readers. Consequently, formulas that incorporate IQ to arrive at discrepancy indices have frequently been found to be in disagreement with each other regarding diagnostic decisions. For instance, Forness *et al.* (1983) tested the degree of consensus among eight discrepancy formulas in identifying 92 potentially learning-disabled children and found that there was consensus among all the formulas regarding only seven children. Similar conclusions have been reached by Smith *et al.* (1977) as well as by Algozzine, Yesseldyke, and Shinn (1982). Recently, the Board of Trustees of the Council for Learning Disabilities expressed opposition to the use of discrepancy formulas to determine eligibility for learning disability services on the grounds that such formulas often create a false sense of objectivity and precision and that technically adequate and age-appropriate assessment instruments are not currently available (*Journal of Learning Disabilities* 20, p. 349, 1987).

There are additional problems in utilizing IQ scores in the differential diagnosis of reading disabilities. Even though, as some occasional reports claim, reading achievement and IQ scores may have a correlation coefficient as high as 0.7 by grade 4, IQ accounts for less than half of the variance seen in reading achievement. In actuality, even this figure may be somewhat inflated. For instance, Stanovich *et al.* (1984b), who have reviewed some 40 research publications, conclude that a typical correlation between intelligence and reading ability would fall in the 0.3 to 0.5 range in early elementary grades and in the 0.45 to 0.65 range in the middle grades and that the value of 0.68 is typical of only adult performance patterns. These figures indicate that diagnostic procedures which rely on IQ tests alone ignore other important potential factors that contribute to individual differences in reading achievement.

A problem of an unexpected nature in the use of IQ tests has, of late, come to the fore: the legal injunction that prohibits the use of intelligence test scores for making educational placement decisions. Recently, the California Supreme Court reissued its former verdict that IQ tests cannot be used in the decision-making processes that involve minority children for placement in special education and learning disability classes (Landers, 1986). A far more serious problem of an educational nature is the fact that intelligence tests do not provide guidance to the practitioner or the teacher as to remedial approaches. Even assuming that an IQ test can tell whether the child has specific reading disability, it does not tell what is to be done once the reading problem is identified.

These limitations of the traditional assessment procedure have led researchers to explore alternative criteria and procedures that will be helpful in the diagnosis of reading disabilities. A major change that is taking place in the field of reading disabilities is to carry out an analysis of the system's primary processes, rather than an assessment of some underlying deficit in mental ability, and to make diagnosis on the basis of the child's performance on ecologically valid reading-related tasks. This procedure, sometimes referred to as the *componential approach*, has the advantage of linking diagnosis with suggestions regarding remedial instruction.

The procedure described in this chapter uses a form of componential analysis of the reading process and attempts to carry out the diagnosis by utilizing some of the desirable features of the traditional psychometric methods. The diagnostic procedure is developed with the following five objectives in mind: (1) For differential diagnosis of reading disabilities, the diagnostic procedure should be able to distinguish the dyslexic child from the NSRD child and from the poor reader who has comprehension deficit only (i.e., hyperlexia-like) (2) The procedure should evaluate the process of reading by identifying the component that is functioning at sub-optimal level (3) It should be easily adaptable for classroom use; the teacher or the school psychologist should be able to carry out the procedure with a minimal amount of time and effort and without the need to use special apparatus (4) The procedure should be flexible so that the teacher/psychologist should be able to modify it for local use and develop local norms for the tests (5) The diagnostic procedure should be comprehensive enough to include quantitative as well as qualitative information that is relevant to the reading process.

2. RATIONALE OF THE DIAGNOSTIC PROCEDURE

The diagnostic procedure is based on the assumption that the level of any cognitive operation is determined by the performance of its weakest component. In other words, the component which functions the least efficiently will act as the factor that limits the cognitive operation. Diagnosis aims to identify that component which operates at sub-optimal level. Consequently, two questions can be asked: What are the components of reading, and how do we evaluate the efficiency of the components so identified?

2.1. *Components of Reading*

A *component* is defined as an elementary information process that operates upon internal representations of objects and symbols (Sternberg, 1985). A process that is elementary enough to be labeled a *component* depends upon the independence of the process from other factors as well as the desired level of theorizing chosen by the researcher. For example, Stanovich *et al.* (1984b) have identified verbal comprehension, phonological awareness, and decoding speed as the three most important factors or components of reading skill. Jackson and McClelland (1979) found a measure of letter and word name access and listening comprehension to be the two most important components accounting for most of the variability seen in reading ability. After studying college students of different reading abilities, Palmer *et al.* (1985) concluded that the speed of accessing visual codes and comprehension are the two major components of reading. Frederiksen (1982), on the other hand, breaks down the code analysis process into four components: encoding multigraphemic units, translating graphemic units to phonemic units, assigning approriate speech patterns to multi-word units, and retrieving lexical categories.

The diagnostic procedure described in this chapter is based on the model of reading which presumes that decoding and comprehension are the two most important components of reading. In addition to the findings of experimental studies, the existence of hyperlexic children who can decode print with extraordinary skill but cannot comprehend what is read and dyslexic children who cannot decode print efficiently but can demonstrate adequate comprehension (Frith and Snowling, 1983) as well as the phenomenon of deep and surface dyslexia suggest that word-name accessing and comprehension are two major components of reading. The diagnostic procedure described in this book considers letter and word-name access as equivalent to decoding.

These two components of reading also appear to differ in their psychological qualities. According to the classification of cognitive processes proposed by Schneider and Shiffrin (1977), reading comprehension can be viewed as a *controlled process* and decoding as an *automatized process*. Automatic processing is not attention-demanding and can be carried out without the reader's conscious control, whereas controlled processing is attention-demanding and capacity-limited. However, in some individuals, decoding does not become an automatized function (LaBerge and Samuels, 1974) and remains as an attention-demanding operation. Consequently, decoding draws upon the resources available for the comprehension process and thereby compromises it. Dyslexic readers appear to fit this description.

For these reasons, the diagnostic procedure presented in this book considers decoding and comprehension as the two most important components of reading. Speed of accessing verbal stimuli is not used as a dependent measure in testing children from grades 1 through 3, because measuring reaction time, independent of name accessing ability, would require presenting highly familiar verbal stimuli (such as letters of the alphabet) and taking precise measurements. This would require the use of complex instruments not available in the classroom. The time taken to read a list of highly familiar words, however, is used in the evaluation of children from grades 4 and up.

2.2. *Evaluation of Reading Components*

The componential nature of the reading process enables us to carry out differential diagnosis and identify poor readers with decoding deficit, comprehension deficit, or a combination of the two deficits. Because two variables — the ability to access letter and word name and comprehension ability — account for nearly all of the variance seen in reading achievement, it is possible to assess the contribution made by either one of these variables by partialling out the contribution made by the other. Such a procedure has, indeed, been adopted by researchers. For this reason, if a child with good comprehension ability performs poorly in a reading achievement test, it is likely to be due to poor decoding skill; conversely, if a child with good decoding skill performs poorly in a reading achievement test, it may be inferred that the reading deficit is the result of inadequate comprehension.

Such a subtractive procedure, however, is possible only if we can measure reading comprehension independent of decoding. This requires that reading comprehension be assessed with the aid of a test which does not require decoding. Fortunately, it is possible to estimate reading comprehension without requiring the subject to decode written language. This can be accomplished by assessing the child's listening comprehension which obviously does not involve the decoding of print.

It was noted in Chapter 2 that beyond the factors associated with the modality of input, reading comprehension and listening comprehension may share the same cognitive mechanisms and that the two forms of comprehension are intimately related to each other. It was also observed that the correlation between reading comprehension and listening comprehension steadily increases until grade 4 and stays in the neighborhood of 0.6 thereafter. In their study of college students, Palmer *et al.* (1985) obtained a correlation of 0.82 between these two forms of comprehension which led them to conclude: "reading comprehension can be predicted almost perfectly by a listening measure. Indeed, one can substitute listening comprehension, which obviously does not depend upon visual processes, for reading comprehension" (p. 80). The idea of using listening comprehension as a predictor of reading comprehension is not an entirely new one. Several years ago, Ladd (1970) noted that listening comprehension is one of the most important indicators of reading ability. Durrell and Hayes (1969) also pointed out that "listening comprehension is more directly related to reading than are most tests of intelligence" (p. 12), and Carroll (1977) was explicit in advocating the use of listening comprehension for assessing reading comprehension potential. These statements do not deny that poor reading achievement can be caused by extraneous factors such as lack of reading experience and poor academic history. The use of listening comprehension as part of the diagnostic procedure is intended to evaluate intrinsic factors that contribute to reading disability.

While reading and listening comprehension are very closely related to each other in children in higher grades, the correlation between reading comprehension and listening comprehension is not very impressive in the first two grades (Curtis, 1980). For this reason, listening comprehension cannot be used effectively to estimate reading comprehension in the first two grades. Even at the third grade, the correlation between listening comprehension and reading comprehension is not substantially above the correlation between decoding and reading comprehension. In the first two grades, measures of decoding correlate better with reading comprehension than listening comprehension does. According to a survey by Harris and Sipay (1985), correlations between decoding ability and reading achievement in primary grades range from 0.49 to 0.86. For this reason, it is desirable to use a measure of decoding to estimate the reading potential of children in the lower elementary grades.

A good deal of variation is often seen in the amount and technique of reading instruction to which first and second graders are exposed. Consequently, the decoding skill of these children can be expected to be influenced by environmental factors to a substantial degree. The variation seen in the decoding skill of these young readers, therefore, cannot be attributed to intrinsic factors alone. Furthermore, a number of disabled readers from grades 1 and 2 are virtually nonreaders. As a result, oral reading samples sufficient enough to make meaningful analysis of these children's decoding skill might be hard to obtain. For this reason, in order to estimate the reading potential of children in the first two or three grades, it is desirable to use a task that is closely related to decoding but is not greatly influenced by environmental factors. To be in consonance with the procedure adopted in the assessment of children from grades 4 and above, an instrument that does not involve the use of written language must be used.

A number of studies show that a good predictor of reading achievement in the early elementary grades is the phoneme analysis skill. Several studies show that phoneme analysis skill (or phonological awareness) is a good predictor of reading success in young children (see, for example, Bradley and Bryant, 1983; Liberman and Shankweiler, in press; Wagner and Torgesen, 1987). The close relationship between phoneme analysis skill and reading ability was discussed in Chapter 3. The possibility of a reciprocal relationship between phoneme analysis skill and reading experience was also disccussed, and it was noted that prediction studies (Fox and Routh, 1980; Stanovich *et al.*, 1984a) and studies that matched good and poor readers for reading age support the possibility that phoneme analysis skill is not totally dependent on reading experience.

The differential diagnosis presented in this chapter is based on the rationale that the poor reading achievement of a child with good phoneme analysis skill is caused by poor comprehension and the poor reading achievement of a child with good listening comprehension (as measured by the Peabody Picture Vocabulary test or some other test of listening comprehension) is attributable to poor decoding skill. Children who can be classified as NSRD are likely to show deficits in both phoneme analysis skill and listening comprehension. Unlike in the higher grades, listening comprehension is used in the lower grades as a measure of general cognitive ability; it is not used to predict reading ability. The logic underlying this differential diagnostic procedure at lower and higher primary grades is shown in Table 6.1.

TABLE 6.1.

Logic underlying the differential diagnostic procedure

Level	Test finding	Postulated etiology and diagnostic category
Upper grades (4 and above)	Average or better listening comprehension with poor reading comprehension Poor decoding	Deficit in Component 1: decoding deficit (Category I: Dyslexia)
	Poor listening comprehension with reading comprehension equal to listening comprehension Adequate decoding skill	Deficit in Component 2: poor comprehension (Category II: Hyperlexia-like)
	Poor listening comprehension with reading comprehension worse than listening comprehension Poor decoding	Deficit in both Components 1 and 2 (Category III: NSRD)
Lower grades	Poor phoneme analysis skill with average or better listening comprehension or vocabulary and poor reading comprehension	Deficit in Component 1: poor decoding (Category I: Dyslexia)

Table 6.1. (continued)

Level	Test finding	Postulated etiology and diagnostic category
	Average or better phoneme analysis skill with poor listening comprehension or vocabulary Reading comprehension equal to listening comprehension	Deficit in Component 2: poor comprehension (Category II: Hyperlexia-like)
	Poor phoneme analysis skill with poor listening comprehension or vocabulary Poor reading comprehension	Deficit in both Components 1 and 2 (Category III: NSRD)

3. DIAGNOSTIC PROCEDURE: GRADES 4 AND ABOVE

The diagnostic procedure not only is intended to determine whether the child is achieving but, more importantly, is also designed to find out why the child is not achieving. These objectives are accomplished by tracing the reading deficit to the associated component and placing the disabled reader in one of the three categories shown in Table 6.1. The data presented in this chapter are obtained from limited population samples and are intended to serve as guidelines rather than normative values. The reading teacher and the school psychologist are encouraged to develop their own local norms for the test items shown in Appendix II. In the following sections, the procedure used in reaching a diagnostic decision is first described; then it is demonstrated as administered to seven children with reading disabilities. The diagnostic decision is based on data derived from three different procedures: diagnostic evaluation, quantitative evaluation, and qualitative evaluation.

3.1. *Diagnostic Evaluation*

Diagnostic evaluation is the first step in the procedure and is intended to make a preliminary placement of the child into one of the three categories on the basis of the discrepancy seen between his reading and listening comprehension. The extent of discrepancy is computed with the aid of a regression formula. Even though there is a high degree of correlation between reading comprehension and listening comprehension, the relationship may not be uniform at all age levels but may vary from grade to grade. For this reason, the relationship between these two forms of comprehension is computed with the help of a regression formula. Once such a formula is available, it can be used to *predict* the reading comprehension of the disabled reader based on his listening comprehension. In this section, the procedure used to derive the regression formula is described.

Data for deriving the regression formula were obtained from the group of 98 children from grades 4 through 9 described in Chapter 2. The Passage Comprehension subtest of the Woodcock Reading Mastery Tests, Form A, was used to collect data regarding these children's reading comprehension. Data pertaining to their listening comprehension were obtained by converting the Passage Comprehension reading subtest of the Woodcock Reading Mastery Tests, Form B, into a test of listening comprehension and administering it to them. An experimenter read the sentences to each of the 98 children, and the child was required to supply the missing word or words in each sentence. Because the two forms of the subtest (Form A used for reading comprehension and Form B used for listening comprehension) are equated for number of inferential questions, length, and difficulty level, both forms of the test provide comparable data. Even though the Woodcock Passage Comprehension test is not standardized for use as a test of listening comprehension, using the alternate form of a reading test as a listening test is a procedure often followed by researchers, probably because several confounding factors can thus be controlled. The raw scores obtained from these two forms of tests were then converted into standard scores and the correlation coefficients were computed. The correlation coefficient for the entire group of 98 children was 0.78, a figure consistent with the one reported by other researchers who have compared reading comprehension with listening comprehension. Thus, listening comprehension accounts for nearly 61 percent of the variance of reading comprehension seen in this group of children. From these data, the regression formula was developed. The relevant data are shown in Table 6.2.

Placement of the reading-disabled child into one of the three diagnostic categories is based on the following procedure. First, reading

TABLE 6.2.

Psychometric information of the normative group used in deriving the regression formula

Grade	N	FIQ (WISC-R)	Listening[1] comprehension	Reading comprehension	Correlation Coefficients Reading comprehension and	
					FIQ	Listening comprehenion
4	27	105.2	56.58	54.31	0.54	0.87
5	14	100.3	51.01	48.73	0.56	0.59
6	15	98.8	49.24	47.06	0.72	0.87
7	18	96.8	44.80	44.60	0.52	0.73
8	12	98.8	44.91	43.73	0.39	0.40
9	12	96.8	44.80	44.60	0.51	0.77
Mean		99.4	48.05	47.17	0.54	0.78
SD		11.93	5.98	5.31		

[1] Listening comprehension and reading comprehension are expressed in the form of standard scores.

comprehension score and listening comprehension score of the disabled reader are obtained by administering Forms A and B of the passage comprehension subtest from the Woodcock battery. After this, the regression formula is applied to the listening comprehension score to predict the child's reading comprehension.

A diagnostic decision is reached by comparing the actual reading comprehension with the predicted reading comprehension. If the child has a listening comprehension score that is average or above, but has an actual reading comprehension score (from Woodcock Passage Comprehension subtest) 1 SD below the predicted reading comprehension score (derived from the regression formula from the listening comprehension score), the child is considered as having a disability that is specific to written language which is due to poor decoding skills. The diagnosis would then be developmental dyslexia (Category I). The discrepancy of 1 SD is arbitrary and is not dictated by psychological concerns. Any difference between scores of listening comprehension and reading comprehension indicates that there is a discrepancy between the two skills. The severity of the discrepancy that will qualify the child for special educational and remedial programs is an administrative decision.

If the child obtains a standard score 1 SD below mean in listening comprehension and a reading comprehension score within one standard deviation below the predicted reading comprehension score (i.e., listening and reading comprehension are more or less equal and poor), he/she is considered to have below average comprehension ability and that the reading problem is not caused by a defect in decoding the written language. The diagnosis would be that the child has hyperlexia-like deficit (Category II).

If the child has a listening comprehension score 1 SD below the mean and a reading comprehension score 1 SD below the one predicted by the regression formula, (i.e., listening comprehension poor, reading comprehension even worse), he/she is considered to have a broad-spectrum, generalized reading disorder that results from a combination of poor comprehension and poor decoding skills. A child who displays this pattern of performance is considered to belong to the NSRD group (Category III).

3.2. *Quantitative Evaluation*

It is unsafe to rely on a single source of information to reach diagnostic decisions about the disabled reader. Quantitative data obtained from supplementary tests are used to augment the decision reached by the diagnostic evaluation procedure described earlier. Test results that are obtained for quantitative evaluation can also be used to validate the diagnostic decision which was reached by using the regression formula. There has to be a high degree of agreement between the diagnostic decision reached by the application of the regression formula and the findings of the quantitative evaluation.

Quantitative evaluation of the disabled reader is based on the evaluation of five different aspects of reading related behavior. They are: nonword reading skill, spelling ability, reading speed, dependency on context, and on-line reading comprehension. The first four factors are related to decoding skill, and the fifth one is a measure of comprehension. These five aspects are associated with the five invariant symptoms of developmental dyslexia described in Chapter 5. Findings of tasks that are administered to evaluate the child's performance in these five aspects are used to confirm or disconfirm the decision reached by using the regression formula. For instance, the dyslexic child is expected to perform poorly on the first four tasks (which evaluate grapheme–phoneme-conversion skill) but should be normal in the fifth task (which measures comprehension); conversely, the child with hyperlexia-like disorder is expected to do well in the first four tasks but poorly in the last one. The NSRD child is expected to do poorly in all five tasks. Normative data for these five tasks were obtained by administering them to the standardization group of 98 children. The tasks and tests that are used to evaluate the poor reader's performance in regard to these five factors and the procedures involved in obtaining normative data are briefly described in the following paragraphs. Sample items of these tests are shown in Appendix II.

(1) *Decoding.* Acquisition of the skill to pronounce the written word is based on the progressive mastery of a set of grapheme–phoneme-conversion rules. By examining the literature on the development of pronunciation skills (Calfee *et al.*, 1969; Venezky, 1976; Wijk, 1966), a list of 36 pronounceable nonwords was prepared. These nonwords were typed on a sheet of paper and each of the 98 children was asked to read the words aloud. The responses were taped and analyzed, and the means and SD were computed for each grade.

(2) *Spelling.* Spelling skill is used in this study as an additional measure of the child's mastery of grapheme–phoneme-conversion rules. The spelling list was made up of 38 common words taken from textbooks from grade 4 and below. These words were based on the same rules as the pronounceable nonwords. An experimenter read each word to the child, read a sentence in which the word was embedded, and repeated the word. The child then wrote the word. (Appendix I)

(3) *Speed of reading.* A list of twenty highly familiar 3- and 4-letter function words (frequency above 500 per 5,088,721 words of running text; Carroll *et al.*, 1971) was used to compute the reading speed. It was assumed that by the time they reach grade 4, children would have encountered these function words several times and, therefore, could read them by sight without decoding. These words were typed on a sheet of paper and each child was asked to read the list as fast as he/she could, taking care not to make mistakes. The response was taped and the time taken to read the list was computed. (Appendix II)

(4) *Dependency on context.* It was noted in Chapter 5 that, consistent with the Interactive-Compensatory Model of reading proposed by Stanovich (1980) that deficit in any particular process will result in a greater reliance on other knowledge sources, dyslexic readers rely heavily on context for recognizing words in the printed sentence. For

this reason, elimination of contextual cues from the passage to be read would have a more deleterious effect on the dyslexic reader than it would on the poor reader with adequate decoding skills. The 98 children involved in the standarization procedure were asked to read aloud two standard passages and two passages from which contextual cues were eliminated by reversing the order of words within each sentence of the standard passages. Each child read passages that were appropriate to his/her level of reading comprehension. Their performance was taped and later analyzed for errors. (Appendix II, Table II)

(5) *On-line reading comprehension.* It has been argued throughout this book that if dyslexic readers appear to have poor reading comprehension, it is because their decoding deficit compromises comprehension and not because they have a primary comprehension deficit. If this premise is correct, children diagnosed as dyslexic should show no unusual deficits in comprehending written passages if such passages are easy to decode. Children placed in the other two diagnostic categories, on the contrary, are expected to perform poorly on tests of reading comprehension, regardless of the requirements of decoding. On-line reading comprehension was assessed by using a Cloze version of the standard passages described earlier. The Cloze version is in a maze format; every fifth word in the passage is transformed into three-word multiple-choice items and the reader has to select the word which he/she thinks fits the context. The children read passages that were equivalent to their reading comprehension.

Normative data obtained on these tests and tasks are shown in Appendix II.

3.3. *Qualitative Evaluation*

Qualitative evaluation of the disabled reader includes information regarding factors such as the child's educational history, health history, handedness, and genetic history.

It is reasonable to expect a child who has not attended school regularly for health or other reasons and who has had an erratic academic history not to attain proficiency in decoding skill. When a child with such a background does poorly on tests of decoding, it does not necessarily mean that he or she has developmental dyslexia. Under such circumstances, the differential diagnostic conclusion arrived at by using the regression formula and the other quantitative measures must be viewed with extreme caution.

Similarly, the child's level of motivation and the teaching method he has been exposed to are important factors. If the child had been taught primarily through the "look—say" method, it is obvious that his decoding skills may not be fully developed.

It was noted earlier that left handedness has more than a casual association with developmental dyslexia. Sinistrality, in conjunction with evidences of superior skill in the use of simultaneous strategy, can provide support to a diagnosis of developmental dyslexia. In addition, the presence of reading disability in members of the biological family can be seen as corroborative evidence of developmental dyslexia. It has to be pointed out that the mere report of poor readers in the family need not necessarily imply the presence of a genetic factor, for people tend to be poor readers for several reasons including poor education and nature of vocation. However, when unequivocal evidence for the involvement of genetic factor is present, it can strengthen diagnostic conclusion of dyslexia.

The important contribution genetic information can make to diagnosis is illustrated with the aid of two reading disabled children who were studied by the author (see Box 6.1.; see also Table 3.2.).

BOX 6.1.
The case of the dyslexic twins

Jimmy B and John B, two fourth graders, were referred to the School Psychology Clinic for reading disability. Both boys looked alike and their mother said they were identical twins born within a few minutes of each other. Both boys had good health history and their delivery had been normal. They were active children who came from a middle-class home with the father employed as an electrician. Their mother reported that their father seldom read and that she herself was a poor speller even though a good reader. In addition to the WISC-R, these children were given the tests described in this chapter and the following results were obtained:

Tests	Jimmy B.	John B.	Mean for the grade
WISC-R: VIQ, PIQ, FIQ	86, 136, 110	80, 120, 98	
Actual reading achievement (Woodcock, Grade Equiv.)	2.4	2.4	
Listening comprehension	4.8	5.0	5.3
Predicted reading comprehension	4.9	5.0	5.2
Actual reading comprehension	3.9	4.1	5.5
Nonwords read correctly (N = 38)	19	13	24
Words spelled correctly (N = 38)	13	19	28
Errors in reading standard passages	11	20	10.7

Errors in reading reversed passages	24	34	20.1
Function word reading time (secs)	20	30	20.3
Errors in reading Cloze passages	4	4	6.0

These data show that there is about one year discrepancy between the predicted reading comprehension and the actual reading comprehension of the twins even though their actual reading achievement is much lower than these measures. The reading achievement score is a composite of five subtests which include decoding skills, whereas the reading comprehension score is based on a single subtest. The two boys also show a profile typical of the dyslexic child: adequate listening comprehension but poor nonword reading and spelling. They also committed many reading errors and this was exacerbated when they read the passages with contextual cues removed. Their performance on the Cloze test is good. These data demonstrate that poor decoding is a factor that limits their reading achievement.

Another interesting point is the striking discrepancy between their verbal and performance IQs. Normally, discrepancies of this magnitude (50 and 40 IQ points) would be considered to be of neuropsychological significance indicative of probable impairment of the left cerebral hemisphere. The likelihood of two siblings sustaining similar cerebral injury during birth is remote. This, along with the fact that they are identical twins, makes the statement that they represent an extreme position within the range of normal variation in information processing style credible.

3.4. *Application of the Diagnostic Procedure* (*Grades 4 and Above*)

The diagnostic procedure described in the previous section will now be illustrated by applying it to seven children referred to the School Psychology Clinic, during the course of one semester, for reading difficulties. The diagnostic conclusion as to which of the components causes reading disability and in which of the three diagnostic categories the disabled reader should be placed was arrived at by using the following procedure:

(1) Administering the listening comprehension test,

(2) Applying the regression formula to listening comprehension score to predict reading comprehension,

(3) Administering reading comprehension subtest from Woodcock Reading Mastery Tests to assess the child's actual reading comprehension,

(4) Placing the child in one of the three diagnostic categories, and

(5) Administering the five quantitative tasks to verify the diagnostic decision.

Results of the tests administered to the seven clinical children are shown in Table 6.3.

TABLE 6.3.

Psychometric information about the seven clinical children[1]

Child. No.	Grade	Full-scale IQ (WISC-R)	Listening comprehension[2]	Predicted reading comprehension[3]	Actual reading comprehension
1	4	94	45	44	38
2	4	104	54	52	43
3	6	115	50	48	42
4	6	89	36	37	41
5	6	68	38	38	31
6	8	86	40	40	34
7	5	112	51	49	48

[1] All comprehension measures in standard scores.
[2] Mean listening comprehension of normative group = 48.05; SD = 5.98.
[3] Mean reading comprehension of normative group = 47.17; SD = 5.31.

It can be seen that these children do not constitute a homogeneous group and their performances in the tests show a great deal of variability. Four children (Nos. 1, 2, 3, and 7) had adequate listening comprehension scores. The reading score of one of these children (No. 7) is within the range predicted by the regression formula. His performances on tests of listening and reading comprehension were average. He was, therefore, not considered as reading disabled and if he appeared to have reading problems in the classroom, it might be due to some extraneous factor. The actual reading comprehension scores of three of these four children (Nos. 1, 2, and 3), however, were 1 SD or more below those predicted by the regression formula. These three children (Nos. 1, 2, and 3) were, therefore, placed in Diagnostic Category I (dyslexia) because their comprehension deficit appears to be due to demands of decoding the written language.

The listening comprehension scores of three subjects (Nos. 4, 5, and 6) fell 1 SD below the grade mean leading to the conclusion that these children were deficient in comprehension. The actual reading comprehension score of one of these subjects, No. 4, however, was in line with the predicted reading comprehension score indicating that decoding written language did not impose an additional burden on his reading comprehension. Because he had comprehension deficit and no decoding deficit, this child was placed in Category II (hyperlexia-like). The reading comprehension scores obtained by subjects Nos. 5 and 6 fell

1 SD below those predicted by the regression formula. This means that these children experienced difficulties in decoding print in addition to having deficits of comprehension. These two children were, therefore, placed in Category III (NSRD).

To repeat, six children (Nos. 1 through 6) had poor reading comprehension scores. Of these, three children (Nos. 1, 2, and 3) had adequate listening comprehension. Their problem appears to be due to poor decoding skills. These children were, therefore, considered dyslexic. Three children had poor listening comprehension. Of these three, one had a reading comprehension score that was in line with his listening comprehension. Because he did not appear to have decoding deficit, he was considered to have hyperlexia-like problem. The remaining two poor comprehenders had poor listening comprehension scores and reading comprehension scores that were even worse. They were considered as NSRD because they had both comprehension and decoding deficits.

Subsequently, these children were administered tasks to assess their performance relating to the five factors of quantitative evaluation. The results are shown in Table 6.4. Inspection of data in Table 6.4. indicates that there is general agreement between the diagnostic decision arrived at by using listening comprehension and the regression formula and the children's performance in the five tasks. For instance, the three children diagnosed as dyslexic (Nos. 1, 2, and 3) did poorly in nonword reading and spelling tasks but showed normal performance in the Cloze test.

TABLE 6.4.
Performance of the seven children on tests of quantitative evaluation

Child. No.	Nonwords read correctly (n = 38)	Words spelled correctly (n = 38)	Errors in reading		Function word-list reading time (secs)	Errors in Cloze choice
			Standard passages	Reversed passages		
1	7	15	10	26	23	0
2	15	9	14	37	48	7
3	18	14	22	39	20	6
4	29	32	5	19	11	12
5	20	29	13	46	13	12
6	15	30	14	23	13	14
7	26	36	6	10	16	6

Child No. 4 who was placed in Category II had no deficit in decoding tasks, but did poorly in the Cloze test suggesting hyperlexia-like deficit. The performance of the two children diagnosed as NSRD (Nos. 5 and 6), however, did not provide a clear-cut picture. Even though their performance on the nonword reading test is suggestive of decoding deficit, they appear not to have serious deficiency in spelling. Their comprehension, assessed by the Cloze test, however, is well below average. Child No. 7 who was diagnosed as not having any specific reading disability had average or above average scores in all the tasks.

4. DIAGNOSTIC PROCEDURE: GRADES 1 AND 2

Because children in grades 1 and 2 have limited exposure to reading instruction, it is not practical to expect tests such as nonword reading and spelling to yield a corpus of data that can be meaningfully interpreted. As a matter of fact, many young children referred to the clinic for reading difficulty are virtually nonreaders. For this reason, assessment of these children has to be limited to the diagnostic evaluation procedure and to any qualitative information that is available.

4.1. *Diagnostic Evaluation*

The logic underlying diagnostic evaluation is to estimate the reading-disabled child's reading potential on the basis of his/her phoneme analysis skill. If the child has poor phoneme analysis skills but average or better vocabulary or listening comprehension, his reading disability is presumed to be caused by poor decoding skill. In contrast, if the poor reader has adequate phoneme analysis skill but below average vocabulary or listening comprehension, his reading disability can be attributed to poor comprehension skill. Thus, as it was in the case of children in grades 4 and above, the differential diagnosis is based on tracing the deficit to one of the two components of reading.

As noted earlier in this chapter, several studies indicate that phoneme awareness is a good predictor of reading success in early grades. Some of these studies were also described in Chapters 2 and 3. The diagnostic test that is described here is a combination of an abbreviated form of the test used by Stanovich *et al.* (1984a) in their longitudinal predictive study and the one developed by Rosner and Simon (1971). Stanovich *et al.* administered ten different phonological awareness tasks to a group of kindergarten children whose reading ability was assessed one year later. An example of the phoneme awareness task is: "Initial phoneme same" (e.g., *milk*: *mix*, *klik*, *drink*). The examiner says the target word *MILK* and follows it with the three test words, *mix*, *klik*, and *drink*. The child has to tell which of the three words has the same initial sound as the target word. They found that seven out of the ten tasks were moderately related to later reading ability and collectively were very strong predictors of reading performance and, in this respect, were equal to or better than intelligence test and reading readiness test.

In order to develop local norms, we made an adaptation of the Stanovich *et al.* battery by leaving out two rhyming subtasks (which, according to these authors, correlated poorly with reading ability) and by leaving out two more tasks, "initial *consonant* same" and "final *consonant* same" which are similar to "initial *consonant* not same" and "final *consonant* different." To this battery, the first 20 items from the "phoneme deletion" task (Rosner and Simon, 1971) were added. We retained the general format of the Stanovich *et al.* battery but furnished our own test items for each task. The final battery, therefore, had seven subtasks: the "phoneme deletion" task and the following six tasks from the Stanovich *et al.* battery: (1) initial phoneme same, (2) final phoneme same, (3) strip initial phoneme, (4) substitute initial phoneme, (5) initial phoneme different, and (6) supply initial phoneme.

The battery was then administered to 20 first graders, 20 second graders, and 14 third graders during the month of April. These children were also administered the Metropolitan Achievement Test and the Peabody Picture Vocabulary Test. The correlation coefficients were then computed. The correlation coefficient between phoneme analysis score and reading achievement was 0.78 for grade 1, 0.85 for grade 2, and 0.22 for grade 3. Because a very low correlation coefficient was obtained for grade 3, it was decided that further analysis should be limited to grades 1 and 2. Possible reason for this very low correlation coefficient for grade 3 is discussed at the end of this section. These data for the first and second grade children were combined and then entered into stepwise regression analysis to see which of the seven subtasks accounted for most of the variance seen in reading. It was found that four of the seven subtasks (initial phoneme same, final phoneme same, substitute initial phoneme, and supply initial phoneme) accounted for 58 percent ($r = 0.76$) of the variance seen in reading. Finally, a single regression formula to predict reading achievement of first- and second-grade children was developed using these four subtasks. These subtasks of the phoneme analysis test are shown in Appendix II.

Some teachers who administered these tasks wondered if memory skill might play a confounding role. For instance, in the "initial phoneme same" task, the child has to hold in memory the target word and the four test words. Naturally, poor memory could affect the test performance of the child which could then be misinterpreted as poor phoneme analysis skill. It was necessary, therefore, to see what role memory played in the phoneme analysis task. This was accomplished by comparing the performance of children from grades 1 and 2 on memory loaded subtasks such as "initial phoneme same" with tasks that do not put as much stress on memory such as the "phoneme deletion task" (e.g., "What does *play* sound like if the sound *p* is taken away"?). Three of the seven tasks are not memory-loaded. Statistical analysis of children's performance showed that there was no significant difference between memory-loaded tasks and the other tasks. In fact, children from both grades had higher scores on memory-loaded tasks. The final battery from which the regression formula was developed contains two memory-loaded tasks and two tasks which are not loaded.

4.2. *Qualitative Evaluation*

As with the case of children from grades 4 and above, information regarding the child's educational history, family background, and genetic characteristics was utilized in qualitative evaluation of the poor reader.

4.3. *Application of the Diagnostic Procedure*

Among the 20 children tested in grade 1, there were four whose reading achievement was low. These children had a grade equivalent reading achievement score of 1 year and 3 months or less. Because the reading test was administered towards the end of the academic year, these children had been expected to have an achievement score close to grade 2.

The regression formula was applied to the scores these children obtained on the four phoneme analysis tasks and their reading achievement was predicted. Subsequently, the predicted reading achievement was compared with their actual reading achievement. These data are shown in Table 6.5.

This comparison showed that one child (No. 1) had a discrepancy of less than 1 SD between expected reading achievement and actual reading achievement. His reading achievement was in line with what was predicted on the basis of his phoneme analysis skill. His poor reading achievement could, therefore, be attributed entirely to poor phonological skills. This conclusion is strengthened by the fact that his performance on the phoneme awareness task was poor but his score on the Peabody Picture Vocabulary test was within normal range. This child was, therefore, diagnosed as dyslexic. The remaining three children had substantial discrepancies between predicted reading achievement and actual reading achievement. Such a discrepancy can be due to poor phonological skills, poor comprehension skills, or a combination of the two. Children Nos. 3 and 4 had below-average phonological skills; their Peabody Picture Vocabulary scores were also very low. These two children, therefore, have decoding as well as comprehension deficits. The diagnosis is NSRD. The fourth child (No. 4), unlike the other three children, had average phonological awareness skill. In spite of this, he was a poor achiever. His poor reading achievement could not, therefore, be attributed to poor phonological skills but should be due to poor comprehension. This diagnosis is supported by

TABLE 6.5.

Performance of the four first-grade poor readers on the diagnostic tests

Sub. No.	Grade	Phoneme Analysis[1]	Predicted Reading Achievement[2]	Actual Reading Achievement		Peabody Picture Vocabulary	Diagnosis
				Standard score	Grade equivalent		
1	1.9	26	39.4	37.0	1.4	100	Dyslexia
2	1.9	24	37.9	25.0	1.2	77	NSRD
3	1.9	20	31.3	20.0	1.1	66	NSRD
4	1.9	35	54.4	35.0	1.3	87	Hyperlexia-like

[1] Max. 40; mean score for normative group = 34.5; S.D. = 2.8.
[2] Standard score S.D. = 10.

the fact that he did poorly on the Peabody Picture Vocabulary test. This child, therefore, displayed hyperlexia-like symptoms.

Despite some shortcomings, utilizing phoneme analysis skill in the diagnosis of reading disabilities has one advantage. In the event a reading test cannot be administered because the child is a nonreader, administration of the phonological analysis test and the Peabody Picture Vocabulary test would be sufficient to carry out the diagnosis. Under such a circumstance, decisions regarding differential diagnosis will be based on the rationale shown in Table 6.6.

The correlation coefficient obtained between reading achievement and phonological analysis skill was very low in grade 3, because many children in this grade obtained perfect phoneme analysis scores. The variability in the phoneme awareness scores was thus reduced which, in turn, depressed the phoneme awareness task's ability to predict reading achievement. This resulted in a very low correlation coefficient. Even though only a small number of third graders was studied, this finding is in agreement with other studies which report that a ceiling in the performance on phoneme analysis tasks is reached by about third grade. The observation that children master phoneme analysis skill by the time they are in grade 3 but some of them still continue to have problems in decoding the written language raises the question of whether phoneme analysis skill plays a causal role in grapheme—phoneme conversion. A tentative answer to this question is that phoneme analysis skill, as tested by these tasks, assesses the ability to

TABLE 6.6.

Differential diagnosis of reading disability in nonreaders

Test performance	Diagnosis
1. Poor performance in phoneme awareness test; average or better in PPVT or a test of listening comprehension	Decoding deficit
2. Good performance in phoneme awareness test; poor performance in PPVT or a test of listening comprehension	Comprehension deficit
3. Poor performance in both tests	Decoding and comprehension deficits (NSRD)

recognize basic units of language sound. Such a skill may represent a fundamental operation which is acquired by most children by the time they are in the third grade. Grapheme—phoneme conversion, however, requires mastery of relationships that go beyond the one-phoneme—one-grapheme association; the relationship is governed by complex rules. Earlier it was seen that the study of spelling errors committed by dyslexic readers indicates that they have mastered the one-to-one relationship between graphemes and phonemes but have failed to acquire the more complex relationships. A similar explanation can be advanced in the case of reading as well. That is, even though they are slow to master the one-grapheme—one-phoneme association, dyslexic children eventually learn this simple relationship; however, they fail to progress beyond this level. Assessment of reading-disabled children in the pivotal third grade, therefore, can still utilize phoneme analysis tasks because poor performance in this area will indicate decoding deficit.

The diagnostic procedure described in this section is based on limited field-testing and, therefore, must be viewed only as suggestive. However, within the field of Educational and School Psychology, there is a strong trend not to rely solely upon norm-referenced standardized tests but to create and use locally developed evaluation materials. This indigenous evaluation procedure is known by a variety of names such as *process assessment*, *direct assessment*, *intra-individual assessment*, and *curriculum-based assessment*.

In spite of such a diversity of labels, they all share certain common characteristics. Among them is the belief that the student should not be assessed only in terms of the standardized performance of the "average" student in the nation but should be evaluated in the context of his/her local education program. Evaluation should be linked to instructional purposes as well as to the curriculum requirements of his/her school setting, and this can be accomplished by teachers developing their own test materials based on local curriculum. Also the individual student should be repeatedly assessed and his progress continuously monitored (Tucker, 1985). Research studies which have tried this form of evaluation report success (Deno, 1985; Marston *et al.*, 1984). The diagnostic procedure described in this chapter can be carried out within this framework.

5. IDENTIFICATION OF THE HYPERLEXIC CHILD

From the descriptions provided by researchers, it is apparent that some hyperlexic children are so cognitively disabled that they cannot be administered diagnostic tests and, even if these could be administered, their results could not be meaningfully interpreted. Furthermore, we do not have adequate normative data to decide what level of decoding skill can be considered a marker of hyperlexia, nor do we have information regarding the extent of the discrepancy between chronological age and comprehension that can be used to identify the syndrome of hyperlexia. Fortunately, qualitative information regarding the syndrome, such as fluent decoding, substandard language skill, and a preschool history that clearly indicates spontaneous and precocious acquisition of decoding skill can be used in the identification of hyperlexia without much ambiguity.

The characteristics specified by Needleman (1982) can be useful in this regard. A slightly modified version of Needleman's specifications is presented here. They are: (a) word-decoding ability that is higher than predicted by chronological age (b) early manifestation of decoding, as early as 3 years but before 5 years (c) spontaneous onset of reading without specific instruction (d) a driven, compulsive, and indiscriminate reading behavior (e) occurrence of developmental disability such as language delay, and (f) poor listening comprehension.

There are many children who have decoding skill that is in line with their chronological age but who lag in comprehension skill by a year or so. These children, however, do not manifest other signs of hyperlexia such as unique preschool history of spontaneous and compulsive decoding behavior, or disordered communication skills. In this book, these children are distinguished from hyperlexic readers and are described as having hyperlexia-like reading behavior.

OUTLINE OF CHAPTER 7
['TREATMENT AND MANAGEMENT OF READING DISABILITIES']

CHAPTER 7

TREATMENT AND MANAGEMENT OF READING DISABILITIES

1. INTRODUCTION

In this chapter, the philosophy that underlies the treatment and management of reading disabilities is described in broad terms along with a general outline of the procedures and techniques that emanate from this philosophy. The specific methods are not described in great detail, because materials for treatment can be developed locally once the general approach to treatment is understood.

First, a distinction between *treatment* and *management* must be made. The term *treatment* refers to specific efforts and techniques utilized to improve reading skill; in contrast, *management* refers to efforts undertaken to help an individual cope with academic demands but not necessarily to improve the reading skill itself. For example, in the case of a primary school child, the teacher's efforts would be focused on increasing the child's reading skill; in the case of a college student, the reading specialist's primary objective would be to help him obtain satisfactory grades in his courses. This is not to say that the reading specialist is uninterested in improving the reading and writing skills of the disabled student; only that such a goal is considered as incidental to academic achievement. It nevertheless, has to be pointed out that some reading specialists (see, for example, Henry, 1987) think that improvement not only in decoding but also in spelling and vocabulary can be achieved by teaching students the syllable patterns and the Latin and Greek origins of root morphemes of the English orthography. While such strategies of teaching may be more productive than the traditional decoding approaches, it is this writer's experience that time is a factor that renders extended remedial work impractical in the college situation. Being under pressure, most college students have neither the inclination to undergo any extended training nor the patience to await the positive results of such training procedures. In general, remedial treatment of reading disability is the goal at elementary grades, whereas management of the reading problem may be the goal at the college level.

Another distinction to be noted is the difference between the terms *approach* and *method*. The term *approach* refers to a particular orientation adopted by the reading specialist in the remediation of the reading problem, whereas the term *method* refers to the specific technique the specialist would use to turn this philosophy into action. As a result, a single treatment approach can be represented by more than one technique or method. For example, the belief that improving decoding skill will improve reading achievement may be realized through the phonics approach, but specific methods and techniques such as the Orton—Gillingham method, the Herman method, the Bannatyne phonics system, or the Distar Reading Program may be used to translate this approach into action.

2. TREATMENT OF READING DISABILITIES

2.1. *Determining Factors in Choosing the Method of Treatment*

The choice of any specific treatment method will depend upon decisions such as whether the treatment method should aim at improving decoding skill or comprehension skill and whether the dyslexic child should be taught through his strength by using the whole-word method or through the remediation of his phonic deficiencies by using the phonics approach. These decisions depend upon factors such as the nature of the reading disability, the severity of the reading deficit, and the interest and motivation of the student. It is quite likely that, in spite of intense evaluation, there will be occasions when no decision can be reached regarding the teaching approach and methods to be adopted. Under those circumstances, a short period of trial teaching can be undertaken to resolve these questions.

These four factors, viz., nature of reading disability, severity of the problem, interest and motivation of the reader, and the outcome of trial teaching are briefly discussed in the following sections.

2.1.1. *Nature of the Reading Disability*

In the previous chapter it was noted that depending upon the component of reading that is affected, poor readers can be classified into three diagnostic categories: poor decoder (dyslexia), poor comprehender (hyperlexia-like), and poor comprehender—decoder (NSRD). It would appear reasonable to expect the poor decoder to make the greatest progress when remediation is aimed at improving his decoding skill and the poor comprehender to make optimal progress when remedial efforts are targeted at improving his comprehension skill. It has been proposed in this book that decoding skill and not comprehension is the primary deficit of the dyslexic reader and that poor decoding is the factor which limits his reading achievement. If this is the case, efforts to improve the dyslexic reader's comprehension may not produce additional gains in reading achievement above and beyond what has already been accomplished through training in decoding. Conversely, because the child with hyperlexia-like symptoms has no decoding deficits, training in decoding cannot be expected to produce striking improvement in reading. Such a matching of the reading disability subtype with a specific method of teaching reading is referred to as *differential treatment*. It has to be pointed out that the treatment methods recommended in this book are reading-related and are, therefore, ecologically valid. Past history shows that remedial methods which tried to correct putative perceptual and neurological processes that are unrelated to reading have failed (see Box 7.1.).

BOX 7.1.

Reading disability and process oriented remedial approaches

Several process-oriented remedial approaches have been tried in the past and found wanting. The list includes vision training, training ocular control, training form perception, body awareness, spatial awareness, auditory memory and sequencing, perceptual training, perceptual-motor training, and a variety of neuropsychological approaches. The ineffectiveness of process-oriented approaches such as perceptual-motor training in improving reading skill is well documented. Reviewing some of these studies, Hammill (1974) concluded that "teachers should be urged to implement perceptual-motor training on a remedial basis in only those few cases where improvement in perception is the goal . . . and is never recommended as a substitute for teaching language, reading, or arithmetic skill" (p.230).

There is no single method of teaching reading that can be considered uniquely neuropsychological. Even though, in the past, reflex training had been considered as *the* neuropsychological remedial method, in recent years, what is termed as neuropsychological approach uses traditional teaching methods such as letter—sound association and phonetic skill training (see, for example Mattis, 1981). When implemented, however, this approach also has failed to produce tangible results, probably because the classification of dyslexic children into subtypes, on the basis of patterns of performance on neuropsychological tests was at fault. In their review of some of these neuropsychological remedial efforts, Hynd and Cohen (1983) write:

> "Although the neuropsychological approach to the remediation of dyslexic children appears to be theoretically sound, the empirical validation of this method remains to be accomplished before any claims as to its effectiveness can be made" (p. 229).

This situation has not changed since that time.

Very few experimental studies have investigated the effects of differential treatment of reading disabilities. In an attempt to decide whether different remedial methods produce different results, one such study was undertaken by the author and his associates (Aaron *et al.*, 1982). In two experiments, 17 poor readers from grades 2 and 3 were divided into dysphonetics (poor phonological skill) and dyseidetics (poor sight vocabulary) following Boder's (1973) classification. In the second experiment, a control group of normal readers was added. The children were taught through two different methods: phonetic-sequential and gestalt-whole word. Five dyseidetic and five dysphonetic children were trained by the phonetic method; three dyseidetic and four dysphonetic children were trained through the whole-word method. In the phonetic method, each word in a sentence was broken down into its letter components, each letter of the word was displayed on the video-monitor, and the experimenter sounded out the name of each letter as it appeared on the screen. After all the letters of the word had been presented sequentially, the entire word appeared on the screen and the word was pronounced by the experimenter. After three such repeated presentations, the word was presented two more times without the accompanying sound and the child was encouraged to sound it out. After this, the second word in the sentence was presented and, finally, the entire sentence. In the whole-word method, the same sequence was followed but each word was presented as a single unit and pronounced. The first study lasted for four weeks and the second study for seven months. Pre- and posttest results showed that, in general, poor readers registered greater gain in reading comprehesion when they were taught through their strengths than when the treatment was aimed at remedying the deficiency. Although this study is of limited scope, it is cited here to demonstrate the application of differential treatment of reading deficits.

A more elaborate study which used a different form of classification is reported by Fiedorowicz (1986). She selected five boys from each of the following reading disability subtypes: Type O, oral reading deficit group; Type A, inter-modal association deficit group; and Type S, sequential relations deficit group. This classification method was based on earlier work by Doehring and Hoshko (1977). Even though this classification method does not correspond to the component-based classification of poor readers into phonology-deficient or comprehension-deficient as proposed in this book, it is possible that some of the

15 poor readers could be dyslexic (i.e., phonology-deficient) and others non-dyslexic (i.e.,comprehension-deficient), since the Full-scale IQ of these children ranged from 86 to 109. These children were trained for a period of two and one-half months by presenting three different tasks with the aid of a computer. Type O children were given training in oral reading; children classified as Type A matched auditory stimuli with correct visual items; and Type S children matched visual stimuli with correct visual choices. Eight children were trained during the first semester; the remaining seven were trained during the second half of the academic year. Analysis of test results showed that after the first semester, poor readers who were trained were significantly better on reading tasks than were the seven poor readers who had not yet received any training. At the end of the year, all 15 children had gained in reading. The results of subgroup comparison showed that each group showed significant improvement in the targeted skill. Feidorowicz concluded that training according to subgroup classification is an effective approach for teaching reading-disabled children. Even though this study does not inform us whether a subgroup of some reading-disabled children gains more from a particular remedial method than other methods, it lends general support to the belief that training procedures specific to the reading-disability subtype can be effective in improving the targeted component of reading skill.

2.1.2. *Severity of the Reading Problem*

Whether improving the reading skill of the student should be addressed by rectifying his weakness or through the strength he already has continues to be a persistent question in the area of reading disabilities. For example, in the case of dyslexic children, this question can be translated into making a choice between the phonics approach or whole-word approach. Because dyslexic children are deficient in phonological skills, the phonics approach would amount to remediating the weak skill, whereas teaching through the whole-word method would mean using the strength. The choice of the remedial approach will depend partly on factors such as the severity of the problem, the age of the disabled reader, and his previous educational history. A dyslexic reader from junior high school, who has been instructed for many years in the phonics approach (including training in syllabication, identification of the morphology of root word, etc.) but still remains an extremely poor reader, is unlikely to make much further progress with phonics training. Additional phonics training would only frustrate him. Under such circumstances using the whole-word method to teach reading should be seriously considered. It is the author's experience that dyslexic students at the college level profit little by simple phonics training regardless of the length and intensity of the training.

2.1.3. *Interest and Motivation of the Reader*

By the time they reach fourth or fifth grade, many dyslexic children have developed a distaste for reading. However, it is not unusual to encounter dyslexic children who are avid readers. When quite young, these children become interested in topics on machines or dinosaurs and this interest sustains their reading. Albeit their slow reading and word-recognition skill, these children spend long hours reading books that interest them. Prognosis for such children is good. From the author's experience, a similar statement cannot be made for children who have comprehension deficit.

Unless the disabled reader is motivated to overcome his reading problems and improve his skill, remedial efforts, no matter how refined and how intense, are not going to produce positive results. For this reason, *excessive* drill in phonics and spelling can become a chore and have deleterious effects on reading by destroying children's interest. There is a fine line between children's perception of these exercises as useful devices and their rejection of phonics training as tedious exercises to be avoided. The remedial teacher has to be extremely sensitive to this issue. If one has to choose between flawless oral reading and imperfect performance accompanied by genuine interest, the latter is to be preferred. Letting children choose their own library books and getting them enrolled in book clubs can serve as useful devices to promote interest in reading.

2.1.4. *Outcome of Trial Teaching*

Trial teaching involves teaching reading for a brief trial period in which different methods and techniques are used and the student's progress in learning to read is monitored. The method which produces the best results will then become the treatment of choice. Harris and Sipay (1985, p. 225) provide a detailed description of steps to be followed in trial teaching for improving word-recognition skill. Later, in this chapter, several methods to improve comprehension are described.

2.2. *Treatment of Reading Disability in Dyslexic Students*

2.2.1. *Improving Phonological Skills*

The premise on which the idea of differential treatment is based leads to the expectation that dyslexic children will show significant improvement in reading when treatment efforts are aimed at improving their decoding skills. In general, improving the decoding skills of poor readers including those labeled as NSRD can be expected to produce positive results. Thus, decoding training is likely to benefit a large number of young poor readers, if not all. In her revised edition of the book *Learning to Read: The Great Debate*, Chall (1983) provides a considerable amount of evidence to show that elementary reading programs that use a "code emphasis" and teach letter—sound correspondences directly are more successful than those using a "sight word" approach. This is because many poor decoder-readers, instead of making use of the phonemic features of the graphemes, tend to rely on a holistic word-name association for word recognition. This strategy eventually leads to difficulty as reading requirements increase and as new words have to be identified. The principle behind the remedial approach is to change the dyslexic readers' "Chinese" strategy into the "Phoenician" strategy by making them use spelling-to-sound association rather than the whole-word-name association to recognize words.

Many poor readers, particularly those in the early primary grades, do not realize that reading involves relating letters of the alphabet to certain phonemes and that there is a complex relationship between the two. Even though some young children might have learned the names of the letters, many are not aware of the phonemes these letters represent. Associating a letter with its name rather than the phonemes it represents can actually hamper the acquisition of reading skill. Some poor readers, in fact, start pronouncing the written word with the first letter name and search their mental lexicon for a word that fits it. For example, while reading the word *kite* the dyslexic reader may look for a word that starts with the sound /*k*/ and not /ki/ and produce the word *Kate*. The facts that, in speech, phonemes are linked together (as letters are linked in cursive writing) and that more than one phoneme can represent a single acoustic segment or syllable make reading a skill that cannot be expected to be learned without specific instruction. For this reason, beginning readers need to be taught the relationship between graphemes and the sounds they represent.

It was noted earlier that a number of studies report improvement in the reading skill of young children when they are taught phoneme awareness and phoneme analysis skills (see also Treiman and Baron, 1983; Bus, 1986). In this section, some of the basic principles that underlie training in phonological analysis skill are introduced and one study which used such a procedure is presented in some detail. A few programs that incorporate some of the principles of phoneme analysis training are also commercially available (see, for example, Lindamood and Lindamood, 1969; Wallach and Wallach, 1976). The test items used in the Phonological Analysis Test (see Appendix II, Tables IV and V) and similar ones can be used for training purposes.

According to Lewkowicz (1980), phoneme analysis (or awareness) training methods have included the following tasks: (a) sound-to-word matching (Does *fish* start with /f/?[1]); (b) word-word matching (Does *fish* start with the same sound as *fat*?); (c) recognition of rhyme (Does *fish* rhyme with *dish*?); (d) isolation (What is the first sound of *fish*?); (e) phonemic segmentation (What are the three sounds in *fish*?); (f) counting the phonemes (Knock on the desk as many times as there are sounds in the word *fish*); (g) blending (What word is made up of /f/ /i/ /sh/?); (h) phoneme deletion (Say *fish*; now say it without the sound /fi/); (i) identifying missing phoneme (Say *man*; now say *an*. What sound was left out?); and (j) phoneme substitution (Say *fish*; now say it with /d/ instead of /f/).

In general, these tasks can be classified into three categories: tasks which require analysis (segmentation), synthesis (blending), or both. In this book, phoneme analysis is used as a generic term to include all the three skills.

Lewkowicz, after reviewing relevant research found that among these 10 tasks, isolation of the initial phoneme is the most useful in teaching decoding skill. Word matching and rhyming tasks were of doubtful value. It was noted in Chapter 6 that even kindergarten children find the rhyming tasks to be easy probably because these tasks involve phoneme discrimination rather than phoneme identification.

There are a few principles to be observed in phoneme analysis training. These tips are taken from the writings of Lewkowicz (1980); Liberman *et al.* (1980); and Williams (1979). Some of these principles are:

(1) Phoneme analysis requires a very slow "stretched" pronunciation of the word to be segmented.

(2) All the tasks are first auditorily presented; only after these tasks are mastered, are letters and words visually presented.

(3) In auditory tasks, children learn first to analyze short words into phonemes; blending phonemes into syllables and words is introduced later.

(4) Stop consonants such as *b*, *d*, *g*, *p*, *t*, and *k* are introduced first; voiced and fricative consonants are introduced later.

(5) Analysis of words with two phoneme segments is mastered before segmental analysis of three phonemes is presented.

(6) VC syllables such as *in* and *am* should be introduced before CV syllables such as *no* and *ma* are introduced.

(7) Decoding of simple words is introduced after these skills are mastered.

To this list of guidelines, another important principle of teaching the dyslexic reader needs to be added. In my observation, dyslexic readers do not appear to have difficulty in learning to associate one sound with one letter. If no explicit training is given in phoneme analysis, this sound is the name of the letter. They also appear to overlearn the letter–name association to such a degree that they are not able to extricate themselves from this bond which prevents them from learning other phonemes associated with that letter. Eventually, this becomes one of the major impediments to their learning to recognize words correctly. One possible way to avoid this potential predicament is to simultaneously teach all the possible phoneme values associated with a letter. This can be done at the visual letter–phoneme association stage which precedes the word decoding stage. For example, the child can be presented the letter *a* along with its different phonemic values with the help of the following words: *at*, *ate*, *care*, *add*, *about*, *arm*, *ask*, *sofa*, etc. Examples of corresponding phonemic values for other vowels are: *e* as in *eve*, *here*, *event*, *end*, *silent*, *maker*; *i* as in *ice*, *ill*; *o* as in *odd*, *obey*, *come*, *foot*, *food*, *out*, *on*; *u* as in *cut*, *cute*, *put*, and *menu*. Other phonemic values of vowels and those of consonants can also be presented in this manner.

This recommendation is the opposite of the one advocated by Bloomfield (Bloomfield and Barnhart, 1961) who wrote:

> Our first material must show each letter in only one phonetic value; thus, if we have words with *g* in the value that it has in "get", "got", "gun", our first material must not contain words like "gem", where same letter has different value; similarly, if we have words like "can", "cat", "cot", our first material must not contain words like "cent." (p. 39)

The format in which this training is carried out can vary considerably. Liberman *et al.* (1980) recommend the procedure described by Elkonin (1973). The entire training is carried out in two stages: a purely auditory analysis stage followed by an auditory-visual association stage. In this procedure, the child is presented with a line drawing of a familiar object or animal. Below the picture is a rectangle divided into sections equivalent to the number of phonemes in the word that represents the picture. Thus, under the picture of a man, there would be a rectangle with three sections. The child is taught to say the word slowly and put three check marks in the appropriate sections of the rectangle as he pronounces the word. After this "game" has been played with many different pictures, the picture is removed and the child puts the check marks in the boxes after hearing the teacher say the word. Subsequently, the idea of vowel and consonant sounds is introduced, and the boxes may be shown in two colors: one for vowels and another for consonants. After the child can carry out these auditory tasks successfully, the printed form of the alphabet is introduced and the child repeats phoneme analysis of the written word instead of the picture.

Blending, is the next major step. Fusion of the phonemes can be taught in several ways, but Liberman *et al.* (1980) recommend a procedure described by Slingerland (1971). In this procedure, the teacher first slowly says a word, *ham*, for example, emphasizing the medial vowel. The child repeats the word, listens for the vowel sound, selects the card from a bank of cards on which that letter is printed (which is color coded for vowels and consonants), and places it on a chart. The teacher then repeats the whole word and asks the child for the initial sound in the word. The child selects the appropriate consonant, identifies it, and places it in front of the vowel. The teacher now says: "Now we have made *ha*. Let's listen to the word again. Our word is *ham*. What is the last sound we hear in *ham*? That is right; it's *mm*. Find the letter that makes the *mm* sound. Where do we put the *m*? At the end of the word."

Williams (1979, 1980) presents an experimental study in which decoding was taught using phoneme analysis and blending. Children taught by this method reportedly made significant improvement in reading skill. This program was named as the ABD of reading (for Analysis, Blending, and Decoding) by Williams and involves four steps: syllable segmentation, phoneme analysis, phoneme synthesis, and decoding of words. In this procedure, the child is first taught to analyze an orally presented word into its constituent syllables (not phonemes). The child tells not only the number of syllables in the auditorilly presented word but also their position as first, medial, or end syllable in the word. Visual cues in the form of wooden blocks of different colors may be used to facilitate this part of the program. Once the child has mastered syllable segmentation, he is introduced to phoneme analysis which is first taught as an auditory task. Real words and pronounceable nonwords with two and three phonemes are introduced, and the child is asked first to identify the number of phonemes (by using colored wooden blocks) and then to sound out the separate phonemes. Williams (1979) recommends that the first phase of phoneme analysis training be limited to nine phonemes (/a/, /o/, /b/, /m/, /p/, /s/, /c/, /g/, and /t/).

During the next stage, phoneme blending is introduced. Even though blending can be taught in more than one way, Williams recommends the one developed by Coleman (1970). After phoneme analysis and synthesis are learned, letter—sound correspondence for the nine phonemes is taught visually by presenting the letters and associating the several phonemes with the letters. Finally, written words are presented and the child is helped to decode them by integrating the skills already learned in isolation. The wooden blocks, which now have letters on them, are used to make bi- and trigram words and the child is encouraged to pronounce them. After this, the remaining letter—sound correspondences are introduced.

Williams trained 51 reading-disabled children ranging in age from 7 to 12 years. Some of these children had below average IQs. Compared to a control group of children who did not receive the ABD training, the trained children demonstrated superior performance in decoding tests after one and two years of training. There was a transfer effect of the training as shown in their ability to decode unfamiliar words.

There is no clear indication of a particular age beyond which phoneme analysis training may not be productive. Since phoneme awareness appears not to be fully developed in dyslexics, it can be expected to produce desirable effects at all age levels. But empirical data are not available to evaluate the validity of this assertion. Henry (1987) proposes that decoding instruction should go beyond simple letter—sound association and should include developing an understanding of word structure and morpheme analysis (syllable patterns, prefixes and suffixes, root morphemes) and word origin (Latin and Greek influence). She considers decoding as a conceptual issue rather than training in the basic skill of letter—sound association. In a study of children from grades 3, 4, and 5 she found that, after training, word analysis strategies and spelling performance of these children as well as those of dyslexics increased significantly. Henry believes (personal communication) that even adult dyslexics and college students can profit much from such an approach. The book entitled *Instant Vocabulary* (Ehrlich, 1968), which presents a large number of words organized according to their root structure as well as their suffixes and prefixes, could be helpful in increasing students' conceptual knowledge regarding the nature of different words. Obviously, a conceptual approach to decoding can be beneficial only after the child has mastered the basic phoneme awareness skills. In the absence of phoneme awareness and analysis skill, it will be the most fundamental skill to be developed.

Whole-word method and the use of flash cards are not recommended for dyslexic children because these methods may actually increase their dependency on the whole-word "Chinese" strategy for word recognition.

2.2.2. *Spelling as a Means of Improving Decoding Skills*

As discussed earlier in the book, spelling is recognized as a complex cognitive skill which makes use of grapheme—phoneme relational skill and is not merely a visual—perceptual operation. The grapheme—phoneme-conversion skill, therefore, is a common denominator for reading and spelling. Consequently, spelling a word can be expected to draw the attention of the student to these rules and thereby have a positive transfer effect on reading. In the author's experience, spelling itself is extremely resistant to improvement and spelling problems of many poor readers persist through college into adult life. For this reason, improvement expected in dyslexic children's spelling following training has to be modest and realistic.

Gentry (1987) has made some recommendations regarding the strategies for teaching spelling: De-emphasize correctness, memorization, and writing mechanics; teach spelling as part of the whole curriculum; have children write frequently; encourage children to invent spelling for words they may not have learned to spell; respond to children's writing in ways that help them discover more about spelling. That is, teach a few rules that apply to a large number of words and draw their attention to word origins, root morphemes, and suffixes.

Wong (1986) describes an approach to the teaching of spelling which makes use of the phonological, orthographic, syntactic, and semantic features of the word. In this procedure, not only are spelling patterns and phonics emphasized, but the meaning and linguistic structure of words are also attended to. More specifically, the word to be spelled is read aloud by the teacher and its meaning is given. Students are then taught to break the word into syllables. They then are taught about the structure of the word. The word is decomposed into the root word and its suffix. Children are shown how adding the suffix changes the spelling. Then they carry out a cognitive self-instructional task by asking themselves the following questions: Do I know the word? How many syllables do I hear in this word? I will spell the word. Do I have the right number of syllables? Is there any part of the word whose spelling I am not sure of? (Student underlines that part he is uncertain about.) Now, does the word look right to me? If it doesn't look right, let me hear the word in my head and spell it again. When I finish spelling, I tell myself I'm a good worker. It may be noticed that this "conceptual" approach to spelling is similar to the decoding approach advocated by Henry (1987). In an exploratory study, Wong (1986) used this method to train 30 poor spellers from sixth grade. After three weeks of training, striking improvement was seen in the spelling performance of these children.

2.2.3. *Using Computers to Improve Decoding Skills*

Microcomputers are being increasingly used in teaching reading. Even though most microcomputers available today have limitations in voice input—output and memory capacities, the state of the art is improving rapidly so that modestly priced computers with such capabilities are likely to be available in the very near future. The computer has certain advantages because it can provide immediate feedback to many students at the same time and can keep accurate record of the learner's performance, tasks too difficult for a single teacher to carry out. The problem of boredom associated with computers can be minimized by presenting many of the programs in a game format.

Perfetti (1985) describes a program developed by Frederiksen and his associates. The program is designed to improve three aspects of reading: perception of multi-letter units, decoding of written words, and accessing and integrating meaning of words. The goal of the training program is to increase the speed with which these three activities can be carried out. The procedure is in a game-like format and numerous training trials are presented in a preset order of hierarchy. For example, decoding is taught through a game called *Racer* in which the race is between a sailboat, whose speed is determined by the student's expected rate of decoding, and a horse, whose speed is preset on the basis of the student's previous record of decoding. Frederiksen and his associates trained 10 poor readers and found that all the students showed gains in the specific component in which they had been trained. For example, students trained in decoding showed gains in decoding but not in multi—letter perception. The effect of the training program on reading comprehension was positive but somewhat inconclusive.

Using a program called *Hint and Hunt*, Jones *et al.* (1987) trained 20 disabled readers for 15 minutes per day, 5 days a week, for 10 weeks. The *Hint* portion of the program stressed accuracy in decoding whereas the *Hunt* portion stressed speed. These investigators found that children trained by this program showed substantial improvements in correctly pronouncing not only words directly practiced in the program but also words not used in training.

Several programs are being commercially produced and are frequently reviewed by journals and magazines such as *Journal of Learning Disabilities* and *Electronic Learning*. Furthermore, resourceful teachers can develop their own programs for instructional purposes. Easy-to-follow instructions as to how to write one's own programs can be found in a book by McRae (1985) entitled *Apples for Teachers*. This book gives simple and understandable instructions for writing 101 programs for teaching reading-related activities such as spelling and reading comprehension. The programs are in BASIC language and can be used with Apple computers. In addition to this source, a book by Blanchard *et al.* (1987) describes the potential of computers in reading instruction and includes information about the sources of reading-related software that can be used by computers of different makes.

2.3. *Treatment of Reading Problems in Poor Comprehenders*

Comprehension training is primarily intended for poor readers who display hyperlexia-like deficit (Category II) and poor readers who are suspected of having nonspecific reading disability (NSRD, Category III). Because it appears that the dyslexic readers' disability is caused by poor decoding skill and not by poor comprehension, they are not expected to profit much from comprehension training. This is a rational judgment and is not made on the basis of empirical evidence. If, in reading, they appear to comprehend poorly, it is because their inefficient decoding skill acts as a factor that limits their comprehension.

In the present context, the word *comprehension* is used as a generic term which includes both reading and listening. Efforts to improve reading comprehension are, therefore, to be viewed not as methods that are unique to the improvement of reading skill but as efforts to improve the readers' cognitive skills and their fund of concepts. In Chapter 2 the comprehension process was described in terms of four processes, and comprehension training employs these four processes: word level comprehension or vocabulary, sentence level comprehension, text level comprehension, and metacognition. It is useful to remember that these processes do not function in isolation but facilitate comprehension by interacting with each other. For this reason, improving any one of these operations is likely to have a positive effect on comprehension as a whole. Conversely, a deficit in any one of these operations can hold back the comprehension process. This chapter provides broad guidelines for remedial teaching to improve comprehension skills and does not furnish step-by-step, "how to" instructions. More detailed information regarding teaching for comprehension can be found in books by Flood (1984), Harris and Sipay (1985), and Pearson and Johnson (1978).

2.3.1. *Improving Word Knowledge and Vocabulary*

Word knowledge and vocabulary refer to an understanding of the meaning and significance of the word, both written and spoken. Lack of adequate vocabulary is generally considered one of the most important factors affecting the comprehension of disabled readers (Becker, 1977). There is, however, some doubt about whether direct instruction in vocabulary alone can improve comprehension (Graves, 1984). This is a legitimate concern because vocabulary size is positively correlated with reading experience and reading itself can play a causal role in vocabulary acquisition. Nevertheless, it is obvious that words constitute the basic building blocks of meaning and, therefore, poor word knowledge will hinder comprehension.

According to Sternberg *et al.* (1983), three methods are commonly used for vocabulary building: rote learning, keyword method, and learning-from-context. Of the three methods, rote learning has been found to be the least effective. Since this method does not make full use of the meaning of the word but depends on forming a mechanical association with a synonym, it is a form of learning which severely strains the memory capacity of the learner. Even if rote learning is accomplished with the aid of a dictionary, the learner may not acquire the precise meaning of words because the new word and the words used in the dictionary to explain it may not have identical meanings. Consequently, learning a word by associating it with its dictionary meaning can lead to some bizarre sentences as the following examples from Miller and Gildea (1987) show: *correlate* = (dictionary meaning): to be related; (child's use of the word): "Me and my parents are correlated"; *tenet* = (dictionary meaning): truth; (child's use of the word): "That news is very tenet".

The keyword method is basically a mnemonic strategy in which the learner constructs visual images which may combine the meaning of the word with a part of the new word that resembles a familiar word. For example, the English word *carlin* means 'old woman'. The visual image generated might be that of an old woman driving a car. When the word *carlin* is presented later, retrieval of *car* leads to the retrieval of the image containing the old woman (Pressley *et al.*, 1987). The keyword method appears to be highly contrived and artificial and requires the acquisition of meaning as a separate additional step. Many children may also require external help in generating suitable visual images. But Pressley *et al.* (1987) report that the mnemonic keyword method has proven to be a potent and versatile vocabulary-remembering strategy and that it has promoted the vocabulary learning of learning-disabled children and low-ability college students.

The learning-from-context method is based on the fact that young children learn new words at a very rapid rate and try to make use of factors that facilitate such acquisition. Although reports of children's vocabulary vary considerably, a figure of 40,000 words appears to be a resonable estimate for an average high school senior (Nagy and Herman, 1987). If this figure is correct, the child learns about 3,000 words per year during the school years. Learning of vocabulary, apparently, does not depend on formal instruction alone but might be facilitated by other means such as listening and informal reading that occur outside the classroom. This type of incidental vocabulary acquisition, however, is possible only if the child encounters the same word several times in different contexts. And this does seem to happen. According to Miller (1986), children learn new words by encountering them in several different contexts of speech. After they have learned to read, reading further increases the size of their vocabulary by providing additional instances of context. It is not surprising, therefore, that children who read very little also do poorly on tests such as the WISC vocabulary subtest.

According to Sternberg *et al.* (1983), the context method does well in facilitating the development of an internally connected cognitive structure that links the word to the mental lexicon. Acquisition and retention of new words are, therefore, accomplished quite readily when this method is used (for counter argument, see Kameenui *et al.*, 1987). Miller and Gildea (1987) propose a computer program which can present the word in different contexts. Suppose, for example, when reading a passage presented by a computer, a student comes across the unfamiliar word *erode* in the sentence: "The President's popularity was eroded by his bad relation with Congress." In order to know the meaning of the word *erode*, the student can move the cursor on the computer monitor to that word and press a button. The computer then might present the word in different contexts by embedding it in several sentences such as: "Things can erode, wear away or wash away; soil can be eroded by wind and rain. A person's power and authority can erode too. That kind of erosion is meant in the sentence about the President." Programs of this kind which can present sentences visually as well as auditorily are likely to become available in the near future. In case computer facilities are not available, the teacher can follow the same procedure even though it might be a very time-consuming task. Such direct teaching of vocabulary and word meaning has been found by many research studies to be highly beneficial (Chall, 1987). Direct teaching can be effective when the word is presented many times, in different contexts, and when the learner is required to construct sentences making use of the new word.

2.3.2. *Improving Sentence Comprehension*

Pearson and Johnson (1978) discuss reading comprehension from two levels: concept level and propositional level. Concept-level comprehension includes understanding of synonyms, antonyms, analogies, ambiguous words, and words with multiple meanings. Propositional-level comprehension includes the ability to process figurative language, a sequence of ideas, and the main idea, and the ability to paraphrase. Direct training in the proper use of analogies, disambiguating words in sentences, resolving multiple meanings, and proper use of anaphora can be expected to improve reading comprehension at the sentence level. The teacher may also prepare a small list of crucial questions and present it to the students before they begin to read. Memory (1983) found that open-ended questions which required below-average readers to answer cause—effect questions improved their comprehension of such relationships. Examples of simple lessons that can promote sentence comprehension are provided by Lapp and Flood (1984).

Because not all the information needed for comprehension is provided in the written sentence, one of the important requirements for successful reading comprehension is the reader's ability to make inferences. For this reason, exercises that require the reader to make inferences can be helpful. The use of Cloze passages such as the one shown in Appendix II, Table II can be used to accomplish this purpose. McKenna and Robinson (1980), who have reviewed research in this area, found that Cloze, as a teaching device, has produced some promising results. Similarly, Jongsma (1980) concluded that the Cloze technique can be an effective instructional method for developing comprehension. He has made the following suggestions when using the Cloze technique to improve comprehension: (a) The sentences and passages have to be carefully developed with the readers' ability in mind; (b) selective deletion of words which requires the reader to make inferences is superior to random deletion (such as every fifth word in a sentence); and (c) Cloze procedure may not be effective in narrative or expository texts.

Guthrie *et al.* (1974) used a "maze-guided" instruction for a period of four months to teach reading-disabled children. They found that while a few children gained only one year in comprehension, a majority of children gained two years while a few gained three years. On the basis of this experience, they have suggested a few principles to be observed in the construction and use of the maze Cloze passages: (a) Passages used should be new to the child; (b) each passage should be about 120 words long with approximately every fifth word or less being replaced with three alternatives; and (c) the incorrect alternatives should be of the same part of speech as the correct word. Furthermore, if a child is performing at about 90 percent accuracy in three or four passages, more difficult material should be introduced. The optimal beginning level of passage would have the child performing at 60 to 70 percent accuracy. When the child reaches 85 to 100 percent accuracy, the next higher level should be introduced. From their experience, these authors state that it takes about three weeks for a child to move from one level to the next. They list the following factors as responsible for the low performance of some children: (a) The story is difficult because of uncommon vocabulary or proper names; (b) the child is emotionally distraught or fatigued; and (c) the child attempts to read at a fast rate. Guthrie *et al.* caution that the maze procedure serves as a thermostat which will be helpful in regulating comprehension instruction but the teacher should not rely exclusively on Cloze procedures to improve comprehension but should utilize several different approaches.

Several computer programs that use a Cloze format are available. The program *Monkeynews* (Published by Artworx) is intended for grades 1 through 6. In this program, the student reads a story making plot choices and then rereads the passage filling in the missing words. The program *Word Blaster* (Random House) is suitable for grades 2 through 6 and is in a game format. In it, the reader must complete a sentence by shooting a missile at the correct word from among the many words moving across the screen.

2.3.3. *Improving Text Comprehension*

Comprehension of the text is crucially dependent upon the reader's ability to understand sentences, and many of the suggestions made in connection with sentence-level comprehension are equally applicable to texts. Nevertheless, as described in Chapter 2, texts have certain unique properties which make some of the resources the reader possesses valuable aids in the comprehension of texts. For example, the schemata the reader has which are relevant to the text at hand can facilitate comprehension a great deal. Because schema is a form of organized knowledge and is generalized from the reader's personal experience, increasing the individual's experience also fosters schema development. We noted in Chapter 2 that reading comprehension may be adversely affected if the reader does not have adequate schema regarding the material he is reading or if he fails to activate suitable schema. One approach that aims at developing experience and relating reading to that experience is the Language Experience Approach. There is no single method that can be described as *the* typical Language Experience Approach but, regardless of minor differences, all methods share some common features. The Language Experience Approach is defined as a method in which instruction is built upon the use of reading materials created by writing down children's spoken language. The written material thus created represents the experience and language patterns of the learner. The approach integrates the learner's listening, speaking, reading, and writing activities (Hall, 1978). In case children lack experience specific to the reading task such experience can be developed by undertaking activities such as taking trips to museums, hospitals, or banks; carrying out a science project; or even enacting a play. After such an activity, children are encouraged to express their experience orally with the teacher writing their stories on the chalk board. If the teacher works on an individual basis with the child, the narrative may be written down in a notebook. Subsequently, children are asked to copy what is on the chalkboard or in the notebook and then read what they have copied. The written sheets may be bound together and each child eventually will have his/her own book. Some guidelines for writing Language Experience texts are provided by Reimer (1983).

Newman (1980) makes these suggestions to be followed in implementing a Language Experience Approach:

(1) Establish a good relationship with the learner.

(2) As you proceed, ask questions as needed to help enrich the story or the narrative.

(3) Make the written material easy to see and read.

(4) Write or print slowly so the learner can identify with the process.

(5) Write the learner's words just as he says them, but use standard spelling.

(6) Record the learner's language patterns even when nonstandard.

(7) When the story is written, read the first sentence aloud, pointing to each word.

(8) Have the learner read the sentence aloud, pointing to each word.

(9) Repeat the process until the learner develops some fluency.

(10) Finally, keep the written material in a file folder so that it can be used later for review.

Hall (1978), after reviewing a number of studies, found the overall reading achievement of students who received Language Experience instruction to be satisfactory and, in some cases, superior to the achievement of children instructed by other approaches. Studies also indicate that students improve in spelling and creative writing. According to Hall (1978), the persistent criticism of Language Experience instruction, that students may not develop a satisfactory reading vocabulary, is refuted by research. According to her, Language Experience instruction presents learners with meaningful vocabulary, and a reading vocabulary is acquired by children who are taught through this method.

Schemata are also important for constructing the macrostructure (or general idea) of the text because the execution of processes such as deletion, generalization, and integration of propositions, which yield the main idea of the text, depend on the previous knowledge of the reader. According to the model proposed by Kintsch and van Dijk (1978) (discussed in Chapter 2), the propositions are organized into a hierarchy with those propositions that express the main idea of the text occupying the uppermost levels of the hierarchy. There is evidence to show that learning-disabled children are less capable of identifying the main idea of texts than are normally achieving children (Bridge *et al.*, 1984). Instructional activities such as asking children to summarize a paragraph in one sentence or encouraging them to ask questions about the passage have been found to increase the poor readers' abilities to identify main ideas.

Williams (1986) has described an instructional program that was used with poor readers for successfully developing comprehension of the main idea. In this instructional program, the main idea was called the "general topic" and the subordinate ideas the "specific topics." The ten lessons of the instructional sequence were divided into two parts.

The first part focused on identifying the general and specific topics of the discourse and writing summary sentences. During the initial stages of instruction, children were given training in producing super-ordinate labels (e.g., phrases such as "wooden ball," "red wagon," "paper kites" all represent toys). After this, simple paragraphs were introduced, and the children were asked to provide the general topic. Subsequently, the children were given training in identifying specific topics through a question—answer sequence. For example, if the child read a paragraph about bicycle safety, he may be asked questions such as "Does this paragraph tell us everything about bicycles?" (Answer: No) "Does this paragraph tell us how bicycles are made?" (Answer: No) "Does this paragraph tell us about the traffic rules to be followed while riding the bicycle?" (Answer: Yes). In the second part of the program, paragraphs containing anomalous sentences were introduced, and the reader was asked to determine whether an anomalous sentence was present and, if so, to cross it out. After this, the children wrote a summary of the paragraph in one sentence. When a group of learning-disabled children were trained using this method, they showed substantial improvement in their abilities to identify the main idea of paragraphs and to summarize them. Williams (1986) suggests that training should start with simple and short paragraphs and a great deal of practice should be provided to develop these skills.

2.3.4. *Improving Metacognition Skills*

In Chapter 2, metacognition was described as a knowledge of one's own cognitive processing and the ability to take corrective action when comprehension fails. The effectiveness of metacognition training on reading achievement has not been extensively studied. The few studies which have examined the benefits of metacognitive instruction have concluded that such training produces positive results. Paris *et al.* (1984) taught 8- to 12-year-old children what comprehension strategies are, when they should be used, and why they are effective. Because this comprehension instruction was designed to stimulate children's awareness about reading procedures and to teach them how to evaluate, plan, and regulate their own comprehension strategies, it can be considered as metacognitive training. Paris *et al.* (1984) found that such training was beneficial to children of all ages and reading abilities. Duffy *et al.*

(1986) also found that teachers who provide explicit descriptions of strategies to be used during reading promote students' understanding of lesson content.

The following descriptions of strategies recommended to be used in metacognition training are adopted from the instructional programs used by Paris *et al.* (1984) and Jacobs and Paris (1987) and from the *Index of Reading Awareness* measurement instrument used in these studies. Children are given the following instruction and demonstrations of the skills to be developed in seven steps:

Step (1). Set up your goal. Realize that reading has different goals and purposes. Some materials are read for details, whereas others are read for the main idea. Some materials are read for information, and some materials are read for enjoyment.

Step (2). Know the purpose of reading. The general purpose of reading is to understand the meaning and not necessarily to read fast or to read without making mistakes.

Step (3). Plan your strategy. If you read for details, you should read every sentence. If the purpose is to get the main idea, you can skim and leave out unimportant sentences. (Some useful suggestions for developing skimming skills are provided by Memory and Moore, 1981.)

Step (4). Use comprehension strategies. Focus on important points; you can underline the text if you wish. If you do not understand a word, use the words and sentences around it and guess. If you do not understand what you are reading, slow down. Figure out the most important sentences in a story by identifying the sentences that tell most about the characters or events in the story. Try to identify the unimportant sentences in the story; often they do not tell anything about the characters or events in the story. Pay special attention to sentences in the beginning of the story because they tell you what the story is about. If you do not understand a sentence and you think it is important, go back and reread it. If you still do not understand it, think about other sentences in that paragraph.

Step (5). Monitor your comprehension continuously. As you read along, ask yourself these questions. Can I tell what happened up to now? Can I tell the main idea of the story? Do I remember what has happened thus far? Do the sentences I have read fit together? As you read along, ask "who," "what," "when," and "where" questions.

Step (6). Try to resolve comprehension failure. If you cannot answer these questions satisfactorily, identify the sentence(s) that are difficult. Again, ask yourself why this sentence is difficult: Is it because the words are difficult? Is it because the sentence is too long? Once the problem is identified you can solve it by taking appropriate measures such as rereading, asking the teacher, or consulting the dictionary.

Step (7). Evaluate your reading accomplishment. Ask yourself the following questions. Can I tell the story in my own words? Can I summarize the passage? Can I identify the main idea?

In the program described above, as well as in the one that is described below, students are given explicit training with the teacher illustrating and demonstrating each step. Once the students have mastered the skills described in each step, fewer explicit instructions are given and students assume more responsibility in guiding their own instruction.

The metacognitive strategy instruction described by Palinscar (1986) is called *Reciprocal Teaching* and endeavors to teach students to plan, implement, and evaluate strategic approaches to reading and reading comprehension. The concept of strategy is introduced by using a football game metaphor. The students are told that the successful team not only knows many strategies, but selects the one that best fits the play. This involves consideration of the nature of their opponents and knowledge of their own strengths and weaknesses. Furthermore, the team continually evaluates the effectiveness of the strategy and changes it if necessary. Similarly, the reader selects appropriate strategy (e.g., reading for details or skimming), continually evaluates his/her progress, and takes corrective action when necessary.

Skills such as question generating; clarifying, predicting or anticipating the next idea; summarizing the main idea and separating it from subordinate ideas; and deleting redundancies are explicitly taught. The instructional program is carried out in the form of *Reciprocal Teaching.* In this procedure, before starting reading each day, the group of students and the teacher review these skills. Then, the title of the text is presented and the group is encouraged to make use of the background information they have regarding the topic at hand. Next, the classroom teacher models and provides instruction regarding these strategies. As the days progress, the teacher slowly transfers the responsibility to the students. Palinscar reports that this procedure was used to teach junior high school students who were *adequate decoders* but poor comprehenders. After a trial of 20 consecutive school days, the group, which had ranked below the 20th percentile on comprehension tests before intervention, earned scores that placed them in the 50th percentile and higher following reciprocal teaching.

2.3.5. *Improving Comprehension Through Writing*

Because the act of writing draws the attention of the child to both syntactic and morphological features of sentences as well as to the organizational features of the text, it can be expected that exercises in writing will improve reading comprehension. Even though reading and writing can differ from each other in some subtle ways, both are generative processes in which meaning is constructed by establishing a relationship between what the student knows and the written language. Harris and Sipay (1985), nevertheless, caution that only limited evidence is available to show that there is a transfer of skills between writing and reading. Other investigators (discussed below), however, report positive results. Both writing and reading for meaning involve building relations among words, sentences, and the text. Because successful writing requires providing supporting evidence, paying attention to the narrative sequence, working out cause—effect relationship, and correctly using similes and metaphors, writing experience can be expected to facilitate the reading process by making the reader sensitive to these features of prose. As a matter of fact, a majority of studies that have investigated the relationship between reading achievement and writing skill report a positive correlation. For example, Stotsky (1983), after a review of literature, observes that a number of studies suggest that writing activities are useful for improving comprehension and retention of information. Of the many studies reviewed by her, 15 investigated the influence of writing on reading. The writing exercises used in these studies were in the form of combining sentences, paraphrasing text, writing a one-sentence summary of a paragraph, creative writing, and note taking. The dependent variables in these studies were measures of reading comprehension, retention of vocabulary, and comprehension of the subject matter. Stotsky reports that 13 of the 15 studies found a positive effect of writing on reading which led her to conclude that "almost all studies that used writing activities or exercises specifically to improve reading comprehension or retention of information in instructional material found significant gains" (p. 636).

In recent years, it has come to be recognized that reading and writing are integral parts of learning, that children should be encouraged to write about matters they consider important, and that they should be encouraged to write in an uninhibited manner. While the teacher may provide the necessary guidance, he/she should be careful not to impose his/her own order and structure on children so much so that it becomes one more excercise in academics. Several books are available on the topic of teaching writing and the following are among the ones recently published: Hansen (1987): *When Writers Read*; Calkins, (1986): *The Art of Teaching Writing*; Graves (1983): *Writing: Teachers and Children at Work*. The following suggestions are adopted from an article by Lehr (1981) which contains some specific instructions for the mechanics of integrating reading and writing instruction. The write-to-read program should follow a sequence starting with simple exercises. The teacher should first present children with model sentences and break them into various parts; children may then be asked to assemble the sentences. Next, children may be encouraged to write their own sentences based on concepts such as same—different, cause—effect, time sequence, interrogations, and problem solving. These sentences are then to be combined into paragraphs. Finally, children are shown how to combine paragraphs into a story. This form of exercise has been found to help students to understand the nature of the structure of stories.

3. MANAGEMENT OF READING DISABILITIES

When the student's reading disability is so severe that it has not shown a significant degree of abatement in spite of many years of classroom instruction combined with special tutoring and when the academic demands the student faces are overwhelming, it may be unreasonable to expect remedial teaching to produce positive results. Under these circumstances, helping the student to cope with the academic requirements will be the most pragmatic course of action to follow. Instruction in improving word-attack and word-analysis skills has to be carried out in the context of the learning of subject matter, and any improvement in reading skill that may occur from the tutorial program has to be considered fortuitous. Many college students with developmental dyslexia fall in the category of poor readers whose reading problems can be only managed and not successfully remedied.

3.1. *Management of Dyslexia*

The following principles of management apply to dyslexic college student only and are not intended for students with comprehension deficit. The educational prognosis for college students with poor comprehension, unfortunately, is not very good. In an informal survey conducted by the author, it was found that among the college students who attended the learning skills center, 65 percent of those with decoding deficits but adequate comprehension graduated after 4 to 5 years of college. The corresponding figure for students with comprehension deficit was 16.5 and many of them dropped out before completing four years of college. Furthermore, the prospects of graduating from college does not appear to be significantly different for dyslexic students than it is for normal readers, provided highly specialized and intensive training is given while they are in high school. Finucci *et al.* (1985) found that out of 468 dyslexic students who attended the Gow School, an independent boarding school for boys with developmental dyslexia, 42.7 percent obtained a bachelor's degree. The comparable figure for nondyslexic boys from another school was 44.8 percent.

The management program has three components: (1) academic advisement and study techniques, (2) student advocacy, and (3) counseling.

3.1.1. *Academic Advisement and Study Techniques*

It is logical to expect that a student with reading disability will find courses which require a vast amount of reading to be difficult. Certain courses in humanities fall into this category. Freshmen college students would be wise to avoid too many of these courses when they start their academic careers. Furthermore, the reading requirements of the same course may vary from one instructor to another. A knowledgeable adviser can guide the student with dyslexia to judiciously select courses. It is also prudent not to carry too many courses in one semester but to limit the number to three or four. Sooner or later, the student will have to decide on an academic major and the choice will depend on his/her strengths and weaknesses. In the author's experience, many dyslexic college students who choose majors in fine arts, interior design, industrial technology, drafting, graphic arts, and even computer science have successfully graduated from college. Those who chose majors which require a great deal of reading and correct spelling such as psychology and business education (secretarial courses) have been less successful. One area dyslexic students should be advised to avoid is primary school teaching where the teaching of correct spelling and reading are emphasized. This statement, however, does not apply to teaching in general. The academic major chosen by the student, of course, will depend on his cognitive strengths as well as his interests. The student's strengths can be roughly assessed with the aid of tests such as Wechsler's Adult Intelligence Scale and Differential Aptitude Tests. A better than average WAIS Performance IQ, as is frequently seen in dyslexic students, would suggest that the student is likely to succeed in areas where visual—spatial skills are important.

Early in the academic year, the student has to be taught efficient study techniques. This will include good note-taking skills, proper study habits, and the ability to determine what is important and what is unimportant in a lecture. Several guide books are available on this topic. A simple, down-to-earth, but eminently readable book is by Annis (1983) and is entitled *Study Techniques*. When circumstances permit, the student may tape the lectures and later transfer what is on the tapes to the notebook. In this way, he can avoid dividing his attention between listening and note-taking, the latter not being an easy task for the dyslexic reader.

In recent years, many colleges have established special programs which provide tutorial help for learning-disabled students. The following tips for tutors are taken from a handbook written by C. Baker (1986), Director of Learning Skills Center, at Indiana State University.

The main goal of tutors is to help the dyslexic student pass classes. While the tutor should assist the student to attain this goal, he/she should not do the work for the student.

Tutors must maintain an attitude of respect and not superiority toward their tutees. While the student may not read fluently, he may very well possess other areas of competence.

If the student makes oral reading errors while reading aloud, the tutor should ignore them unless they will interfere with comprehension. However, if the dyslexic student is an extremely slow reader and has great difficulty in recognizing words, the tutor will have to read the text aloud so the student can listen. The tutor has to keep in mind that the goal is to help the student understand the lesson and not necessarily to improve his reading skill.

The tutor should try to avoid using terms such as *no, don't, not like that,* and *you are wrong.* The tutor should also be a good listener.

The tutor must be aware of the fact that there are different kinds of reading problems. There may be some students who can pronounce the words well but not grasp the meaning; some can understand the meaning of words but cannot pronounce them. Dyslexic students have difficulty in pronouncing words and spelling but this problem is not associated with intellectual deficit; in fact, many dyslexic college students are quite bright.

Finally, the tutor should remember that tutoring is a cooperative venture; it is not helpful when a tutor sends a student to a room alone with instructions to outline chapters.

3.1.2. *Student Advocacy*

The reading specialist or the director of the Learning Skills Center has responsibility not only for guiding the dyslexic student but also for acting as an advocate with regard to his/her special needs and requirements. Many college teachers do not have a clear understanding of developmental dyslexia and tend to associate it with letter reversals and brain damage; many do not distinguish between decoding deficit and comprehension deficit. They are likely to be horrified at the spelling mistakes committed by the dyslexic student and will wonder if such a poor speller deserves a college degree. While the reading specialist cannot make excessive demands for special privileges on behalf of the dyslexic students he/she can explain to instructors the nature of developmental dyslexia and point out specifically that it is independent of general intellectual ability and that, in spite of their poor spelling and faulty "grammar," some of them can be excellent creative writers.

It is unreasonable to request that special privileges be extended to the dyslexic students. Nevertheless, because slow reading is one of their problems, the college instructor may be requested to allow the student extra time to finish assignments and tests in the classroom. This is not an unreasonable request because the student's knowledge of the subject matter is more important than how quickly he can answer questions. With the permission of the instructor, the dyslexic students can tape the lectures.

3.1.3. *Counseling*

Counseling the dyslexic student is an integral part of the management program. Counseling the dyslexic student requires a combination of counseling skills such as active listening, establishing empathy, and an expert knowledge of reading disabilities. While a nondirective form of counseling in which the reading specialist explains the nature of the problem, the weaknesses and strengths of the student, and lets the student arrive at his own decisions is perhaps the most desirable form of counseling, correct understanding of the reading process is essential for such counseling to be productive. The best counseling cannot compensate for a sloppy diagnosis or a poor understanding of the nature of the reading disability the student has.

Understandably, many dyslexic college students have poor self-image even though this may not be apparent by superficial observation. They often wonder why they are not able to read rapidly and accurately, a trick which even fifth graders seem to perform without much effort. This feeling leads them to conclude that they are either stupid or have something wrong with their brains. A clear but simple exposition of what dyslexia is can often be helpful in alleviating these feelings of self-doubt. The students may be told that there are several intelligences and that spelling and decoding are automatized functions which are independent of general intelligence. Because dyslexic students do reasonably well on intelligence tests, particularly the performance part of the WAIS IQ test, their scores on these tests can be used to reinforce the message that they are not intellectually deficient.

The dyslexic student could also be told that some famous men such as Woodrow Wilson, Leonardo da Vinci, and Hans Christian Andersen had reading and spelling problems and that these men were able to overcome their handicaps through a combination of hard work and motivation (Aaron *et al.*, 1988). Books written by successful people who have developmental dyslexia (see, for example, Simpson, 1979; Hampshire, 1982; Fleming, 1984) can be a source of inspiration for the student with dyslexia.

3.2. *Management of Hyperlexia*

Little empirical data are available to warrant any definitive recommendations regarding the treatment of comprehension deficits in the hyperlexic child. If any recommendation at all can be made, it would be to try the methods suggested in the previous section of this chapter with regard to the improvement of reading skills of children who are poor comprehenders. However, because many hyperlexic children are severely language disabled, managing their problems may turn out to be the most practical course of action to follow.

Healy *et al.* (1982) emphasize that in hyperlexic children, reading has replaced normal play and other normal childhood activities. Consequently, these children evidence a paucity of cognitive schemata usually acquired during the sensori-motor and pre-operational periods from common childhood experiences. Children who exhibit hyperlexic symptoms should, therefore, be redirected towards pursuing age-appropriate enactive activities. This would mean discouraging or even preventing the hyperlexic child from being preoccupied with print and obsessively engaged in reading and replacing this with play or other interesting concept-building activities. Thus, the treatment of the hyperlexic child would be radically different from the one to be used in the case of the dyslexic child.

NOTE

[1] /f/ stands for the first sound or phoneme in the word *fish* and not for the name of the letter.

REFERENCES

Aaron, P. G.: 1978, 'Dyslexia, an Imbalance in Cerebral Information Processing Strategies,' *Perceptual and Motor Skills* **47**, 699—706.

Aaron, P. G.: 1982, 'The Neuropsychology of Developmental Dyslexia,' in R. N. Malatesha and P. G. Aaron (eds.) *Reading Disorders: Varieties and Treatments*, Academic Press, New York.

Aaron, P. G.: 1985, 'The Paradoxical Relationship between Intelligence and Reading Disability,' *Perceptual and Motor Skills* **61**, 1251—1261.

Aaron, P. G.: 1987, 'Developmental Dyslexia: Is It Different from Other Forms of Reading Disability?' *Annals of Dyslexia* **37**, 109—125.

Aaron, P. G., Baxter, C. and Lucenti, J.: 1980, 'Developmental Dyslexia and Acquired Alexia: Two Sides of the Same Coin?' *Brain and Language* **11**, 1—11.

Aaron, P. G., Grantham, S. and Campbell, N.: 1982, 'Differential Treatment of Reading Disability of Diverse Etiologies,' in R. N. Malatesha and P. G. Aaron (eds.) *Reading Disorders: Varieties and Treatments*, Academic Press, New York.

Aaron, P. G., Bommarito, T. and Baker, C.: 1984, 'The Three Phases of Developmental Dyslexia,' in R. N. Malatesha and H. A. Whitaker (eds.) *Dyslexia: A Global Issue*, Martinus Nijhoff, The Hague.

Aaron, P. G., Olsen, J. and Baker, C.: 1985, 'The Dyslexic College Student: Is He Also Dysphasic?' *Cognitive Neuropsychology* **2** (2), 115—147.

Aaron, P. G. and Phillips, S.: 1986, 'A Decade of Research with Dyslexic College Students: A Summary of Findings,' *Annals of Dyslexia* **36**, 44—65.

Aaron, P. G., Phillips, S., Kleinschrodt, R. and Gregory, C.: 1987, *Can Reading Disabilities Be Diagnosed Without Using IQ Tests*? unpublished manuscript, Indiana State University.

Aaron, P. G., Phillips, S. and Larsen, S.: 1988, 'Specific Reading Disability in Historical Men of Eminence,' *Journal of Learning Disabilities* **21** (9), 523–538.

Aaronson, D. and Ferres, S.: 1984, 'The Word-By-Word Reading Paradigm: An Experimental and Theoretical Approach,' in D. E. Kieras and M. A. Just (eds.) *New Methods in Reading Comprehension*, Lawrence Erlbaum, Hillsdale, NJ.

Abell, A. M.: 1894, 'Rapid Reading and Slow Reading,' *Educational Review* **8**, 283—287.

Adams, M. J.: 1979, 'Models of Word Recognition,' *Cognitive Psychology* **11**, 133—176.

Adams, M. J.: 1981, 'What Good Is Orthographic Redundancy?' in O. L. Tzeng and H. Singer (eds.) *Perception of Print*, Lawrence Erlbaum, Hillsdale, NJ.

Adams, R. B.: 1969, 'Dyslexia: A Discussion of Its Definitions,' *Journal of Learning Disabilities* **2** (12), 617—633.

Adams, R., Kocsis, J. and Estes, R. E.: 1974, 'Soft Neurological Signs in Learning-Disabled Children and Controls,' *American Journal of Diseases of Children* **128**, 614—618.

Aderman, D. and Smith, E. E.: 1971, 'Expectancy As a Determinant of Functional Units in Perceptual Recognition,' *Cognitive Psychology* **2**, 117—129.

Algozzine, D., Yesseldyke, J. E. and Shinn, M.: 1982, 'Identifying Children with Learning Disabilities: When Is Discrepancy Severe?' *Journal of School Psychology* **20**(4), 299–305.

Allington, R. and Fleming, J. T.: 1978, 'The Misreading of High-Frequency Words,' *Journal of Special Education* **12**, 417–421.

Allington, R. and Strange, M.: 1977, 'Effects of Grapheme Substitution in Connected Text upon Reading Behaviors,' *Visible Language* **11**, 285–297.

Anderson, R. C.: 1984, 'Role of the Reader's Schema in Comprehension, Learning, and Memory,' in R. C. Anderson, J. Osborn and R. J. Tierney (eds.) *Learning to Read in American Schools*, Lawrence Erlbaum, Hillsdale, NJ.

Annis, L. F.: 1983, *Study Techniques*, Wm. C. Brown Co, Dubuque, IA.

Aquino, M. R.: 1969, 'The Validity of the Miller—Coleman Readabiltiy Scale,' *Reading Research Quarterly* **4**, 342–357.

Aram, D. M., Ekelman, B. L. and Healy, J. M.: 1984a, *Reading Profiles of Hyperlexic Children*, Paper presented at the meeting of the International Neuropsychology Society, Aachen, West Germany.

Aram, D. M., Rose, D. F. and Horwitz, S. J.: 1984b, 'Hyperlexia: Developmental Reading Without Meaning,' in R. N. Malatesha and H. A. Whitaker (eds.) *Dyslexia: A Global Issue*, Martinus Nijhoff, The Hague.

Aram, D. M. and Healy, J. M.: 1987, 'Hyperlexia: A Review of Extraordinary Word-Recognition,' in L. K. Obler and D. Fein (eds.) *Neuropsychology of Talent and Special Abilities*, Guilford Press, New York.

Arnett, L. J. and DiLollo, V.: 1979, 'Visual Information Processing in Relation to Age and to Reading Ability,' *Journal of Experimental Child Psychology* **27**, 143–152.

Artley, A. S.: 1980, 'Learning Disabilities versus Reading Disabilities: A Vexing Problem,' in C. McCullough (ed.) *Inchworm, Inchworm: Persistent Problems in Reading Education*, International Reading Association, Newark, DE.

Atchison, M. J. and Canter, G. T.: 1979, 'Variables Influencing Phonemic Discrimination Performance in Normal and Learning Disabled Children,' *Journal of Speech and Hearing Disorders* **44**(4), 543–556.

Baddeley, A. D.: 1966, 'Shortterm Memory for Word Sequences as a Function of Acoustic, Semantic and Form Similarity,' *Quarterly Journal of Experimental Psychology* **18**, 362–365.

Baddeley, A. D.: 1978, 'The Trouble with Levels: A Reexamination of Craik and Lockhart's Framework for Memory Research,' *Psychological Review* **85**, 135–152.

Baddeley, A. D.: 1979, 'Working Memory and Reading,' in P. A. Kolers, M. E. Wrolstad, and H. Bouma (eds.) *Processing of Visible Language*, Vol. 1, Plenum, New York.

Baddeley, A. D. and Hitch, G.: 1974, 'Working Memory,' in G. H. Bower (ed.) *The Psychology of Learning and Motivation*, Vol. 8, Academic Press, New York.

Baker, C.: 1986, *Tips for Tutors*, Unpublished manuscript, Learning Skills Center, Indiana State University, Terre Haute, IN.

Baker, L. and Brown, A. L.: 1984, 'Metacognitive Skills and Reading,' in D. P. Pearson (ed.) *Handbook of Reading Research*, Longman, New York.

Bannatyne, A. D.: 1966, 'The Color Phonics System,' in J. Money (ed.) *The Disabled Reader*, Johns Hopkins University Press, Baltimore.

Baron, J.: 1973, 'Phonemic Stage Not Necessary for Reading,' *Quarterly Journal of Experimental Psychology* **25**, 241–266.

Baron, J.: 1981, 'Mechanisms for Pronouncing Printed Words: Use and Acquisition,' in

D. LaBerge and S. Samuels (eds.) *Basic Processes in Reading: Perception and Comprehension*, Lawrence Erlbaum, Hillsdale, NJ.
Baron, J., Treiman, R., Wilf, F. and Kellman, P.: 1980, 'Spelling and Reading by Rules,' in U. Frith (ed.) *Cognitive Processes in Spelling*, Academic Press, London.
Baron, J. and Thurston, I.: 1973, 'An Analysis of Word-Superiority Effect,' *Cognitive Psychology* **4**, 207—228.
Bauer, D. W. and Stanovich, K. E.: 1980, 'Lexical Access and the Spelling-to-Sound Regularity Effect,' *Memory and Cognition* **8**, 424—432.
Bauer, R.: 1977, 'Memory Processes in Children with Learning Disabilities,' *Journal of Experimental Child Psychology* **24**, 415—430.
Beck, I. L. and Roth, S. F.: 1984a, *Construct-A-Word* (Computer Software), Developmental Learning Materials, Allen, TX.
Beck, I. L. and Roth, S. F.: 1984b, *Hint and Hunt* (Computer Software), Developmental Learning Materials, Allen, TX.
Becker, W. C.: 1977, 'Teaching Reading and Language to the Disadvantaged: What We Have Learned from Field Research,' *Harvard Educational Review* **47**, 518—543.
Belanger, J. F.: 1978, 'Calculating the Syntactic Density Score: A Mathematical Problem,' *Research in the Teaching of English* **12**, 149—153.
Benton, A. L.: 1978, 'Some Conclusions about Dyslexia,' in A. L. Benton and D. Pearl (eds.) *Dyslexia: An Appraisal of Current Knowledge*, Oxford University Press, New York.
Benton, A. L.: 1980, 'Dyslexia: Evolution of a Concept,' *Bulletin of the Orton Society* **30**, 10—26.
Berger, N. S. and Perfetti, C. A.: 1977, 'Reading Skill and Memory for Spoken and Written Discourse,' *Journal of Reading Behavior* **9**, 7—16.
Blanchard, J. S., Mason, G. E. and Daniel, D.: 1987, *Computer Applications in Reading* (3rd ed.), International Reading Association, Newark, DE.
Blank, M.: 1985, 'A Word Is a Word — Or Is It?' in D. G. Gray and J. F. Kavanagh (eds.) *Biobehavioral Measures of Dyslexia*, York Press, Parkton, MD.
Blank, M. and Bruskin, C.: 1984, 'The Reading of Content and Noncontent Words by Dyslexics,' in S. J. White and V. Teller (eds.) *Discourses in Reading and Linguistics, Annals of New York Academy of Science* **443**, 59—70.
Bloom, A., Wagner, M., Reskin, L. and Bergman, A.: 1980, 'A Comparison of Intellectually Delayed and Primary Reading Disabled Children on Measures of Intelligence and Achievement,' *Journal of Clinical Psychology* **336** (3), 788—790.
Bloomfield, D. L.: 1961, 'Teaching Children to Read,' in D. L. Bloomfield and C. Barnhart, *Let's Read: A Linguistic Approach*, Wayne State University Press, Detroit, MI.
Bock, K.: 1982, 'Toward a Cognitive Psychology of Syntax: Information Processing Contributions to Sentence Formation,' *Psychological Review* **89** (1), 1—47.
Boder, E.: 1973, 'A Diagnostic Approach Based on Three Atypical Reading—Spelling Patterns,' *Developmental Medicine and Child Neurology* **15**, 663—687.
Boder, E. and Jarrico, S.: 1982, *Boder Reading and Spelling Pattern Test: A Diagnostic Screening Test for Developmental Dyslexia*, Grune and Stratton, New York.
Bormuth, J. R.: 1972, 'Review of "Durrell Listening—Reading Series,"' in K. Buros (ed.) *The Seventh Mental Measurement Year Book*, Gryphon Press, Highland Park, NJ.

Bos, C. S. and Flip, C.: 1982, 'Comprehension Monitoring Skills in Learning Disabled and Average Students,' in B. Y. Wong (ed.) *Metacognition and Learning Disabilities*, Aspens Systems Corp., Rockville, MD.

Bradley, L. and Bryant, P.: 1978, 'Difficulties in Auditory Organization as a Possible Cause of Reading Backwardness,' *Nature* **271**, 746—747.

Bradley, L. and Bryant, P.: 1983, 'Categorizing Sounds and Learning to Read: A Causal Connection,' *Nature* **301**, 419—421.

Bradley, D. C., Garrett, M. F. and Zurif, E. G.: 1980, 'Syntactic Deficits in Broca's Aphasia,' in D. Caplan (ed.) *Biological Studies of Mental Processes*, MIT Press, Cambridge, MA.

Brady, S.: 1986, 'Short-term Memory, Phonological Processing, and Reading Ability,' *Annals of Dyslexia* **36**, 138—153.

Brady, S., Shankweiler, D. and Mann, V.: 1983, 'Speech Perception and Memory Coding in Relation to Reading Ability,' *Journal of Experimental Child Psychology* **35**, 345—367.

Bransford, J. D. and McCarrell, N. S.: 1974, 'A Sketch of a Cognitive Approach to Comprehension: Some Thoughts about Understanding What It Means to Comprehend,' in W. B. Weimer and D. S. Palermo (eds.) *Cognition and the Symbolic Process*, Lawrence Erlbaum, Hillsdale, NJ.

Bridge, C. A., Belmore, S. M., Moskow, S. P., Cohen, S. S. and Mathews, P. D.: 1984, 'Topicalization and Memory for Main Idea in Prose,' *Journal of Reading Behavior* **16**, 61—80.

Bronner, A. F.: 1917, *The Psychology of Special Abilities and Disabilities*, Little, Brown and Co., Boston, MA.

Brown, A. L. and Campione, J. C.: 1986, 'Psychological Theory and the Study of Learning Disabilities,' *American Psychologist* **41** (10), 1059—1068.

Bryant, P. and Bradley, L.: 1980, 'Why Children Sometimes Write Words Which They Do Not Read,' in U. Frith (ed.) *Cognitive Processes in Spelling*, Academic Press, London.

Bryant, P. and Goswami, U.: 1986, 'The Strengths and Weaknesses of the Reading Level Design,' *Psychological Bulletin* **100**, 101—103.

Bryant, P. and Impey, L.: 1986, 'The Similarities between Normal Readers and Developmental and Acquired Dyslelxics,' *Cognition* **24**, 121—137.

Bryden, M. P.: 1982, *Laterality: Functional Asymmetry in the Intact Brain*, Academic Press, New York.

Burd, L., Kerbeshian, J. and Fisher, W.: 1985, 'Inquiry into the Incidence of Hyperlexia in a State-wide Population of Children with Pervasive Developmental Disorder,' *Psychological Reports* **57**, 236—238.

Burt, C.: 1921, *Mental and Scholastic Tests*, P. S. King and Son, London.

Bus, A. G.: 1986, 'Preparatory Reading Instruction in Kindergarten: Some Comparative Research into Methods of Auditory and Auditory—Visual Training of Phonemic Analysis and Blending,' *Perceptual and Motor Skills* **62**, 11—24.

Bryne, B. and Arnold, L.: 1981, 'Dissociation of the Recency Effect and Immediate Memory Span: Evidence from Beginning Readers,' *British Journal of Psychology* **72**, 371—376.

Byrne, B. and Shea, P.: 1979, 'Semantic and Phonetic Memory Codes in Beginning Readers, *Memory and Cognition* 7 (5), 333—338.

Calfee, R. C., Venezky, R. L. and Chapman, R. S.: 1969, 'Pronunciation of Synthetic Words with Predictable and Unpredictable Letter—Sound Correspondences,' *Technical Report No. 11*, University of Wisconsin, Research and Developmental Center.

Calkins, L. M.: 1986, *The Art of Teaching Writing*, Heinemann Educational Books, Portsmouth, NH.

Campbell, D. D.: 1971, 'Response to Symposium: Continuum or Continua?' *The Journal of Special Education* **5** (3), 253—255.

Canney, G. and Winograd, P.: 1979, 'Schemata for Reading and Reading Comprehension Performance,' *Technical Report 120*, University of Illinois, Champaign, IL.

Carr, T. H.: 1982, 'What's in a Model: Reading Theory and Reading Instruction,' in H. Singer (ed.) *Competent Reader, Disabled Reader: Research and Application*, Lawrence Erlbaum, Hillsdale, NJ.

Carr, T. H. and Pollatsek, A.: 1985, 'Recognizing Printed Words: A Look at Current Models,' in D. Besner, T. G. Waller and G. E. MacKinnon (eds.) *Reading Research: Advances in Theory and Practice*, vol. 5, Academic Press, Orlando, FL.

Carroll, J. B.: 1964: *Language and Thought*, Prentice Hall, Englewood Cliffs, NJ.

Carroll, J. B.: 1977, 'Developmental Parameters of Reading Comprehension,' in J. T. Guthrie (ed.) *Cognition, Curriculum, and Comprehension*, International Reading Association, Newark, DE.

Carroll, J. B., Davies, P. and Richman, B.: 1971, *Word Frequency Book*. Houghton Mifflin, New York.

Carver, R. P.: 1973, 'Effect of Increasing the Rate of Speech Presentation upon Comprehension,' *Journal of Educational Psychology* **65**, 118—126.

Carver, R. P.: 1977, 'Toward a Theory of Reading Comprehension and Rauding,' *Reading Research Quarterly* **1**, 8—63.

Cattell, J. M.: 1885, 'The Inertia of the Eye and Brain,' *Brain* **8**, 295—312.

Cattell, J. M.: 1886, 'The Time Taken Up by Cerebral Operations,' in T. A. Poffenberger (ed.) *James Keen Cattell*, Basic Books, New York. [1947]

Chall, J.: 1967, *Learning to Read: The Great Debate*, McGraw-Hill, New York.

Chall, J.: 1983, *Learning to Read: The Great Debate* (2nd ed.), McGraw-Hill, New York.

Chall, J.: 1987, 'Two Vocabularies for Reading: Recognition and Meaning,' in M. G. McKeown and M. E. Curtis (eds.) *The Nature of Vocabulary Acquisition*, Lawrence Erlbaum, Hillsdale, NJ.

Chambers, S. M.: 1979, 'Letter and Order Information in Lexical Access,' *Journal of Verbal Learning and Verbal Behavior* **18**, 225—241.

Chang, T. M.: 1986, 'Semantic Memory: Facts and Models,' *Psychological Bulletin* **99**, 199—220.

Chi, M. T.: 1976, 'Short-Term Memory Limitations in Children: Capacity or Processing Deficits?,' *Memory and Cognition* **4**, 559—572.

Chomsky, C.: 1969, 'The Acquisition of Syntax in Children from 5 to 10,' *Research Monograph No. 57*, The MIT Press, Cambridge, MA.

Chomsky, N. and Halle, M.: 1968, *The Sound Pattern of English*, Harper and Row, New York.

Clairborne, J. H.: 1906, 'Types of Congenital Amblyopia,' *Journal of the American Medical Association* **47**, 1813—1816.

Cobrinik, L.: 1974, 'Unusual Reading Ability in Severely Disturbed Children,' *Journal of Autism and Childhood Schizophrenia* **4**, 163—175.

Cobrinik, L.: 1982, 'The Performance of Hyperlexic Children on an "Incomplete Words" Task,' *Neuropsychologia* **20**, 569—577.

Cohen, R. and Netley, C.: 1978, 'Cognitive Deficits, Learning Disabilities, and WISC Verbal-performance Consistency,' *Developmental Psychology* **14**, 624—634.

Cohen, R. and Netley, C.: 1981, 'Short-term Memory Deficits in Reading Disabled Children in the Absence of Opportunity for Rehearsal,' *Intelligence* **5**, 69—76.

Coleman, E. B.: 1970, 'Collecting a Data Base for a Reading Technology,' *Journal of Educational Psychology* **6**, 1—23.

Coltheart, M.: 1978, 'Lexical Access in Simple Reading Tasks,' in G. Underwood (ed.) *Strategies of Information Processing*, Academic Press, New York.

Coltheart, M.: 1980a, 'Reading, Phonological Recoding and Deep Dyslexia,' in M. Coltheart, K. Patterson and J. C. Marshall (eds.) *Deep Dyslexia*, Kegan Paul, London.

Coltheart, M.: 1980b, 'Deep Dyslexia: A Right Hemisphere Hypothesis,' in M. Coltheart, K. Patterson and J. C. Marshall (eds.) *Deep Dyslexia*, Kegan Paul, London.

Coltheart, M.: 1987, 'Varieties of Surface Dyslexia: A Comment on Bryant and Impey,' *Cognition* **27**, 97—101.

Coltheart, M., Davelaar, E., Jonasson, J. T. and Besner, D.: 1977, 'Access to the Internal Lexicon,' in S. Dornic (ed.) *Attention and Performance*, vol. VI, Lawrence Erlbaum, Hillsdale, NJ.

Coltheart, M., Masterson, J., Byng, S., Prior, M. and Riddoch, M. J.: 1983, 'Surface Dyslexia,' *Quarterly Journal of Experimental Psychology* **35**, 469—495.

Conrad, R.: 1964, 'Acoustic Confusions in Immediate Memory,' *British Journal of Psychology* **55**, 75—84.

Conrad, R.: 1972, 'Speech and Reading,' in J. Kavanagh and I. Mattingly (eds.) *Language by Ear and by Eye*, MIT Press, Cambridge, MA.

Cook, L.: 1981, 'Misspelling Analysis in Dyslexia. Observation of Developmental Strategy Shifts,' *Bulletin of the Orton Society* **31**, 123—134.

Cooper, W. and Cooper, J.: 1980, *Syntax and Speech*. Harvard University Press, Cambridge, MA.

Coslet, H. B., Rothi, L. G. and Heilman, K. M.: 1985, 'Reading: Dissociation of the Lexical and Phonological Mechanisms,' *Brain and Language* **24**, 20—35.

Craik, F. M. and Lockhart, R. S.: 1972, 'Levels of Processing: A Framework for Memory Research,' *Journal of Verbal Learning and Verbal Behavior* **11**, 671—684.

Critchley, M. and Critchley, E.: 1978, *Dyslexia Defined*, Charles Thomas, Springfield, IL.

Cromer, R. F.: 1970, 'Children Are Nice to Understand: Surface Structure Clues for the Recovery of Deep Structure,' *British Journal of Psychology* **61**, 397—408.

Crowder, R. G.: 1982a, 'The Demise of Short-term Memory,' *Acta Psychologica* **50**, 291—323.

Crowder, R. G.: 1982b, *The Psychology of Reading*, Oxford University Press, New York.

Curtis, M. E.: 1980, 'Development of Components of Reading Skill,' *Journal of Educational Psychology* **72** (5), 656—669.

Danks, J.: 1980, 'Comprehension in Listening and Reading: Same or Different,' in J. Danks and K. Pezdek (eds.) *Reading and Understanding*, International Reading Association, Newark, DE.

Das, J. P., Kirby, J. R. and Jarman, R.: 1979, *Simultaneous and Successive Cognitive Processes*, Academic Press, New York.

Davelaar, E., Coltheart, M., Besner, D. and Jonasson, J.: 1978, 'Phonological Recoding and Lexical Access,' *Memory and Cognition* **6**, 391—402.

Davenport, L., Yingling, C. D., Fein, G., Galin, D. and Johnstone, J.: 1986, 'Narrative Speech Deficits in Dyslexics,' *Journal of Clinical and Experimental Neuropsychology* **8** (4), 341—361.

Davidson, H.: 1935, 'A Study of the Confusing Letters *b, d, p*, and *q*,' *Journal of Genetic Psychology* **47**, 458—467.

Davis, R. D. and Cashdon, A.: 1963, 'Specific Dyslexia,' *British Journal of Psychology* **33**, 80—82.

Dearborn, W. F.: 1925, 'The Etiology of Word Blindness,' in E. Lord, L. Carmichael and W. F. Dearborn (eds.) *Special Disabilities in Learning to Read and Write, Harvard Monographs in Education*, vol. II, Series I, No. 1.

Decker, S. N. and Vandenberg, S.: 1985, 'Colorado Twin Study of Reading Disability,' in D. B. Gray and J. F. Kavanagh (eds.) *Behavioral Measures of Dyslexia*, York Press, Parkton, MD.

DeFries, J. C.: 1985, 'Colorado Reading Project,' in D. B. Gray and J. G. Kavanagh (eds.) *Behavioral Measures of Dyslexia*, York Press, Parkton, MD.

de Hirsch, K.: 1971, 'Are Hyperlexics Dyslexics?' *Journal of Special Education* **5** (3), 243—246.

Dejerine, J. C.: 1891, 'Sur un Cas de Cécité Verbale avec Agraphie, Suivi d'Autopsie,' *Mem. Soc. Biol.* **3**, 197—201. (Cited in N. Geschwind (ed.) *Selected Papers in Language and the Brain*, Reidel, Boston, 1974.)

Dejerine, J. C.: 1892, 'Des Différentes Variétés de Cécité Verbale,' *Mem. Soc. Biol.* **4**, 1—30. (Cited in N. Geschwind (ed.) *Selected Papers in Language and the Brain*, Reidel, Boston, 1974.)

Dempster, F. N.: 1981, 'Memory Span: Sources of Individual and Developmental Differences,' *Psychological Bulletin* **89**, 63—100.

Denckla, M. B. and Rudel, R. G.: 1976a, 'Naming of Object Drawings by Dyslexic and Other Learning Disabled Children,' *Brain and Language* **3**, 1—16.

Denckla, M. B. and Rudel, R. G.: 1976b, 'Rapid Automatized Naming: Dyslexia Differentiated from Other Learning Disabilities,' *Neuropsychologia* **14**, 471—479.

Deno, S.: 1985, 'Curriculum-based Measurement: The Emerging Alternative,' *Exceptional Children* **52** (3), 219—232.

de Villiers, P. A.: 1974, 'Imagery and Theme in Recall of Connected Discourse,' *Journal of Experimental Psychology* **103**, 263—268.

Di Lollo, V., Hanson, D. and McIntyre, S.: 1983, 'Initial Stages of Visual Information Processing in Dyslexia,' *Journal of Experimental Psychology (Human Perception and Performance)* **9** (6), 923—935.

Di Vesta, F. J., Hayward, K. G. and Orlando, V. P.: 1979, 'Developmental Trends in Monitoring Text for Comprehension,' *Child Development* **50**, 97—105.

Doctor, E. and Coltheart, M.: 1980, 'Children's Use of Phonological Encoding When Reading for Meaning,' *Memory and Cognition* **8** (3), 195—209.

Doehring, D.: 1984, 'Subtyping of Reading Disorders: Implications for Remediation,' *Annals of Dyslexia* **34**, 205—216.

Doehring, D. and Hoshko, I.: 1977, 'Classification of Reading Problems by the Q-technique of Factor Analysis,' *Cortex* **13**, 281—294.

Doehring, D., Trites, R., Patel, P. and Fiedorowicz, C.: 1981, *Reading Disabilities: The Interaction of Reading, Language, and Neuropsychological Deficits*, Academic Press, New York.

Done, D. J. and Miles, T. R.: 1978, 'Learning, Memory, and Dyslexia,' in M. M. Gruneberg, P. E. Morris and R. N. Sykes (eds.) *Practical Aspects of Memory*, Academic Press, London.

Duffy, F. H. and McAnulty, G. B.: 1985, 'Brain Electrical Activity Mapping (BEAM): The Search for a Physiological Signature of Dyslexia,' in F. H. Duffy and N. Geschwind (eds.) *Dyslexia: A Neuroscientific Approach to Clinical Evaluation*, Little, Brown and Co., Boston, MA.

Duffy, G., Roehler, L. and Rackliffe, G.: 1986, 'How Teachers' Instructional Task Influences Students' Understanding of Lesson Content,' *Elementary School Journal* **87**, 3—16.

Duker, S.: 1965, 'Listening and Reading,' *Elementary School Journal* **65**, 321—324.

Durrell, D. D.: 1955, *Durrell Analysis of Reading Difficulties*, Harcourt, Brace, and Jovanovich, New York.

Durrell, D. D.: 1969, 'Listening Comprehension versus Reading Comprehension,' *Journal of Reading* **12**, 455—460.

Durrell, D. D. and Hayes, M.: 1969, *Durrell Listening—Reading Series. Manual for Listening and Reading Tests — Primary Level*, Psychological Corp., New York.

Ehrlich, B. F. and Rayner, K.: 1981, 'Contextual Effects on Word Perception and Eye Movements During Reading,' *Journal of Verbal Learning and Verbal Behavior* **20**, 641—655.

Ehrlich, I. L.: 1968, *Instant Vocabulary*, Simon and Schuster, New York.

Elkonin, D. B.: 1973, 'Reading in U.S.S.R.,' in J. Downing (ed.) *Comparative Reading*, MacMillan, New York.

Elliott, D. E. and Needleman, R. M.: 1976, 'The Syndrome of Hyperlexia,' *Brain and Language* **3**, 339—349.

Ellis, A. W.: 1979, 'Developmental and Acquired Dyslexia: Some Observations on Jorm (1979),' *Cognition* **7**, 413—420.

Ellis, A. W.: 1984, *Reading, Writing and Dyslexia: A Cognitive Approach*, Lawrence Erlbaum, Hillsdale, NJ.

Ellis, N. and Miles, T. R.: 1978a, 'Visual Information Processing in Dyslexic Children,' in M. M. Gruneberg, P. E. Morris and R. N. Sykes (eds.) *Practical Aspects of Memory*, Academic Press, London.

Ellis, N. and Miles, T. R.: 1978b, 'Visual Information Processing as Determinant of Reading Speed,' *Journal of Reading Research* **1** (2), 108—120.

Erdmann, B. and Dodge, R.: 1898, 'Psychologische Untersuchungen uber das Lesen auf Experimentaller Grundlage,' Halle.

Eriksen, C. W. and Collins, J. F.: 1967, 'Some Temporal Characteristics of Visual Pattern Perception,' *Journal of Experimental Psychology* **74**, 476—484.

Eriksen, C. W. and Collins, J. F.: 1968, 'Sensory Traces versus the Psychological Moment in the Temporal Organization of Form,' *Journal of Experimental Psychology* **77**, 376–382.

Fernald, G. and Keller, H.: 1921, 'The Effect of Kinesthetic Factors in Development of Word Recognition in the Case of Nonreaders,' *Journal of Educational Research* **4**, 357–377.

Fiedorowicz, C. A.: 1986, 'Training of Component Reading Skills,' *Annals of Dyslexia* **36**, 318–334.

Fildes, L. G.: 1921, 'A Psychological Inquiry into the Nature of the Condition Known as Congenital Word Blindness,' *Brain* **44**, 286–304.

Finucci, J. M., Gottfredson, L. S. and Childs, B.: 1985, 'A Follow-up Study of Dyslexic Boys,' *Annals of Dyslexia* **30**, 117–136.

Finucci, J. M., Isaacs, S. D., Whitehouse, C. C. and Childs, B.: 1983, 'Classification of Spelling Errors and Their Relationship to Reading Ability, Sex, Grade Placement, and Intelligence,' *Brain and Language* **20**, 340–355.

Firth, I.: 1972, *Components of Reading Ability*, Unpublished doctoral dissertation, University of New South Wales. (Cited in A. Jorm and D. L. Share, 1983, 'Phonological Recoding and Reading Acquisition,' *Applied Psycholinguistics* **4**, 103–147.)

Fischer, F. W., Liberman, I. Y. and Shankweiler, D.: 1978, 'Reading Reversals and Developmental Dyslexia: A Further Study,' *Cortex* **14**, 496–510.

Fischer, F. W., Shankweiler, D. and Liberman, I. Y.: 1985, 'Spelling Proficiency and Sensitivity to Word Structure,' *Journal of Memory and Language* **24**, 423–441.

Fisher, H.: 1910, 'Congenital Word-blindness,' *Transactions of the Ophthalmological Society* **30**, 216–222.

Fisher, P. F. and Frankfurter, A.: 1977, 'Normal and Disabled Readers Can Locate and Identify Letters: Where Is the Perceptual Deficit?' *Journal of Reading Behavior* **9**, 31–43.

Fleming, E.: 1984, *Believe the Heart*, Strawberry Hill Press, San Francisco, CA.

Flood, J.: 1984, *Understanding Reading Comprehension*, International Reading Association, Newark, DE.

Foder, J. A.: 1983, *The Modularity of Mind*, Bradford, Montgomery, VT.

Fontenelle, S. and Alarcon, M.: 1982, 'Hyperlexia: Precocious Word Recognition in Developmentally Delayed Children,' *Perceptual and Motor Skills* **55**, 247–252.

Forness, S. R., Sinclair, E. and Guthrie, D.: 1983, 'Learning Disability Discrepancy Formulas: Their Use in Actual Practice,' *Learning Disability Quarterly* **6**, 107–114.

Forrest, D. L. and Waller, T. S.: 1979, *Cognitive and Metacognitive Aspects of Reading*, Paper presented at the meeting of the Society for Research in Child Development, San Francisco, CA.

Forster, K. I.: 1976, 'Assessing the Mental Lexicon,' in R. J. Wales and E. Walker (eds.) *New Approaches to Language Mechanisms*, New Holland Publishers, Amsterdam.

Foster, K. I. and Chambers, S. M.: 1973, 'Lexical Access and Naming Time,' *Journal of Verbal Learning and Verbal Behavior* **12**, 627–635.

Fox, B. and Routh, D. K.: 1975, 'Analyzing Spoken Language into Words, Syllables, and Phonemes: A Developmental Study,' *Journal of Psycholinguistic Research* **4**, 331–342.

Fox, B. and Routh, D. K.: 1976, 'Phonemic Analysis and Synthesis as Word-attack Skills,' *Journal of Educational Psychology* **68**, 70—74.

Fox, B. and Routh, D. K.: 1980, 'Phonemic Analysis and Severe Reading Disability in Children,' *Journal of Psycholinguistic Research* **9**, 115—119.

Fox, B. and Routh, D. K.: 1983, 'Reading Disability, Phonemic Analysis, and Dysphonetic Spelling: A Follow-up Study,' *Journal of Clinical and Child Psychology* **12**, 28—32.

Frederiksen, J. R.: 1981, 'Sources of Process Interactions in Reading,' in A. M. Lesgold and C. A. Perfetti (eds.) *Interactive Processes in Reading*, Lawrence Erlbaum, Hillsdale, NJ.

Frederiksen, J. R.: 1982, 'A Componential Model of Reading and Their Interrelation,' in R. J. Sternberg (ed.) *Advances in the Psychology of Human Intelligence*, Lawrence Erlbaum, Hillsdale, NJ.

Frederiksen, J. R. and Kroll, J. F.: 1976, 'Spelling and Sound Approaches to the Internal Lexicon,' *Journal of Experimental Psychology: Human Perception and Performance* **2**, 361—379.

Fries, C. C.: 1963, *Linguistics and Reading*, Holt, Rinehart, and Winston, New York.

Frith, U.: 1980, 'Unexpected Spelling Problems,' in U. Frith (ed.) *Cognitive Processes in Spelling*, Academic Press, London.

Frith, U.: 1984, 'Specific Spelling Problems,' in R. N. Malatesha and H. A. Whitaker (eds.) *Dyslexia: A Global Issue*, Martinus Nijhoff, The Hague.

Frith, U. and Snowling, M.: 1983, 'Reading for Meaning and Reading for Sound in Autistic and Dyslexic Children,' *British Journal of Developmental Psychology* **1**, 329—342.

Fromkin, V. A.: 1971, 'The Non-anomalous Nature of Anomalous Utterances,' *Language* **47**, 27—52.

Fry, M. A., Johnson, C. S. and Meuhl, S.: 1970, 'Oral Language Production in Relation to Reading Achievement among Selected Sound Graders,' in D. J. Bakker and P. Satz (eds.) *Specific Reading Disability: Advances in Theory and Method*, Rotterdam University Press, Rotterdam.

Funnell, E.: 1983, 'Phonological Processes in Reading: New Evidence from Acquired Dyslexia,' *British Journal of Psychology* **74**, 159—180.

Galaburda, A. M.: 1985, 'Developmental Dyslexia: A Review of Biological Interactions,' *Annals of Dyslexia* **35**, 21—34.

Ganschow, L.: 1984, 'Analysis of Written Language of a Language Learning Disabled (Dyslexic) College Student and Instructional Implications,' *Annals of Dyslexia* **34**, 271—284.

Gaskins, I.: 1982, 'Let's End the Reading Disabilities/Learning Disabilities Debate,' *Journal of Learning Disabilities* **15**(2), 81—83.

Gates, A. I.: 1922, *The Psychology of Reading and Spelling with Special Reference to Disability*, Teachers College Contribution to Education (No. 129). Columbia University, New York.

Gates, A. I.: 1929, *The Improvement of Reading*, MacMillan, New York.

Geiger, G. and Lettvin, J.: 1987, 'Peripheral Vision in Persons with Dyslexia,' *The New England Journal of Medicine* **316**, 1238—1243.

Gentry, R. J.: 1987, *SPEL is a Four-letter Word*, Heinemann, Portsmouth, NH.

Gerber, M.: 1984, 'Orthographic Problem-solving Ability of Learning Disabled and Normally Achieving Students,' *Learning Disability Quarterly* 7, 158—164.

German, D., Johnson, B. and Schneider, M.: 1985, 'Learning Disability vs. Reading Disability: A Survey of Practioners' Diagnostic Populations and Test Instruments,' *Learning Disability Quarterly* **8**, 141—157.

Geschwind, N.: 1974, 'The Alexias,' in N. Geschwind (ed.) *Selected Papers of Language and the Brain*, Reidel, Dordrecht, Holland/Boston, MA.

Geschwind, N.: 1985, 'The Biology of Dyslexia,' in D. G. Gray and J. F. Kavanagh (eds.) *Biobehavioral Measures of Dyslexia*, York Press, Parkton, MD.

Geschwind, N. and Behan, P.: 1982, 'Left Handedness: Association with Immune Disease, Migraine, and Developmental Learning Disorder,' *Proceedings of the National Academy of Science* **79**, 5097—5100.

Geschwind, N. and Galaburda, A.: 1985a, 'Cerebral Lateralization: Biological Mechanisms, Associations, and Pathology. (1). A Hypothesis and a Program of Research,' *Archives of Neurology* **42**, 428—459.

Geschwind, N. and Galaburda, A.: 1985b, 'Cerebral Lateralization: Biological Mechanisms, Associations, and Pathology. (2). A Hypothesis and a Program of Research,' *Archives of Neurology* **42**, 521—552.

Geschwind, N. and Galaburda, A.: 1985c, 'Cerebral Lateralization: Biological Mechanisms, Associations, and Pathology. (3). A Hypothesis and a Program of Research,' *Archives of Neurology* **42**, 634—654.

Gibson, E. J.: 1977, 'How Perception Really Develops: A View from Outside the Network,' in D. LaBerge and S. J. Samuels (eds.) *Basic Processes in Reading: Perception and Comprehension*, Lawrence Erlbaum, Hillsdale, NJ.

Gibson, E. J. and Guinet, L.: 1971, 'Perception of Inflections in Brief Visual Presentation of Words,' *Journal of Verbal Learning and Verbal Behavior* **10**, 182—189.

Gibson, E. J. and Levin, H.: 1975, *The Psychology of Reading*, MIT Press, Cambridge, MA.

Gillingham, A. and Stillman, B.: 1966, *Remedial Training for Children with Specific Difficulty in Reading, Spelling, and Penmanship* (7th ed.), Educators Publishing Service, Cambridge, MA.

Glushko, R. J.: 1979, 'The Organization and Activation of Orthographic Knowledge in Reading Aloud,' *Journal of Experimental Psychology: Human Perception and Performance* **5**(4), 674—691.

Goldberg, E. and Costa, L. D.: 1981, 'Hemispheric Differences in the Acquisition and Use of Descriptive Systems,' *Brain and Language* **14**, 144—173.

Goldberg, T. E. and Rothermel, R. D.: 1984, 'Hyperlexic Children Reading,' *Brain* **107**, 759—785.

Goldblum, M. C.: 1985, 'Word Comprehension in Surface Dyslexia,' in K. E. Patterson, J. C. Marshall and M. Coltheart (eds.) *Surface Dyslexia*, Lawrence Erlbaum, Hillsdale, NJ.

Golub, L. S. and Kidder, C.: 1974, 'Syntactic Density and the Computer,' *Elementary English* **51**, 1128—1131.

Goodman, K. S.: 1968, 'The Psycholinguistic Nature of the Reading Process,' in K. S. Goodman (ed.) *The Psycholinguistic Nature of the Reading Process*, Wayne State University Press, Detroit, MI.

Gough, P. B.: 1972, 'One Second Reading,' in J. F. Kavanagh and I. G. Mattingly (eds.) *Language by Ear and by Eye*, MIT Press, Cambridge, MA.

Gough, P. B.: 1984, 'Word Recognition,' in D. Pearson (ed.) *Handbook of Reading Research*, Longman, New York.

Gough, P. B. and Stewart, W.: 1970, *Word vs. Nonword Discrimination Latency*, Paper presented at the Midwestern Psychological Association. (Cited in D. W. Massaro, 1975.)

Gough, P. B. and Tunmer, W.: 1986, 'Decoding, Reading, and Reading Disability,' *Remedial and Special Education* 7 (1), 6—10.

Graves, D. H.: 1983, *Writing: Teachers and Children at Work*, Heineman Educational Books, Portsmouth, NH.

Graves, M. F.: 1984, 'Selecting Vocabulary to Teach in the Intermediate and Secondary Grades,' in J. Flood (ed.) *Promoting Reading Comprehension*, International Reading Association, Newark, DE.

Gray, C. T.: 1922, *Deficiencies in Reading Ability: Their Diagnosis and Remedies*, D. C. Heath, Boston, MA.

Gray, W. S.: 1917, 'Studies of Elementary School Reading Through Standardized Tests,' *Educational Monographs Supplementary No. 1*, University of Chicago Press, Chicago.

Gray, W. S.: 1922, 'Remedial Cases in Reading: Their Diagnosis and Treatment,' *Educational Monographs Supplementary No. 221*, University of Chicago Press, Chicago.

Guthrie, J. T., Seifert, M., Burnham, N. and Caplan, R. I.: 1974, 'The Maze Technique to Assess, Monitor Reading Comprehension,' *The Reading Teacher* **28**, 161—168.

Guthrie, J. T. and Tyler, S.: 1976, 'Psycholinguistic Processing in Reading and Listening among Good and Poor Readers,' *Journal of Reading Behavior* **8**, 415—426.

Hall, M.: 1978, *The Language Experience Approach for Teaching Reading*, International Reading Association, Newark, DE.

Hammill, D. D.: 1974, 'Assessing and Training Perceptual-motor Processes,' in D. D. Hammill and N. R. Bartell (eds.) *Teaching Children with Learning and Behavioral Problems*, Allyn and Bacon, Boston.

Hampshire, S.: 1982, *Susan's Story: An Autobiographical Account of My Struggle with Dyslexia*, St. Martin's Press, New York.

Hansen, J.: 1987, *When Writers Read*, Heinman Educational Books, Portsmouth, NH.

Harris, J. A. and Sipay, E. R.: 1980, *How to Increase Reading Ability* (7th ed.), Longman, New York.

Harris, J. A. and Sipay, E. R.: 1985, *How to Increase Reading Ability* (8th ed.), Longman, New York.

Hasan, R.: 1984, 'Coherence and Cohesive Harmony,' in J. Flood (ed.) *Understanding Reading Comprehension: Cognition, Language, and the Structure of Prose*, International Reading Association, Newark, DE.

Healy, J.: 1982, 'The Enigma of Hyperlexia,' *Reading Research Quarterly* **17**, 319—338.

Healy, J., Aram, D. M., Horwitz, S. J. and Kessler, J. W.: 1982, 'A Study of Hyperlexia,' *Brain and Language* **17**, 1—23.

Healy, J. and Aram, D. M.: 1986, 'Hyperlexia and Dyslexia: A Family Study,' *Annals of Dyslexia* **36**, 237—252.

Henderson, L.: 1982, *Orthography and Word Recognition in Reading*, Academic Press, New York.

Henry, M.: 1987, *Understanding English Orthography: Assessment and Instruction for Decoding and Spelling*, Unpublished doctoral dissertation, Stanford University.

Herman, R.: 1979, *The Herman Method for Reversing Reading Failure*, Romar Publications, Sherman Oaks, CA.

Hier, D., Le May, M., Rosenberger, P. and Perlo, P.: 1978, 'Developmental Dyslexia:

Evidence for a Subgroup with a Reversal of Cerebral Asymmetry,' *Archives of Neurology* **35**, 90—92.

Hinshelwood, J.: 1895, 'Word-blindness and Visual Memory,' *The Lancet* **21**, 1564—1570.

Hinshelwood, J.: 1900, 'Congenital Word-Blindness,' *The Lancet* **1**, 1506—1508.

Hinshelwood, J.: 1907, 'Four Cases of Congenital Word-blindness Occurring in the Same Family,' *The British Medical Journal* **2**, 1229—1231.

Hinshelwood, J.: 1917, *Congenital Word-blindness*, Lewis, London.

Holmes, D. and McKeever, W.: 1979, 'Material Specific Serial Memory Deficit in Adolescent Dyslexics,' *Cortex* **15**, 51—62.

Holmes, J. M.: 1973, *A Neurolinguistic Study of Traumatic and Developmental Disorders of Reading*, Unpublished Ph.D. thesis, University of Edinburgh.

Holmes, J. M.: 1978, 'Regression and Reading Breakdown,' in A. Caramazza and E. B. Zurif (eds.) *Language Acquisition and Language Breakdown*, The Johns Hopkins University Press, Baltimore, MD.

Hudson, P. T. and Bergman, M.: 1985, 'Lexical Knowledge in Word Recognition: Word Length and Word Frequency in Naming and Lexical Decision Tasks,' *Journal of Memory and Language* **24**, 46—58.

Huey, E. B.: 1908, *The Psychology and Pedagogy of Reading*, MacMillan, New York. (Reprinted by MIT Press, Cambridge, MA, 1968.)

Hulme, C.: 1981, 'The Effects of Manual Training on Memory in Normal and Retarded Readers: Some Implications for Multi-sensory Teaching,' *Psychological Research* **43**, 179—191.

Humphreys, G. W. and Evett, L. J.: 1985, 'Are There Independent Lexical and Nonlexical Routes in Word Processing? An Evaluation of the Dual-Route Theory of Reading,' *The Behavioral and Brain Sciences* **8**, 689—740.

Hunt, E.: in press, 'The Next Word on Verbal Ability,' in P. E. Vernon (ed.) *Reaction Time and Intelligence*, Ablex, New York.

Hunt, K. W.: 1970, 'Syntactic Maturity in School Children and Adults,' *Monographs of the Society for Research in Child Development*, vol. 35.

Huttenlocher, P. R. and Huttenlocher, J.: 1973, 'A Study of Children with Hyperlexia,' *Neurology* **23**, 1107—1116.

Hynd, G. and Cohen, M.: 1983, *Dyslexia: Neuropsychological Theory, Research, and Clinical Differentiation*, Grune and Stratton, New York.

Jackson, E.: 1906, 'Developmental Alexia (Congenital Word-blindness),' *American Journal of Medical Science* **131**, 843—849.

Jackson, M. D. and McClelland, J. L.: 1979, 'Processing Determinants of Reading Speed,' *Journal of Experimental Psychology: General* **108** (2), 151—181.

Jacobs, J. E. and Paris, S. G.: 1987, 'Children's Metacognition about Reading: Issues in Definition, Measurement, and Instruction,' *Educational Psychologist* **22**, 255—278.

Johnston, J. C. and McClelland, J. L.: 1973, 'Visual Factors in Word Perception,' *Perception and Psychophysics* **14**, 365—370.

Jones, K. M., Torgesen, J. K. and Sexton, M. A.: 1987, 'Using Computer-guided Practice to Increase Decoding Fluency in Learning Disabled Children: A Study Using the Hint and Hunt I Program,' *Journal of Learning Disabilities* **20** (2), 122—128.

Jongsma, E. A.: 1980, *Cloze Instruction Research: A Second Look*, International Reading Association, Newark, DE.

Jorm, A. F.: 1979, 'The Cognitive and Neurological Basis of Developmental Dyslexia: A Theoretical Framework and Review,' *Cognition* **7**, 19—32.

Jorm, A. F.: 1981, 'Children with Reading and Spelling Retardation: Functioning of Whole-word and Correspondence-rule Mechanism,' *Journal of Child Psychology and Psychiatry* **22**, 171—178.

Jorm, A. F.: 1983a, 'Specific Reading Retardation and Working Memory: A Review,' *British Journal of Psychology* **74**, 311—342.

Jorm, A. F.: 1983b, *The Psychology of Reading and Spelling Disabilities*, Routledge and Kegan Paul, London.

Jorm, A. F. and Share, D.: 1983, 'Phonological Recoding and Reading Acquisition,' *Applied Psycholinguistics* **4**, 103—147.

Joshi, M. and Aaron, P. G.: in press, 'Specific Spelling Disability and Specific Reading Disability: Are They Dissociable?' in M. Joshi (ed.) *Written Language Disorders*, Martinus Nijhoff, The Hague.

Joula, J. F., Leavitt, D. D. and Choe, C. S.: 1974, 'Letter Identification in Word, Nonword, and Single Letter Displays,' *Bulletin of the Psychonomic Society* **4**, 278—280.

Joula, J. F., Schadler, M., Chabot, R. J. and McCaughay, D.: 1978, 'The Development of Visual Information Processing Skills Related to Reading,' *Journal of Experimental Child Psychology* **25**, 459—476.

Juel, D.: 1980, 'Comparison of Word Identification Strategies with Varying Context, Word Type, and Reader Skill,' *Reading Research Quarterly* 3, 358—376.

Just, M. A. and Carpenter, P. A.: 1980, 'A Theory of Reading: From Eye Fixations to Comprehension,' *Psychological Review* **87**, 329—354.

Kameenui, E., Dixon, R. and Carnine, D.: 1987, 'Toward a New Perspective of Vocabulary Learning and Reading Comprehension,' in M. G. McKeown and M. E. Curtis (eds.) *The Nature of Vocabulary Acquisition*, Lawrence Erlbaum, Hillsdale, NJ.

Karlin, R.: 1980, 'Learning Disability and Reading: Theory or Fact?' In C. M. McCullough (ed.) *Inchworm, Inchworm: Persistent Problems in Reading Education*, International Reading Association, Newark, DE.

Kavale, K. and Schreiner, R.: 1979, 'The Reading Processes of Above Average and Average Readers: A Comparison of the Use of Reasoning Strategies in Responding to Standardized Comprehension Measures,' *Reading Research Quarterly* **15**, 102—128.

Kay, J. and Patterson, K. E.: 1985, 'Routes to Meaning in Surface Dyslexia,' in K. E. Patterson, J. C. Marshall and M. Coltheart (eds.) *Surface Dyslexia*, Lawrence Erlbaum, Hillsdale, NJ.

Kean, M.: 1977, 'The Linguistic Interpretation of Aphasic Syndromes. Agrammatism in Broca's Aphasia, an Example,' *Cognition* **5**, 9—46.

Kean, M. L.: 1984, 'The Question of Linguistic Anomaly in Developmental Dyslexia,' *Annals of Dyslexia* **34**, 137—154.

Kennedy, D. K.: 1971, *Training with the Cloze Procedure Visually and Auditorially to Improve the Reading and Listening Comprehension of Third Grade Underachieving Readers*, Unpublished doctoral dissertation, Penn State University.

Kennedy, D.K. and Weener, P.: 1973, 'Visual and Auditory Training with the Cloze Procedure to Improve Reading and Listening Comprehension,' *Reading Research Quarterly* **8**, 524—541.

Kershner, J. R.: 1977, 'Cerebral Dominance in Disabled Readers, Good Readers, and Gifted Children: Search for a Valid Model,' *Child Development* **48**, 61—67.

Kintsch, W.: 1977, 'On Comprehending Stories,' in M. A. Just and P. A. Carpenter (eds.) *Cognitive Processes in Comprehension*, Lawrence Erlbaum, Hillsdale, NJ.

Kintsch, W. and Kozminsky, E.: 1977, 'Summarizing Stories after Reading and Listening,' *Journal of Educational Psychology* **69**, 491—499.

Kintsch, W. and van Dijk, T. A.: 1978, 'Toward a Model of Text Comprehension and Production,' *Psychological Review* **85**, 363—394.

Kintsch, W. and Miller, J. R.: 1984, 'Readability: A View from Cognitive Psychology,' in J. Flood (ed.) *Understanding Reading Comprehension: Cognition, Language, and Structure of Prose*, International Reading Association, Newark, DE.

Kirby, J. R. and Robinson, L. W.: 1987, 'Simultaneous and Successive Processing in Reading Disabled Children,' *Journal of Learning Disabilities* **20** (4), 243—252.

Kleiman, G. M.: 1975, 'Speech Recoding in Reading,' *Journal of Verbal Learning and Verbal Behavior* **14**, 323—339.

LaBerge, D. and Samuels, S. J.: 1974, 'Toward a Theory of Automatic Information Processing in Reading,' *Cognitive Psychology* **6**, 293—323.

Ladd, E. M.: 1970, 'More Than Scores from Tests,' *The Reading Teacher* **24** (4), 305—311.

Landers, A.: 1986, 'California Judge Reissues Order Prohibiting Use of Intelligence Tests,' *APA Monitor*, September.

Langmore, S. and Canter, G.: 1983, 'Written Spelling Deficit of Broca's Aphasics,' *Brain and Language* **18**, 293—314.

Lapp, D. and Flood, J.: 1984, 'Promoting Reading Comprehension Which Ensures Continuous Reader Growth,' in J. Flood (ed.) *Promoting Reading Comprehension*, International Reading Association, Newark, DE.

Lee, L.: 1969, *Northwestern Syntax Screening Test*, Northwestern University Press, Evanston, IL.

Lee, L.: 1974, *Developmental Sentence Analysis*, Northwestern University Press, Evanston, IL.

Lehr, F.: 1981, 'Integrating Reading and Writing Instruction,' *The Reading Teacher* **34**, 958—966.

Leong, C. K.: 1974, *An Investigation of Spatial—Temporal Information Processing in Children with Specific Reading Disability*, Unpublished Ph.D. thesis, University of Alberta.

Lesgold, A. M. and Perfetti, C. A.: 1978, 'Interactive Processes in Reading Comprehension,' *Discourse Processes* **1**, 323—336.

Lewkowicz, N.: 1980, 'Phonemic Awareness Training: What to Teach and How to Teach It,' *Journal of Educational Psychology* **72**, 686—700.

Liberman, I. Y., Shankweiler, D., Liberman, A. M., Fowler, C. and Fischer, F. W.: 1977, 'Phonetic Segmentation and Recoding in the Beginning Reader,' in A. S. Reber and D. Scarborough (eds.) *Towards a Psychology of Reading*, Erlbaum, Hillsdale, NJ.

Liberman, I. Y. and Shankweiler, D.: 1978, 'Speech, the Alphabet and Teaching to Read,' in L. Resnick and P. Weaver (eds.) *Theory and Practice of Early Reading*, John Wiley, New York.

Liberman, I. Y., Liberman, A. M., Mattingly, I. G. and Shankweiler, D.: 1980a, 'Orthography and the Beginning Reader,' in J. Kavannagh and R. Venezky (eds.) *Orthography, Reading, and Dyslexia*, University Park Press, Baltimore, MD.

Liberman, I. Y., Shankweiler, D., Camp, L., Blachman, D. and Werfelman, M.: 1980b, 'Steps Toward Literacy,' in P. Levinson and C. H. Sloan (eds.) *Auditory Processing and Language: Clinical and Research Perspectives*, Grune and Stratton, New York.

Liberman, I. Y., Mann, V., Shankweiler, D. and Werfelman, M.: 1982, 'Children's Memory for Recurring Linguistic and Non-linguistic Material in Relation to Reading Ability,' *Cortex* **18**, 367—378.

Liberman, I. Y. and Shankweiler, D.: 1985, 'Phonology and the Problem of Learning to Read and Write,' *Remedial and Special Education* **6**, 41—55.

Lindamood, C. H. and Lindamood, P. C.: 1969, *Auditory Discrimination in Depth*, Teaching Resources, Boston, MA.

Litcher, J. H. and Roberge, L. P.: 1979, 'First-grade Intervention for Reading Achievement of High Risk Children,' *Bulletin of the Orton Society* **29**, 238—244.

Lord, E. E.: 1925, 'The Study and Training of a Child Who Was Word Blind,' in E. Lord, L. Carmichael and W. Dearborn (eds.) *Special Disabilities in Learning to Read and Write. Harvard Monographs in Education* vol. II, Series I, No. 1.

Lovegrove, W. and Brown, C.: 1978, 'Development of Information Processing in Normal and Disabled Readers,' *Perceptual and Motor Skills* **46**, 1047—1054.

Lyle, J. G.: 1969, 'Reading Retardation and Reversal Tendency, a Factorial Study,' *Child Development* **40**, 833—843.

Makita, K.: 1968, 'The Rarity of Reading Disability in Japanese Children,' *American Journal of Orthopsychiatry* **38**, 599—614.

Malatesha, R. and Dougan, D.: 1982, 'Clinical Subtypes of Developmental Dyslexia: Resolution of an Irresolute Problem,' in R. N. Malatesha and P. G. Aaron (eds.) *Reading Disorders: Varieties and Treatments*, Academic Press, New York.

Mann, V. A.: 1984a, 'Reading Skill and Language Skill,' *Developmental Review* **4**, 1—15.

Mann, V. A.: 1984b, 'Longitudinal Prediction and Prevention of Early Reading Difficulty,' *Annals of Dyslexia* **34**, 117—136.

Mann, V. A.: 1986, 'Why Some Children Encounter Learning Problems: The Contribution of Difficulties with Language Processing and Phonological Sophistication in Early Reading Disability,' in J. K. Torgesen and B. L. Young (eds.) *Psychological and Educational Perspectives on Learning Disabilities*, Academic Press, Orlando, FL.

Mann, V. A., Liberman, I. Y. and Shankweiler, D.: 1980, 'Children's Memory for Sentences and Word Strings in Relation to Reading Ability,' *Memory and Cognition* **8**, 329—335.

Mann, V. A., Shankweiler, D. and Smith, S. T.: 1984, 'The Association between Comprehension of Spoken Sentences and Early Reading Ability: The Role of Phonetic Representation,' *Journal of Child Language* **11**, 627—643.

Marsh, G., Desberg, P. and Cooper, J.: 1977, 'Developmental Changes in Reading Strategies,' *Journal of Reading Behavior* **9**, 391—394.

Marshall, J. C.: 1984, 'Toward a Rational Taxonomy of the Acquired Dyslexias,' in R. N. Malatesha and H. A. Whitaker (eds.) *Dyslexia: A Global Issue*, Martinus Nijhoff, The Hague.

Marshall, J. C. and Newcombe, F.: 1966, 'Syntactic and Semantic Errors in Paralexia,' *Neuropsychologia* **4**, 169—176.

Marshall, J. C. and Newcombe, F.: 1973, 'Patterns of Paralexia,' *Journal of Psycholinguistic Research* **2**, 179—199.

Marshall, J. C. and Newcombe, F.: 1980, 'The Conceptual Status of Deep Dyslexia: An Historical Perspective,' in M. Coltheart, K. Patterson and J. C. Marshall (eds.) *Deep Dyslexia*, Routledge and Kegan Paul, London.

Marslen-Wilson, W. and Welsh, A.: 1978, 'Processing Interactions and Lexical Access During Word Recognition in Continuous Speech,' *Cognitive Psychology* **10**, 29—63.

Marston, D., Mirkin, P. and Deno, S.: 1984, 'Curriculum-based Measurements: An Alternative to Traditional Screening, Referral, and Identification,' *The Journal of Special Education* **18** (2), 109—117.

Mason, J.: 1980, 'When Do Children Begin to Read: An Exploration of Four Year Old Children's Letter and Word Reading Competencies,' *Reading Research Quarterly* **15**, 203—227.

Mason, M.: 1978, 'From Print to Sound in Mature Readers as a Function of Reader Ability and Two Forms of Orthographic Regularity,' *Memory and Cognition* **6**, 568—581.

Massaro, D. W.: 1975, 'Primary and Secondary Recognition in Reading,' in D. W. Massaro (ed.) *Understanding Language*, Academic Press, New York.

Massaro, D. W.: 1979, 'Reading and Listening,' in P. A. Kolers, M. E. Wrolstad and H. Bouma (eds.) *Processing Visible Language*, Plenum, New York.

Massaro, D. W. and Klitzke, D.: 1977, 'Letters Are Functional in Word Identification,' *Memory and Cognition* **5** (3), 292—298.

Mattis, S.: 1981, 'Dyslexia Syndromes in Children: Toward the Development of Syndrome-specific Treatment Programs,' in J. Pirozzolo and M. Witrock (eds.) *Neuropsychological and Cognitive Processes in Reading*, Academic Press, New York.

McCarthy, R. and Warrington, E. K.: 1984, 'A Two-route Model of Speech Production: Evidence from Aphasia,' *Brain* **107**, 463—485.

McClelland, J. L.: 1976, 'Preliminary Letter Identification in Perception of Words and Nonwords,' *Journal of Experimental Psychology: Human Perception and Performance* **2**, 80—91.

McCusker, L., Hillinger, M. and Bias, R.: 1981, 'Phonological Recoding and Reading,' *Psychological Bulletin* **89** (2), 217—245.

McKenna, M. C. and Robinson, R. D.: 1980, *An Introduction to the Cloze Procedure*, International Reading Association, Newark, DE.

McNeil, D. C. and Cooney, A. S.: 1971, 'Symposium Response: Is There an End in Sight?' *The Journal of Special Education* **5** (3), 261—264.

McRae, J.: 1985, *Apples for Teachers: 101 Programs for the Classroom*, TAB Books, Blue Ridge Summit, PA.

Mehegan, C. C. and Dreifuss, M. B.: 1972, 'Hyperlexia: Exceptional Reading Ability in Brain-damaged Children,' *Neurology* **22**, 1105—1111.

Memory, D.: 1983, 'Main Idea Prequestions as Adjunct Aids with Good and Low Average Middle Grade Readers,' *Journal of Reading Behavior* **15** (2), 37—48.

Memory, D. and Moore, D.: 1981, 'Selecting Sources in Library Research: An Activity in Skimming and Critical Reading,' *Journal of Reading* **24**, 469—474.

Merikle, P. M., Coltheart, M. and Lowe, D. G.: 1971, 'On the Selective Effects of a Patterned Masking Stimulus,' *Canadian Journal of Psychology* **25** (3), 264—279.

Meyer, D. E., Schvaneveldt, R. W. and Ruddy, M. G.: 1974, 'Functions of Graphemic and Phonemic Codes in Visual Word Recognition,' *Memory and Cognition* **2**, 309—321.

Miles, T. R. and Haslum, M. N.: 1986, 'Dyslexia: Anomaly or Normal Variation?' *Annals of Dyslexia* **36**, 103—117.

Miller, G. A.: 1987, 'Dictionaries in the Mind,' *Language and Cognitive Processes* **1** (3), 171—186.

Miller, G. A. and Gildea, P.: 1987, 'How Children Learn Words,' *Scientific American* September, 94—99.

Miller, G. R. and Coleman, E. B.: 1967, 'A Set of Thirty-six Passages Calibrated for Complexity,' *Journal of Verbal Learning and Verbal Behavior* **6**, 851—854.

Mitchell, D. C.: 1982, *The Process of Reading*, John Wiley and Sons, New York.

Mitchell, D. C.: 1984, 'An Evaluation of Subject-paced Reading Tasks and Other Methods for Investigating Immediate Process in Reading,' in D. E. Kieras and M. A. Just (eds.) *New Methods in Reading Comprehension Research*, Lawrence Erlbaum, Hillsdale, NJ.

Monroe, M.: 1932, *Children Who Cannot Read*, University of Chicago Press, Chicago.

Morgan, W. P.: 1896, 'A Case of Congenital Word-blindness,' *British Medical Journal* **2**, 1368.

Morrison, F., Giordani, B. and Nagy, J.: 1977, 'Reading Disability: An Information Processing Analysis,' *Science* **196**, 77—79.

Morton, J. and Patterson, K.: 1980, 'A New Attempt at an Interpretation and an Attempt at a New Interpretation,' in M. Coltheart, K. Patterson and J. C. Marshall (eds.) *Deep Dyslexia*, Routledge and Kegan Paul, London.

Muma, J. R., Lubinski, R. and Pierce, S.: 1982, 'A New Era in Language Assessment: Data or Evidence,' in N. J. Lass (ed.) *Speech and Language: Advances in Basic Research and Practice*, vol. 7, Academic Press, New York.

Myers, M. and Paris, R. G.: 1978, 'Children's Metacognitive Knowledge about Reading,' *Journal of Educational Psychology* **70**, 680—690.

Nagy, W. and Herman, P.: 1987, 'Breadth and Depth of Vocabulary Knowledge: Implications for Acquisition and Instruction,' in M. G. McKeown and M. E. Curtis (eds.) *The Nature of Vocabulary Acquisition*, Lawrence Erlbaum, Hillsdale, NJ.

Naidoo, S.: 1981, 'Teaching Methods and Their Rationale,' in G. Th. Pavlidis and T. R. Miles (eds.) *Dyslexia Research and Its Application to Education*, John Wiley, New York.

Needleman, R. M.: 1982, 'A Linguistic Analysis of Hyperlexia,' in C. Johnson (ed.) *Proceedings of the Second International Study of Child Language*. University Press of America, Washington, D.C.

Nelson, E. and Warrington, E.: 1974, 'Developmental Spelling Retardation,' *British Journal of Psychology* **65**, 265—274.

Nelson, E. and Warrington, E.: 1976, 'Developmental Spelling Retardation,' in R. M. Knights and D. J. Bakker (eds.) *The Neuropsychology of Learning Disorders*, University Park Press, Baltimore, MD.

Neville, M. H. and Pugh, A. K.: 1976, 'Context in Reading and Listening: Variations in Approach to Cloze Tasks,' *Reading Research Quarterly* **12**, 13—31.

Newcombe, F. and Marshall, J. C.: 1985, 'Reading and Writing by Letter Sounds,' in K. Patterson, J. C. Marshall and M. Coltheart (eds.) *Surface Dyslexia*, Lawrence Erlbaum, Hillsdale, NJ.

Newcomer, P. L. and Magee, P.: 1977, 'The Performance of Learning (Reading) Disabled Children on a Test of Spoken Language,' *Reading Teacher* **30** (8), 896—900.

Newman, A. P.: 1980, *Adult Basic Education*, Allyn and Bacon, Boston, MA.

Nickerson, R. S.: 1981, 'Speech Understanding and Reading: Some Differences and Similarities,' in O. J. Tzeng and H. Singer (eds.) *Perception of Print*, Lawrence Erlbaum, Hillsdale, NJ.

Niensted, S. M.: 1968, 'Hyperlexia: An Educational Disease?' *Exceptional Children* **35**, 162—163.

Noll, J. D.: 1970, *The Use of the Token-Test with Children*, Paper presented at the Annual convention of the American Speech and Hearing Association, New York.

Oakan, R., Wiener, M. and Cromer, W.: 1971, 'Identification, Organization, and Reading Comprehension for Good and Poor Readers,' *Journal of Educational Psychology* **62** (1), 71—78.

Olson, R. K.: 1985, 'Disabled Reading Processes and Cognitive Profiles,' in D. B. Gray and J. F. Kavanagh (eds.) *Biobehavioral Measures of Dyslexia*, York Press, Parkton, MD.

O'Neil, G. and Stanley, G.: 1976, 'Visual Processing of Straight Lines in Dyslexic and Normal Children,' *British Journal of Educational Psychology* **46**, 323—327.

Orton, S.: 1925, 'Word-blindness in School Children,' *Archives of Neurological Psychiatry* **14**, 581—615.

Orton, S.: 1937, *Reading, Writing, and Speech Problems in Children*, W. W. Norton, New York.

Owen, F., Adams, P., Forrest, T., Stolz, S. and Fisher, S.: 1971, 'Learning Disorders in Children: Sibling Studies,' *Monographs of the Society for Research in Child Development* **36** (4), No. 144.

Palinscar, A. S.: 1986, 'Metacognitive Strategy Instruction,' *Exceptional Children* **53** (2), 118—124.

Palmer, J., McCleod, C. M., Hunt, E. and Davidson, J.: 1985, 'Information Processing Correlates of Reading,' *Journal of Memory and Language* **24**, 59—88.

Paradis, M., Hagiwara, H. and Hildebrandt, N.: 1985, *Neurolinguistic Aspects of the Japanese Writing System*, Academic Press, New York.

Paris, S. G., Cross, D. R. and Lipson, M. Y.: 1984, 'Informed Strategies for Learning: A Program to Improve Children's Reading Awareness and Comprehension,' *Journal of Educational Psychology* **76**, 1239—1252.

Parker, S. W.: 1917, 'Pseudo-talent for Words,' *Psychology Clinics* **11**, 1—7.

Parkins, A. J. and Underwood, G.: 1983, 'Orthographic vs. Phonological Irregularity in Lexical Decision,' *Memory and Cognition* **11**, 351—355.

Patterson, K. E.: 1979, 'What is Right with "Deep" Dyslexic Patients?' *Brain and Language* **8**, 111—129.

Patterson, K. E.: 1982, 'The Relation between Reading and Phonological Coding: Further Neuropsychological Observations,' in A. E. Ellis (ed.) *Normality and Pathology in Cognitive Functions*, Academic Press, New York.

Patterson, K. E. and Marcel, A. J.: 1977, 'Aphasia, Dyslexia, and the Phonological Coding of Written Words,' *Quarterly Journal of Experimental Psychology* **29**, 307—318.

Patterson, K. E., Marshall, J. C. and Coltheart, M.: 1985, *Surface Dyslexia*, Lawrence Erlbaum, Hillsdale, NJ.

Patterson, K. E. and Morton, J.: 1985, 'From Orthography to Phonology: An Attempt at an Old Interpretation,' in K. E. Patterson, J. C. Marshall and M. Coltheart (eds.) *Surface Dyslexia*, Lawrence Erlbaum, Hillsdale, NJ.

Pearson, P. D. and Johnson, D. D.: 1978, *Teaching Reading Comprehension*, Holt, Rinehart and Winston, New York.

Pelosi, P. L.: 1977, 'The Roots of Reading Diagnosis,' in H. A. Robinson (ed.) *Reading and Writing Instruction in the United States: Historical Trends*, International Reading Association, Newark, DE.

Pennington, B., McCabe, L., Smith, S., Lefly, D., Bookman, M., Kimberling, W. and Lubs, H.: 1986, 'Spelling Errors in Adults with a Form of Familial Dyslexia,' *Child Development* **57**, 1001–1013.

Pennington, B., Johnson, C. and Welsh, M.: 1987a, 'Unexpected Reading Precocity in Normal Preschooler: Implications for Hyperlexia,' *Brain and Language* **30**, 165–180.

Pennington, B., Lefly, D., Van Orden, G., Bookman, M. and Smith, S. D.: 1987b, 'Is Phonology Bypassed in Normal or Dyslexic Development?' *Annals of Dyslexia* **37**, 62–89.

Perfetti, C. A.: 1985, *Reading Ability*, Oxford University Press, New York.

Perfetti, C. A. and Hogaboam, T. W.: 1975, 'The Relationship between Single Word Decoding and Reading Comprehension Skill,' *Journal of Educational Psychology* **67**, 461–469.

Perfetti, C. A. and Goldman, S. R. (1976), 'Discourse Memory and Reading Comprehension Skill,' *Journal of Verbal Learning and Verbal Behavior* **14**, 33–42.

Perfetti, C. A. and Lesgold, A. M.: 1977, 'Discourse Comprehension and Sources of Individual Differences,' in M. A. Just and P. A. Carpenter (eds.) *Cognitive Processes in Comprehension*, Lawrence Erlbaum, Hillsdale, NJ.

Perfetti, C. A. and McCutchen, D.: 1982, 'Speech Processes in Reading,' in N. Lass (ed.) *Speech and Language: Advance in Basic Research and Practice*, vol. 7, Academic Press, New York.

Petrauskas, R. S. and Rourke, B.: 1979, 'Identification of Subtypes of Retarded Readers: A Neuropsychological, Multivariate Approach,' *Journal of Clinical Neuropsychology* **1**, 17–37.

Phillips, A.: 1930, 'Talented Imbeciles,' *Psychology Clinics* **18**, 246–265.

Phillips, S., Taylor, B. and Aaron, P. G.: 1985, *Developmental Dyslexia: Subtypes or Substages*? Paper presented at the Indiana Psychological Association meeting, Indianapolis.

Pressley, M., Levin, J. R. and McDaniel, M.: 1987, 'Remembering versus Inferring What a Word Means,' in M. G. McKeown and M. E. Curtis (eds.) *The Nature of Vocabulary Acquisition*, Lawrence Erlbaum, Hillsdale, NJ.

Quantz, J. O.: 1887, 'Problems in the Psychology of Reading,' *Psychological Review Monograph Supplements*, No. 2.

Rabinovitch, R. D.: 1962, 'Dyslexia: Psychiatric Considerations,' in J. Money (ed.) *Reading Disability: Progress and Research Needs in Dyslexia*, The Johns Hopkins University Press, Baltimore, MD.

Rawson, M.: 1971, 'Let's Shoot for Eulexia — Not at Hyperlexia,' *The Journal of Special Education* **5** (3), 247–252.

Rayner, K. and Carroll, P.: 1984, 'Eye Movement and Reading Comprehension,' in D. E. Kieras and M. A. Just (eds.) *New Methods in Reading Comprehension Research*, Lawrence Erlbaum, Hillsdale, NJ.

Reicher, G. M.: 1969, 'Perceptual Recognition as a Function of the Meaningfulness of Stimulus Material,' *Journal of Experimental Psychology* **81**, 275—280.

Reimer, B. L.: 1983, 'Recipes for Language Experience Stories,' *The Reading Teacher* **36**, 396—401.

Reitsma, P.: 1984, 'Sound Priming in Beginning Readers,' *Child Development* **55**, 406—423.

Reynolds, C. R.: 1981, 'Neuropsychological Basis of Intelligence,' in G. W. Hynd and J. E. Obrzut (eds.) *Neuropsychological Assessment of the School Aged Child: Issues and Procedures*, Grune and Stratton, New York.

Richman, L. C. and Kitchell, M. D.: 1981, 'Hyperlexia as a Variant of Developmental Language Disorder,' *Brain and Language* **12**, 203—212.

Rock, I.: 1973, *Orientation and Form*, Academic Press, New York.

Rispens, J. and van Berckelaer, I. A.: in press, 'Hyperlexia: Definition and Criterion,' in R. N. Joshi (ed.) *Written Language Disorders*, Martinus Nijhoff, The Hague.

Rosenberger, P. B., Nessen, S. W. and Cogwell, M. L.: 1975, 'Hyperlexia: A Syndrome of Language Deficit,' *Child Neurology Society Abstract*, No. 25.

Rosner, J. and Simon, D. P.: 1971, 'The Auditory Analysis Test: An Initial Report,' *Journal of Learning Disabilities* **4** (7), 384—392.

Rourke, B.: 1978, 'Neuropsychological Research in Reading Retardation: A Review,' in A. L. Benton and D. Pearl (eds.) *Dyslexia: An Appraisal of Current Knowledge*, Oxford University Press, New York.

Rourke, B. and Strang, J.: 1983, 'Subtypes of Reading and Arithmetical Disabilities: A Neuropsychological Analysis,' in M. Rutter (ed.) *Developmental Neuropsychiatry*, Guilford Press, New York.

Rozin, P., Poritsky, S. and Sotsky, R.: 1971, 'American Children with Reading Problems Can Easily Learn to Read English Represented by Chinese Characters,' *Science* **171**, 1264—1267.

Rozin, P. and Gleitman, L. R.: 1977, 'The Structure and Acquisition of Reading: The Reading Process and the Acquisition of the Alphabetic Principle,' in A. S. Reber and D. L. Scarborough (eds.) *Toward a Psychology of Reading*, Lawrence Erlbaum, Hillsdale, NJ.

Rubenstein, H., Lewis, S. S. and Rubenstein, M. A.: 1971, 'Evidence for Phonemic Recoding in Visual Word Recognition,' *Journal of Verbal Learning and Verbal Behavior* **10**, 645—657.

Rudel, R.: 1985, 'The Definition of Dyslexia: Language and Motor Defects,' in F. H. Duffy and N. Geschwind (eds.) *Dyslexia: A Neuroscientific Approach to Clinical Evaluation*, Little, Brown and Co., Boston, MA.

Rugel, R. P.: 1974, 'WISC Subtest Scores of Disabled Readers: A Review with Respect to Bannatyne's Recategorization,' *Journal of Learning Disabilities* **7**, 48—64.

Rumelhart, D. E.: 1984, 'Understanding Understanding,' in J. Flood (ed.) *Understanding Reading Comprehension*, International Reading Association, Newark, DE.

Rutter, M.: 1978, 'Prevalence and Types of Dyslexia,' in A. Benton and D. Pearl (eds.), *Dyslexia: An Appraisal of Current Knowledge*, Oxford University Press, New York.

Rutter, M. and Yule, W.: 1975, 'The Concept of Specific Reading Retardation,' *Journal of Child Psychology and Psychiatry* **16**, 181—197.

Salame, P. and Baddeley, A.: 1982, 'Disruption of Short-term Memory by Unattended Speech: Implications for the Structure of Working Memory,' *Journal of Verbal Learning and Verbal Behavior* **21**, 150—164.

Samuels, S. J., LaBerge, D. and Bremer, D.: 1978, 'Units of Word Recognition: Evidence for Developmental Changes,' *Journal of Verbal Learning and Verbal Behavior* **17**, 715—720.

Samuels, S. J. and Kamil, M. L.: 1984, 'Models of Reading Process,' in P. D. Pearson (ed.) *Handbook of Reading Research*, Longman, New York.

Sartori, G.: 1987, 'Leonardo da Vinci, Omo Sanza Lettere: A Case of Surface Dysgraphia?' *Cognitive Neuropsychology* **4** (1), 1—10.

Satz, P., Morris, R. and Fletcher, J.: 1985, 'Hypotheses, Subtypes, and Individual Differences in Dyslexia: Some Reflections,' in D. B. Gray and F. Kavanagh (eds.) *Biobehavioral Measures of Dyslexia*, York Press, Parkton, MD.

Savin, H. B. and Bever, T. G.: 1970, 'The Nonperceptual Reality of the Phoneme,' *Journal of Verbal Learning and Verbal Behavior* **9**, 295—302.

Scheerer, M., Rothmann, E. and Goldstein, K.: 1945, 'A Case of Idiot-savant: An Experimental Study of Personality Organization,' *Psychological Monographs* **58**, 1—63.

Schmitt, C.: 1918, 'Developmental Alexia: Congenital Word-blindness or Inability to Learn to Read,' *Elementary School Journal* **18**, 680—700.

Schneider, W. and Shiffrin, R. M.: 1977, 'Controlled and Automatic Human Information Processing,' *Psychological Review* **84** (1), 1—66.

Schwartz, M. F., Saffran, E. M. and Marin, D. S.: 1980, 'Fractioning the Reading Process in Dementia: Evidence for Word-specific Print-to-Sound Associations,' in M. Coltheart, K. Patterson and J. C. Marashall (eds.) *Deep Dyslexia*, Routledge and Kegan Paul, London.

Seidenberg, M.: 1985, 'The Time Course of Information Activation and Utilization in Visual Word Recognition,' in D. Besner, T. G. Waller and G. E. MacKinnon (eds.) *Reading Research*, vol. 5, Academic Press, Orlando, FL.

Semel, S. M. and Wiig, E. H.: 1975, 'Comprehension of Syntactic Structures and Critical Verbal Elements by Children with Learning Disabilities,' *Journal of Learning Disabilities* **8** (1), 53—58.

Seymour, P. H.: 1986, *Cognitive Analysis of Dyslexia*, Routledge and Kegan Paul, London.

Shafer, S., Shaffer, D., O'Connor and Stokman, C.: 1983, 'Hard Thoughts on Neurological "Soft Signs",' in M. Rutter (ed.) *Developmental Neuropsychiatry*, Guilford Press, New York.

Shaffer, D., O'Connor, P., Shafer, S. and Prupis, S.: 1983, 'Neurological "soft signs": Their Origins and Significance for Behavior,' in M. Rutter (ed.) *Developmental Neuropsychiatry*, Guilford Press, New York.

Shallice, T. and Warrington, E. K.: 1970, 'Independent Functioning of Verbal Memory Stores: A Neuropsychological Study,' *Quarterly Journal of Experimental Psychology* **22**, 261—273.

Siegel, L.: 1984, 'A Longitudinal Study of a Hyperlexic Child: Hyperlexia as a Language Disorder,' *Neuropsychologia* **22** (5), 577—585.

Siegel, L. and Ryan, E.: 1984, 'Reading Disability As a Language Disorder,' *Remedial and Special Education* **5**, 28—33.

Siegel, L., Levey, P. and Ferris, H.: 1985, 'Subtypes of Developmental Dyslexia: Do They Exist?' in F. J. Morrison (ed.) *Applied Developmental Psychology*, vol. 2, Academic Press, New York.

Silberberg, N. and Silberberg, M.: 1967, 'Hyperlexia: Specific Word Recognition Skills in Young Children,' *Exceptional Children* **34**, 41—42.

Silberberg, N. and Silberberg, M.: 1968, 'Case Histories in Hyperlexia,' *Journal of School Psychology* **7**, 3—7.

Silberberg, N. and Silberberg, M.: 1971, 'Hyperlexia: The Other End of the Continuum,' *Journal of Special Education* **5** (3), 233—242.

Simms, R. B. and Crump, D. W.: 1983, 'Syntactic Development in the Oral Language of Learning Disabled and Normal Students at the Intermediate and Secondary Level,' *Learning Disability Quarterly* **6**, 155—165.

Simpson, E.: 1979, *Reversals: A Personal Account of Victory over Dyslexia*, Houghton Mifflin, Boston, MA.

Slingerland, B. H.: 1971, *A Multi-sensory Approach to Language Arts for Specific Language Disability Children: A Guide for Primary Teachers*, Educators Publishing Service, Cambridge, MA.

Smiley, S. S., Oakley, D. D., Worthen, D., Campione, J. C. and Brown, A. L.: 1977, 'Recall of Thematically Relevant Material by Adolescent Good and Poor Readers as a Function of Written versus Oral Presentation,' *Journal of Educational Psychology* **69**, 381—387.

Smith, E. E.: 1978, 'Theories of Semantic Memory,' in W. K. Estes (ed.) *Handbook of Learning and Cognitive Processes*, vol. 6, Lawrence Erlbaum, Hillsdale, NJ.

Smith, F.: 1971, *Understanding Reading*, Holt, Rinehart, and Winston, New York.

Smith, M. D., Coleman, J. M., Dokecki, P. R. and Davis, E. E.: 1977, 'Intellectual Characteristics of School Labeled Learning Disabled Children,' *Exceptional Children* **43** (6), 352—357.

Smith, P. T. and Sterling, C.: 1982, 'Factors Affecting the Perceived Morphemic Structure of Written Words,' *Journal of Verbal Learning and Verbal Behavior* **21**, 704—721.

Snowling, M.: 1980, 'The Development of Grapheme—Phoneme Correspondence in Normal and Dyslexic Readers,' *Journal of Experimental Child Psychology* **29**, 291—305.

Snowling, M.: 1983, 'The Comparison of Acquired and Developmental Disorders of Reading — A Discussion,' *Cognition* **14**, 105—118.

Snowling, M. and Frith, U.: 1986, 'Comprehension in "Hyperlexic" Readers,' *Journal of Experimental Child Psychology* **42**, 392—415.

Snowling, M., Goulandris, N., Bowlby, M. and Howell, P.: 1986, 'Segmentation and Speech Perception in Relation to Reading Skill: A Developmental Analysis,' *Journal of Experimental Child Psychology* **41**, 489—507.

Soderbergh, R.: 1977, *Reading in Early Childhood: A Linguistic Study of a Preschool Child's Gradual Acquisition of Reading Ability*, Georgetown University Press, Washington D.C.

Spalding, R. B. and Spalding, W. T.: 1962, *The Writing Road to Read*, William Morrow, New York.

Sperling, G.: 1960, 'The Information Available in Brief Visual Presentations,' *Psychological Monographs* **74** (11), Whole No. 498.

Sperling, G.: 1970, 'Short-term Memory and Scanning in the Processing of Visual Information,' in F. A. Young and D. B. Lindsley (eds.) *Early Experience and Visual Information Processing in Perceptual and Reading Disorders*, National Academy of Sciences, Washington D.C.

Spillich, G. J., Vesonder, G. T., Chiesi, H. L. and Voss, J.: 1979, 'Text Processing of Domain-related Information for Individuals with High and Low Domain Knowledge,' *Journal of Verbal Learning and Verbal Behavior* **18**, 275—290.

Spoehr, K. T.: 1978, 'Phonological Encoding in Visual word Recognition,' *Journal of Verbal Learning and Versal Behavior* **17**, 127—141.

Spoehr, K. T. and Smith, E. E.: 1973, 'The Role of Syllable in Perceptual Processing,' *Cognitive Psychology* **5**, 71—79.

Spring, C.: 1976, 'Encoding Speed and Memory Span in Dyslexic Children,' *Journal of Special Education* **10**, 35—46.

Spring, C. and Capps, C.: 1974, 'Encoding Speech, Rehearsal, and Probed Recall of Dyslexic Boys,' *Journal of Educational Psychology* **66**, 780—786.

Standing, L., Conezio, J. and Haber, R.: 1970, 'Perception and Memory for Pictures: Single-trial Learning of 2500 Visual Stimuli,' *Psychonomic Science* **19**, 73—74.

Stanley, G.: 1976, 'The Processing of Digits by Children with Specific Disability (Dyslexia),' *British Journal of Educational Psychology* **46**, 81—84.

Stanley, G. and Hall, R.: 1973, 'Short-term Visual Information Processing,' *Child Development* **44**, 841—844.

Stanovich, K. E.: 1980, 'Toward an Interactive—Compensatory Model of Individual Differences in the Development of Reading Fluency,' *Reading Research Quarterly* **16**, 32—71.

Stanovich, K. E.: 1982a, 'Individual Differences in the Cognitive Processes of Reading: (I) Word Decoding,' *Journal of Learning Disabilities* **15** (8), 485—493.

Stanovich, K. E.: 1982b, 'Individual Differences in the Cognitive Processes of Reading: (II) Text Level Processes,' *Journal of Learning Disabilities* **15** (9), 549—554.

Stanovich, K. E.: 1986a, 'Cognitive Processes and the Reading Problems of Learning-disabled Children: Evaluating the Assumption of Specificity,' in J. K. Torgesen and B. L. Young (eds.) *Psychological and Educational Perspectives on Learning Disabilities*, Academic Press, Orlando, FL.

Stanovich, K. E.: 1986b, 'Mathew Effects in Reading: Some Consequences of Individual Differences in the Acquisition of Literacy,' *Reading Research Quarterly* **21** (4), 360—407.

Stanovich, K. E. and Bauer, D. W.: 1978, 'Experiments in the Spelling-to-Sound Regularity Effect in Word Recognition,' *Memory and Cognition* **6**, 410—415.

Stanovich, K. E., Cunningham, A. E. and Cramer, B.: 1984a, 'Assessing Phonological Awareness in Kindergarten Children: Issues of Task Comparability, *Journal of Experimental Child Psychology* **38**, 175—190.

Stanovich, K. E., Cunningham, A. E. and Feeman, D. J.: 1984b, 'Intelligence, Cognitive Skills, and Early Reading Progress,' *Reading Research Quarterly* **19** (3), 278—303.

Stanovich, K. E., Nathan, R. G. and Vala-Rossi, M.: 1986, 'Developmental Changes in the Cognitive Correlates of Reading Ability and the Developmental Lag Hypothesis,' *Reading Research Quarterly* **21** (3), 267—283.

Stephenson, S.: 1907, 'Six Cases of Congenital Word-blindness Affecting Three Generations of One Family,' *The Ophthalmoscope* **5**, 482—484.

Sternberg, R. J.: 1985, *Beyond IQ: A Triarchic Theory of Human Intelligence*, Cambridge University Press, New York.

Sternberg, R. J., Powell, J. S. and Kaye, D. B.: 1983, 'Teaching Vocabulary-building Skills: A Contextual Approach,' in A. C. Wilkinson (ed.) *Classroom Computers and Cognitive Science*, Academic Press, New York.

Stevenson, H., Stigler, J., Lucker, G., Lee, S., Hsu, C. and Kitamura, S.: 1982, 'Reading Disabilities: The Case of Chinese, Japanese, and English,' *Child Development* **53**, 1164—1181.

Sticht, T. G.: 1984, 'Rate of Comprehending by Listening or Reading,' in J. Flood (ed.) *Understanding Comprehension*, International Reading Association, Newark, DE.

Sticht, T. G. and Glasnapp, D. R.: 1972, 'Effects of Speech Rate, Selection Difficulty, Association Strength, and Mental Aptitude on Learning by Listening,' *Journal of Communication* **22**, 174—188.

Sticht, T. G., Beck, L. J., Hauke, R. N., Kleiman, G. M. and James, J. H.: 1974, *Auding and Reading: A Developmental Model*, HumPro, Alexandria, VA.

Sticht, T. G. and James, J. H.: 1984, 'Listening and Reading,' in P. D. Pearson (ed.) *Handbook of Reading Research*, Longman, New York.

Stotsky, S.: 1983, 'Research on Reading/Writing Relationship: A Synthesis and Suggested Directions,' *Language Arts* **60** (5), 627—642.

Sundet, K.: 1986, 'Sex Differences in Cognitive Impairment Following Unilateral Brain Damage,' *Journal of Clinical and Experimental Neuropsychology* **8** (1), 51—61.

Swanson, L.: 1978, 'Verbal Encoding Effects on the Visual Short-term Memory of Learning-disabled and Normal Readers,' *Journal of Educational Psychology* **70**, 539—544.

Taft, M.: 1985, 'The Decoding of Words in Lexical Access: A Review of the Morphographic Approach,' in D. Besner, T. G. Waller and G. E. MacKinnon (eds.) *Reading Research*, vol. 5, Academic Press, Orlando, FL.

Taft, M. and Forster, K. I.: 1976, 'Lexical Storage and Retrieval of Polymorphemic and Polysyllabic Words,' *Journal of Verbal Learning and Verbal Behavior* **15**, 607—620.

Taylor, G., Satz, P. and Friel, J.: 1979, 'Developmental Dyslexia in Relation to Other Childhood Reading Disorders: Significance and Clinical Utility,' *Reading Research Quarterly* **15** (1), 84—101.

Taylor, I. and Taylor, M.: 1983, *The Psychology of Reading*, Academic Press, New York.

Temple, C. M.: 1985, 'Surface Dyslexia and the Development of Reading,' in K. E. Patterson, J. C. Marshall and M. Coltheart (eds.) *Surface Dyslexia*, Lawrence Erlbaum, Hillsdale, NJ.

Temple, C. M. and Marshall, J. C.: 1983, 'A Case Study of Developmental Phonological Dyslexia,' *British Journal of Psychology* **74**, 517—533.

Terry, P., Samuels, S. J. and LaBerge, D.: 1976, 'The Effects of Letter Degradation and Letter Spacing on Word Recognition,' *Journal of Verbal Learning and Verbal Behavior* **15**, 577—585.

Thomas, C. J.: 1905, 'Congenital Word-blindness and Its Treatment,' *The Ophthalmoscope* **3**, 380—385.

Thorndike, R. L.: 1973—1974, 'Reading as Reasoning,' *Reading Research Quarterly* **9**, 135—147.

Tien, H. C.: 1971, 'Hyperlexia, Hypolexia, or Dyslexia,' *Journal of Special Education* **5** (3), 257—259.

Torgesen, J. K.: 1985, 'Memory Processes in Reading Disabled Children,' *Journal of Learning Disabilities* **18** (6), 350—357.

Torgesen, J. K. and Houck, D. G.: 1980, 'Processing Deficiencies of Learning Disabled Children Who Perform Poorly on Digit Span,' *Journal of Educational Psychology* **72** (2), 141—160.

Torgesen, J. K., Rashotte, C. and Greenstein, I.: 1985, *Language Comprehension in Learning Disabled Chidren Who Perform Poorly on Memory Span Tests*. Unpublished manuscript, Florida State University.

Treiman, R. and Baron, J.: 1983, 'Phonemic-Analysis Training Helps Children Benefit from Spelling-sound Rules,' *Memory and Cognition* **11** (4), 382—389.

Treiman, R., Freyd, J. J. and Baron, J.: 1983, 'Phonological Recoding and Use of Spelling-sound Rules in Reading of Sentences,' *Journal of Verbal Learning and Verbal Behavior* **22**, 682—700.

Tucker, J. A.: 1985, 'Curriculum-based Assessment: An Introduction,' *Exceptional Children* **52** (3), 199—204.

Tzeng, O. L. and Hung, D. L.: 1981, 'Linguistic Determinism: A Written Language Perspective,' in O. L. Tzeng and H. Singer (eds.) *Perception of Print*, Lawrence Erlbaum, Hillsdale, NJ.

Uhl, W. L.: 1916, 'The Use of the Results of Reading Tests as Bases for Planning Remedial Work,' *Elementary School Journal* **17**, 266—275.

van den Bos, K.: 1984, 'Letter Processing in Dyslexic Subgroups,' *Annals of Dyslexia* **34**, 179—194.

van Dijk, T. A.: 1977, 'Semantic Macro-structure and Knowledge Frames in Discourse Comprehension,' in M. A. Just and P. A. Carpenter (eds.) *Cognitive Processes in Comprehension*, Lawrence Erlbaum, Hillsdale, NJ.

Van Orden, G. C.: 1987, 'A Rows is a Rose: Spelling, Sound, and Reading,' *Memory and Cognition* **15** (3), 181—198.

Vellutino, F. R.: 1979, *Dyslexia: Theory and Research*, The MIT Press, Cambridge, MA.

Venezky, R.: 1976, *Theoretical and Experimental Base for Teaching Reading*, Mouton, The Hague.

Venezky, R.: 1979, 'Orthographic Regularities in English Words,' in P. A. Kolers, M. E. Wrolstad and H. Bouma (eds.) *Processing of Visible Language*, Plenum, New York.

Voeller, K. K. and Armus, J.: 1986, 'A Comparison of Reading Strategies in Genetic Dyslexics and Children with Right and Left Brain Deficits,' *Annals of Dyslexia* **36**, 270—286.

Vogel, S.: 1985, 'Syntactic Complexity in Written Expression of College Writers,' *Annals of Dyslexia* **35**, 137—160.

Wagner, R. K. and Torgesen, J. K.: 1987, 'The Nature of Phonological Processing and Its Causal Role in the Acquisition of Reading Skills,' *Psychological Bulletin* **101** (2), 192—212.

Wallach, L. and Wallach, M.: 1976, *The Teaching All Children to Read Kit*, University of Chicago Press, Chicago.

Wallach, L., Wallach, M., Dozier, M. G. and Kaplan, N.: 1977, 'Poor Children Learning to Read Do Not Have Trouble with Phoneme Recognition,' *Journal of Educational Psychology* **69** (1), 36—39.

Wallach, M. and Wallach, L.: 1979, 'Helping Disadvantaged Children Learn to Read by Teaching Them Phoneme Identification Skills,' in L. B. Resnick and P. A. Weaver (eds.) *Theory and Practice in Early Reading*, vol. 3, Lawrence Erlbaum, Hillsdale, NJ.

Wallin, J. E.: 1920, 'Congenital Word-blindness: Some Analysis of Cases,' *The Training School Bulletin* **71**, 37—47.

Waters, S. G., Bruck, M. and Seidenberg, M.: 1985a, 'Do Children Use Similar Processes to Read and Spell Words?' *Journal of Experimental Child Psychology* **39**, 511—530.

Waters, S. G., Komoda, M. K. and Arbuckle, T. Y.: 1985b, 'The Effects of Concurrent Tasks on Reading: Implications for Phonological Recoding,' *Journal of Memory and Language* **24**, 27—45.

Weber, R. M.: 1970, 'A Linguistic Analysis of First-grade Reading Errors,' *Reading Research Quarterly* **5**, 427—451.

Wepman, J.: 1961, 'The Interrelationships of Hearing, Speech, and Reading,' *The Reading Teacher* **14**, 245—247.

Whitehouse, C. C.: 1983, 'Token Test Performance by Dyslexic Adolescents,' *Brain and Language* **18**, 224—235.

Whitehouse, D. and Harris, J.: 1984, 'Hyperlexia in Infantile Autism,' *Journal of Autism and Developmental Disorders* **14**, 281—289.

Wijk, A.: 1966, *Rules of Pronunciation for the English Language: An Account of the Relationship between English Spelling and Pronunciation*, Oxford University Press, London.

Williams, J. P.: 1979, 'The ABD's of Reading: A Program for the Learning-disabled,' in L. B. Resnick and P. A. Weaver (eds.) *Theory and Practice of Early Reading*, vol. 3, Lawrence Erlbaum, Hillsdale, NJ.

Williams, J. P.: 1980, 'Teaching Decoding with an Emphasis on Phoneme Analysis and Phoneme Blending,' *Journal of Educational Psychology* **72**, 1—15.

Williams, J. P.: 1986, 'Teaching Children to Identify the Main Idea of Expository Texts,' *Exceptional Children* **53** (2), 163—168.

Witelson, S.: 1977, 'Developmental Dyslexia: Two Right Hemispheres and None Left?' *Science* **195**, 309—311.

Wolf, M. and Goodglass, H.: 1986, 'Dyslexia, Dysnomia, and Lexical Retrieval: A Longitudinal Investigation,' *Brain and Language* **28**, 154—168.

Wong, B. Y.: 1986, 'A Cognitive Approach to Teaching Spelling,' *Exceptional Children* **53** (2), 169—173.

Zaidel, E.: 1985, 'Language in the Right Hemisphere,' in D. F. Benson and E. Zaidel (eds.) *The Dual Brain: Hemispheric Specialization in Humans*, The Guilford Press, New York.

Zola, D.: 1984, 'Redundancy and Word Perception During Reading,' *Perception and Psychophysics* **36** (3), 277—284.

APPENDIX I

TABLE I

Performance of dyslexic, NSRD, and normal readers on different tasks

Subject		Nonwords read correctly	Words spelled correctly	Errors in reading standard passages	Errors in reading reversed passages	Function words reading time (secs)	Errors in reading Cloze passages
DYS.	1	5	12	10	37	24	1
NSRD	1	32	29	5	19	16	12
CON.	1	22	21	2	10	20	2
DYS.	2	21	22	14	37	22	8
NSRD	2	27	30	19	29	10	7
CON.	2	20	23	2	22	15	12
DYS.	3	15	23	26	51	18	5
NSRD	3	25	32	4	11	17	12
CON.	3	18	22	20	25	18	5
DYS.	4	19	13	11	24	20	4
NSRD	4	29	32	8	14	11	16
CON.	4	27	27	15	13	16	3
DYS.	5	13	19	20	34	30	4
NSRD	5	26	35	2	16	11	5
CON.	5	31	33	2	6	17	9
DYS.	6	12	16	35	54	62	11
NSRD	6	20	29	16	55	15	12
CON.	6	29	26	7	15	19	3
DYS.	7	18	24	22	39	15	6
NSRD	7	25	22	13	23	16	10
CON.	7	25	26	5	17	22	4
DYS.	8	22	26	21	70	17	3
NSRD	8	29	36	13	16	10	5
CON.	8	29	36	10	11	13	4

Table I (continued)

Subject		Nonwords read correctly	Words spelled correctly	Errors in reading standard passages	Errors in reading reversed passages	Function words reading time (secs)	Errors in reading Cloze passages
DYS.	9	18	25	6	25	15	1
NSRD	9	23	32	6	37	12	7
CON.	9	22	29	12	27	15	4
DYS.	10	20	25	9	21	17	5
NSRD	10	25	27	11	40	11	15
CON.	10	32	36	0	7	10	3
DYS.	11	14	5	67	96	31	6
NSRD	11	15	30	14	23	14	14
CON.	11	22	32	20	35	18	10
DYS.	12	8	19	2	15	20	0
NSRD	12	20	30	11	25	8	5
CON.	12	23	30	10	19	18	5
Group mean							
DYS.		15.42	19.08	20.25	41.91	24.25	4.50
NSRD		24.66	30.33	10.17	25.67	12.58	9.92
CON.		25.00	28.41	8.75	17.25	16.75	5.33

TABLE II

The thirteen sound-to-spelling rules and the percent of children from grades 2 through 6 who produced correct spellings (normal readers)

Rule	Target words (high freq.)	Percent correct	Target words (low freq.)	Percent correct	Mean percent correct
1. Initial /k/ → c	Cat Cold	100	Cake Cape	100	100
2. Initial /g/ → g	Girl Game	99	Gift Gait	99	99
3. Terminal /g/ → g	Dog Sing	100	Flag Hung	91	95

Table II (continued)

	Rule	Target words (high freq.)	Percent correct	Target words (low freq.)	Percent correct	Mean percent correct
4.	Middle /g/ → g	Begin Eggs	93	Hanging Forget	98	95
5.	Terminal /dz/ → g	Page Edge	88.25	Merge Ledge	92	89.8
6.	Middle /dz/ → g	Larger Region	83	Digit Rigid	83.75	86.5
7.	Initial /tch/ → ch	Children Chance	76.7	Chess Chap	90	83.5
8.	Initial /dz/ → g	Gentle Giant	73.4	Germ Gender	N.A.[1]	N.A.
9.	Middle /k/ → c	Uncle Fact	59	Local Picnic	88	66.6
10.	Initial /s/ → c	City Certain	59	Cent Circus	77	65
11.	Rule of 'e'	Care Bite	52	Spare Cute	N.A.	N.A.
12.	Middle /s/ → c	Except Faces	40.7	Concern Council	27.7	34.2
13.	Compound vowels and consonants	Daughter Ghosts Bachelor	31.5	Build Couch Luncheon	N.A.	N.A.

[1] NA = not available.

TABLE III
Spelling tests

List 1

1.	Dog	The *dog* makes a good pet.
2.	Cat	The *cat* is also a pet.
3.	Pages	There are many *pages* in the book.
4.	Chance	He has a *chance* of winning the game.
5.	Larger	Jane's house is *larger* than Bill's
6.	Special	Christmas is a very *special* day.
7.	Region	They live in the northern *region* of the country.
8.	Decide	You must *decide* by tomorrow if you can come or not

Table III (continued)

9.	Girl	She is a pretty *girl.*
10	Uncle	You would like my *uncle* but not my aunt.
11.	Changes	When Bill goes swimming he *changes* his clothes.
12.	Discover	Did Columbus *discover* America?
13.	Edge	They live on the *edge* of the town.
14.	Fact	That is an interesting *fact.*
15.	Large	That is a *large* house not a small one.
16.	Cells	There are many *cells* in our body; you have to use a microscope to see them.
17.	City	We live in the *city* not in a village.
18.	Page	Please turn to the first *page* of your book.
19.	Having	Jim was *having* a good time.
20.	Except	I like all kinds of food *except* spinach.
21.	Strong	Bill is very *strong.* He is not weak.
22.	Cold	It is *cold* outside but not inside.
23.	Bring	Will you *bring* me my plate?
24.	Center	He hit it in the *center*, not outside.
25.	Eggs	I had *eggs* for breakfast.
26.	Certain	Are you *certain* of that, or are you not sure?
27.	Sing	I like to *sing* but not dance.
28.	Coming	John is *coming* home tomorrow.
29.	Songs	He knows many *songs* and he sings them.
30.	Became	Jill *became* a school teacher.
31.	Green	The grass is *green.*
32.	Children	Parents have *children.*
33.	Gone	He must have *gone* home.
34.	Cannot	I *cannot* answer that question.
35.	Begin	We will *begin* a new lesson tomorrow.
36.	Game	Basketball is a fun *game.*
37.	Moving	They are *moving* to their new house.
38.	Audible	If the speech is *audible* you can hear it.
List 2		
1.	King	England has a *king* and a queen.
2.	Church	Jane goes to *church* on Sundays.
3.	Huge	Texas is a *huge* state, not a small one.
4.	Chart	They put their results on a *chart* but not on the chalkboard.
5.	Spring	It rains in the *spring*, but snows in the winter

Table III (continued)

6.	Charge	Who is in *charge* here?
7.	Record	Can I borrow that *record*; it has good songs.
8.	Garden	They have tomatoes in their *garden*.
9.	Carry	I can *carry* heavy things.
10.	Glad	He was *glad* to see her.
11.	Include	*Include* milk in your lunch.
12.	Germany	They live in *Germany*, but visit France often.
13.	Necessary	It is *necessary* that you be here.
14.	Strange	That is a *strange* television show.
15.	Increase	I hope they *increase* my allowance.
16.	Ring	She has a wedding *ring*.
17.	Engine	The *engine* in the car is broken.
18.	Process	Do you understand the *process* of adding numbers?
19.	Vegetable	Corn is a *vegetable*.
20.	Gold	*Gold* is expensive, but lead is not.
21.	Forces	The U.S. has strong armed *forces*.
22.	Danger	Fire is a *danger* to be avoided.
23.	Capitol	Washington is our nation's *capitol*.
24.	Hungry	I get *hungry* before lunch.
25.	Cattle	We get beef from *cattle*.
26.	Fingers	John hurt his *fingers*.
27.	Corn	I like *corn* on the cob.
28.	Bags	They had seven *bags* of groceries.
29.	Occur	I hope that mistake does not *occur* again.
30.	Begins	School *begins* on Monday at 8 AM.
31.	Circle	It is easy to draw a *circle* but difficult to draw a square.
32.	General	Patton was a *general* of the army.
33.	Village	A city is different from a *village*.
34.	Giant	A *giant* is a very big man.
35.	Playing	They liked *playing* cards.
36.	Gentle	Be *gentle* to children; don't be rough.
37.	Decimal	In arithmetic you have to use a *decimal* point.
38.	Glass	He broke the *glass* which had the milk.
39.	Pause	Please *pause* between sentences.
40.	Thorough	He is very *thorough* in his work.
41.	Applause	The comedian received much *applause*.
42.	Necessity	Food is a *necessity*.
43.	Docile	He is very *docile* and gentle.

Table III (continued)

List 3

1.	Car	Buick is a niçe *car.*
2.	Mute	Bill is *mute* and cannot hear.
3.	Sit	Please *sit* in your seat.
4.	Came	They *came* home yesterday.
5.	Hug	It is nice to get a *hug* from your friend.
6.	Rate	I read at a fast *rate.*
7.	Mug	John drank coffee from a *mug.*
8.	Cute	She is very *cute* and pretty.
9.	Site	This is a good *site* to build a house.
10.	Rat	The cat ate the *rat.*
11.	Bite	John had a mosquito *bite.*
12.	Glade	A *glade* is a marshy area.
13.	Care	Take good *care* of yourself.
14.	Huge	Tom lives in a *huge* house.
15.	Cut	A sharp knife can *cut* well.
16.	Bit	I ate a little *bit* at a time.
17.	Glad	I am *glad* that you are here.

List 4

1.	Wait	Can you *wait* for me? I'll be back soon.
2.	Cause	What was the *cause* of the accident?
3.	Ghost	Casper is a friendly *ghost.*
4.	Daughter	I have a son and a *daughter.*
5.	Tough	They are a *tough* football team.
6.	Laughter	There was much *laughter* in the movie.
7.	Build	John likes to *build* things.
8.	Caught	Jane *caught* the ball.
9.	Sign	This is a stop *sign.*
10.	Guess	I like to *guess* the answer correctly.

[1] Only those words that are read correctly (from Appendix II) by the child are checked for spelling.

APPENDIX II

TABLE I

Reading tests

Name: **Grade:**

List 1		*List 2*	
1. Dog	20. Except	1. King	22. Danger
2. Cat	21. Strong	2. Church	23. Capitol
3. Pages	22. Cold	3. Huge	24. Hungry
4. Chance	23. Bring	4. Chart	25. Cattle
5. Larger	24. Center	5. Spring	26. Fingers
6. Special	25. Eggs	6. Charge	27. Corn
7. Region	26. Certain	7. Record	28. Bags
8. Decide	27. Sing	8. Garden	29. Occur
9. Girl	28. Coming	9. Carry	30. Begins
10. Uncle	29. Songs	10. Glad	31. Circle
11. Changes	30. Became	11. Include	32. General
12. Discover	31. Green	12. Germany	33. Village
13. Edge	32. Children	13. Necessary	34. Giant
14. Fact	33. Gone	14. Strange	35. Playing
15. Large	34. Cannot	15. Increase	36. Gentle
16. Cells	35. Begin	16. Ring	37. Decimal
17. City	36. Game	17. Engine	38. Glass
18. Page	37. Moving	18. Process	39. Pause
19. Having	38. Audible	19. Vegetable	40. Thorough
		20. Gold	41. Applause
		21. Forces	42. Necessity
			43. Docile

List 3	*List 4*	*List 5: Nonwords*	
1. Car	1. Wait	1. Gare	19. Gend
2. Mute	2. Cause	2. Duncle	20. Cend
3. Sit	3. Ghost	3. Ract	21. Grone
4. Came	4. Daughter	4. Gar	22. Chind
5. hug	5. Tough	5. Bace	23. Gen
6. Rate	6. Laughter	6. Recide	24. Pice
7. Mug	7. Build	7. Kaces	25. Tite
8. Cute	8. Caught	8. Gade	26. Cag
9. Site	9. Sign	9. Skare	27. Dit
10. Rat	10. Guess	10. Chape	28. Cilly

Table I (continued)

11. Bite		11. Skar	29. Cept
12. Glade		12. Kute	30. Colp
13. Care		13. Gite	31. Kar
14. Huge		14. Fedge	32. Pare
15. Cut		15. Git	33. Sute
16. Bit		16. Bage	34. Kare
17. Glad		17. Ling	35. Pir
		18. Gog	36. Sut
Function words		*Content words*	
List 1	*List 2*	*List 1*	*List 2*
Let	Every	Cat	Water
Has	Never	Run	Words
Ago	Could	Men	House
Off	Along	Boy	World
Why	While	Say	Three
Any	Might	Dog	Sound
Yet	Often	She	Think
Nor	Which	Man	Story
Will	Since	Bird	Place
Much	Ahead	Gold	Force
Also	Should	Book	Figure
Must	Except	Feet	Letter
Even	Behind	Back	Family
Such	Though	Room	Father
Once	During	Name	Number
Soon	Almost	Page	School
Ever	Before	Work	Things
Upon	Without	Come	Picture
Else	Perhaps	Look	Morning
Thus	Although	Time	Distance

TABLE II

Reading tests: Grade 2

1. *Standard passage*

Jimmy was a good boy at home. He wanted to help every day. Jimmy fed his dog. Jimmy was very, very happy at home.

Betty was a good girl at home. She wanted to help every day. She fed the birds. Betty was very happy at home.

Jimmy's mother was a friend at home. Jimmy's father was a friend at home. They wanted to help every day. This was what they did. They were very happy at home.

Table II (continued)

Betty's mother and father were good friends at home. They wanted to help every day. This was what they did. They were very happy at home.

Jimmy's father was going home for the night. Jimmy's brothers were going home for the night. Jimmy went to the house for the night. Mother was very happy to see them. The sun was going down.

Walk, walk, Betty's father was going home for the night.

2. *Reversed passage*

Home at boy good a was Jimmy. Day every help to wanted he. Dog his fed Jimmy. Home at happy very, very was Jimmy.

Home at girl good a was Betty. Day every help to wanted she. Birds the fed she. Home at happy very was Betty.

Home at friend a was mother Jimmy's. Home at friend a was father Jimmy's. Day every help to wanted they. Did they what was this. Home at happy very were they.

Home at friends good were father and mother Betty's. Day every help to wanted they. Did they what was this. Home at happy very were they.

Night the for home going was father Jimmy's. Night the for home going were brothers Jimmy's. Night the for house the to went Jimmy. Them see to happy very was mother. Down going was sun the.

Night the for home going was father Betty's, walk, walk.

3. *Cloze passage*

	boy		a		ran
Jimmy was a good	already	at home. He wanted	go	help every day. Jimmy	fed
	girl		to		mailed

	very	
his dog. Jimmy was	over	very happy at home.
	just	

Jimmy		the		take	
Backs	was a good girl	at	home. She wanted to	but	every day.
Betty		on		help	

	a		poor	
She fed	and	birds. Betty was very	happy	at home.
	the		correct	

	was		Yarn's	
Jimmy's mother	are	a friend at home.	Jimmy's	father
	will		Pumpkin's	

Table II (continued)

	from		help		what	
was a friend	to	home. They wanted to	part	every day. This was	when	
	at		hit		can	

	long	
they did. They were	very	happy at home.
	little	

	boys		friends	
Betty's	night	and father were good	children	at home. They wanted
	mother		men	

to		for		was	
go	help every day. This	had	what they did. They	there	very happy at home.
in		was		were	

Mother's		for		have
Dog's	father was going home	was	the night. Jimmy's brothers	what
Jimmy's		are		were

	light		school	
going home for the	night	. Jimmy went to the	world	for the night.
	times		house	

	is		them		on
Mother	on	very happy to see	up	. The sun was going	only
	was		this		down

	will		boys
Walk, walk, Betty's father	was	going home for the	parts
	are		night

TABLE III

Normative data for tests in Appendix I[1] and II

		Grade					
		4	5	6	7	8	9
Reading comprehension	$\bar{X}$	5.18	5.31	5.80	7.12	7.67	8.63
(Woodcock subtest, A;	SD	1.49	1.20	1.40	1.30	1.58	2.87
Grade equivalent)							

Table III (continued)

		Grade					
		4	5	6	7	8	9
Listening comprehension (Woodcock subtest, B; Grade equivalent)	$\bar{X}$	5.31	5.78	6.21	6.96	7.73	9.27
	SD	1.37	1.24	1.62	1.50	2.15	3.06
Spelling test; No. correct from List 1 (Max. 38)	$\bar{X}$	28.46	31.53	32.65	33.31	35.13	35.60
	SD	7.13	6.67	6.25	5.18	3.97	3.66
Word reading; No. correct from List 1 (Max. 38)	$\bar{X}$	33.84	33.75	34.0	35.17	35.90	35.33
	SD	2.41	4.82	2.27	2.77	1.91	3.83
Nonword reading; No. correct (Max. 36)	$\bar{X}$	24.04	27.13	27.73	28.33	29.36	29.44
	SD	6.26	6.61	6.46	4.89	4.96	5.34
Function word reading No. *wrong* from list 1 (Max. 20)	$\bar{X}$	0.82	0.92	0.91	0.72	0.70	0.67
	SD	1.06	1.56	0.99	0.62	1.06	1.21
Function word reading time (Secs.), list 1	$\bar{X}$	20.32	16.00	16.71	15.29	12.70	12.33
	SD	6.27	3.88	6.14	5.69	2.83	3.89
Content word rdg., No. *wrong* from list 1 (Max. 20)	$\bar{X}$	0.20	0.10	0.13	0.10	0.10	0.10
	SD	0.41	0.61	0.30	0.40	0.35	0.38
Content word reading time (secs)	$\bar{X}$	17.36	13.81	12.38	12.10	10.90	11.33
	SD	4.44	4.40	4.56	4.20	5.10	3.90
Errors in reading Standard Passages, A and B	$\bar{X}$	10.76	9.25	10.23	9.44	5.90	6.67
	SD	6.37	4.70	5.98	4.80	4.04	5.12
Errors in reading Reversed Passages, A and B	$\bar{X}$	20.16	21.33	24.25	23.40	16.33	14.33
	SD	10.68	12.22	11.37	13.39	12.61	12.18
Errors in reading Cloze Passages, A and B	$\bar{X}$	6.04	5.25	6.83	7.00	7.67	6.67
	SD	2.96	2.86	4.23	5.33	5.83	3.14

[1] Regression formula for predicting Reading Comprehension from Listening Comprehension: Listening comprehension score (Standard score from Woodcock Passage Comprehension subtest, Form B) $\times$ 0.8283 + 6.930.

TABLE IV

Phonological awareness test I (adapted from Stanovich Cunningham and Cramer 1984)[1]

Note to Examiner

When needed, use the phoneme value (sound) of the letter and not the letter name. For example, the first phoneme in *cat* is /k/ and not /c/.

1. *Final phoneme same*

Instruction: Can you repeat the word *meat*? With what does the word end? /t/, right? What does the word *been* end with? The sound /n/. Let's try again. What does the word *meat* end with? Now, if I say three words can you say which of the words ends with the sound /t/?: *fin, coat, glass*. The word *coat* ends with the sound /t/. Now if I say *meat* and then *fin, coat, glass* which word would you say has the same ending sound as *meat*? If I say *ball* and then say *book, doll,* and *run*, which word ends like *ball*?

1. WORM: warm, wall, ball
2. CUP: car, cap, can
3. PAN: pat, run, gum
4. BEAT: boy, girl, wet
5. LEAF: deaf, love, seed
6. BUD: red, blue, green
7. HOUSE: home, school, base
8. HOOK: rock, pencil, note
9. NAIL: wood, not, tall
10. BUG: but, hut, leg

2. *Substitute initial phoneme*:

Instruction: If I say the word *go*, and then change the first sound to /n/ the new word will be *no*. If I said the word *tall*, can you change the word by changing the first sound? (*ball*) If I say *man* what will you say? (*ran*) Now try these words.

1. TOP
2. BELL
3. LIP
4. FED
5. GUN
6. SICK
7. PIN
8. CAT
9. SAP
10. CUT

3. *Initial phoneme not same*

(This test is similar to No. 7 except for the instructions.)

Instruction: I am going to say a word aloud followed by three more words. Your task is to tell me which word does not begin with the same sound as the first word. I will say the word *mud* and then say the words *mice, dig,* and *mouth*. Can you tell me which word did not have the same beginning sound as *mud*? (*dig*) Now I say the word *run*; and then say *rain, gun, ran,* and *rat*. Which word starts with a different sound? Now, try these.

1. BOY: ball, bun, barn, girl
2. DOLL: tall, drum, dance, drink
3. SUN: sat, fan, sit, sing
4. KITE: kiss, kent, kill, neat
5. MAN: mean, men, boy, much
6. NEST: bell, neat, not, nine
7. FISH: fine, far, dog, five
8. TRAIN: trash, horse, trip, tram
9. PIE: fine, paper, pot, pepper
10. LAMP: luck, dump, lake, love

4. *Supply initial phoneme*

Instruction: You will be hearing two words that are the same except for the beginning sound. You have to tell what sound is missing from the second word. If I say *cat* and *at*, what sound is missing from the second word that is in *cat*? (/k/) If I say *bat* and *at*,

Table IV (continued)

what is missing in the second word? (/b/) If I say *ran* and *an*, what is missing? (/r/) Now try these.

1. MEAL – EEL	6. NEAR – EAR
2. FILL – ILL	7. PAIR – AIR
3. SIT – IT	8. BEND – END
4. LAND – AND	9. TASK – ASK
5. DATE – ATE	10. CAN'T – ANT

5. *Rhyme supply*
Instruction: I will say a word and you will say a word that sounds like it. If I say *fish* you are supposed to say *dish.* If I say *gun* what will you say? [If the *S* does not say a rhyming word, tell him *run* rhymes with *gun.*] Let's try again. If I say *silk* what will you say? (*milk*) I am going to say some words and you are going to say words that rhyme with them. O.K.?

1. NOSE	3. SKY	5. HILL	7. MOUSE	9. NOTE
2. PUP	4. TOY	6. WING	8. TIP	10. LOOK

6. *Rhyme choice*
Instruction: I am going to say one word first and then say three more words. You have to say which of the three words rhymes with the first word. For example, I say *pet*; then I say *barn, net, hand.* Which word rhymes with *pet*? (If the child fails to understand, repeat the example; then give another example; *cat: ball, milk, rat*).

1. STAR: car, run, sun	6. FLASH: Irish, trash, flush
2. MOP: milk, top, gun	7. CAKE: ran, rake, rash
3. GREEN: screen, play, house	8. JUMP: pump, tall, dip
4. PLANE: prime, dream, crane	9. BOX: fix, mix, fox
5. CROWN: brown, green, yellow	10. JEEP: boy, deep, bell

7. *Initial phoneme same*
Instruction: I am going to say a word. Listen to the first sound of the word. If I say *ball*, what is the first sound you hear? /*ba*/, that is right. If I say *foot*, what sound do you hear? Now, I will say a word, and then say three more words. You will have to say which of the three words starts with the same sound as the first one. Here are some examples. RUN: *ball, gun, rat.* What is the answer? *Rat*; because *run* and *rat* begin with the sound /r/. Now, let's try again. BELL: *well, ball, tell. Ball* is the right answer. Let's try one more. CALL: *yell, caught, tall.*

1. MILK: mix, klik, drink	6. TENT: tell, call, mint
2. PEAR: pat, rat, rare	7. LEG: peg, let, got
3. FAN: ran, man, fat	8. DUCK: luck, bird, dull
4. BONE: boat, home, done	9. NEST: best, yell, neat
5. SOAP: rope, sole, real	10. KEY: lock, kiss, love

Table IV (continued)

8. *Strip initial phoneme*

Instruction: Listen to the word I say. The word is *task*. If you take away the /t/ sound, what word is left? (*ask*) If the word is *ball* and you take away the first sound, what word is left? (*all*) Now let us try these words.

1. PINK	3. MAN	5. WIN	7. PITCH	9. FIT
2. TOLD	4. NICE	6. BUS	8. CAR	10. POUT

9. *Initial phoneme different*

Instruction: Listen to these words: *bag, nine, beach, bike*. Can you tell me which one of the following words has a different beginning sound — *bag, nine, beach, bike*?; (*nine*). Now listen to these words: *ran, man, rat*, and *rain* (*man*) Now try these words.

1. EAR: den, eat, elm, end
2. POP: pup, pulp, cap, pen
3. HILL: hen, hat, house, ball
4. BAND: bend, bike, hind, but
5. ARM: germ, all, aunt, autumn
6. GIVE: gun, dive, get, gather
7. VAN: very, vary, run, varnish
8. CART: call, calm, cat, doll
9. RICE: roll, wheat, ring, rich
10. TEETH: teacher, tall, tree, mouth

10. *Final phoneme different*

Instruction: I am going to say some words. One of them ends with a different sound than the other words. For example, *rat, dime, boat*, and *mitt*. Can you tell me which word has a different sound at its end? (*dime*) Let's try some more: *can, pan, man, boy*. Can you tell me which word ends with a different sound? (*boy*) One more trial: *log, pen, bag, dig*. Can you say which word ends with a different sound? (*pen*) Now we have some more.

1. HAM: gum, rim, dim, sun
2. CUP: dip, dog, lap, flip
3. LEAF: deaf, lean, puff, roof
4. FLAG: flat, rug, big, mug
5. DRESS: mess, dream, miss, bus
6. WRIST: twist, ring, best, last
7. BALL: hill, fell, bell, band
8. HAND: ham, end, mind, wind
9. RAIN: sun, tan, moon, raid
10. DESK: best, back, rack, clock

[1] Tests 1—4 constitute the test battery. The regression formula for predicting reading comprehension score from phoneme awareness scores is: $6.393 \times$ test 1 score $+ 0.661 \times$ test 2 score $+ 6.986 \times$ test 3 score $+ 3.21 \times$ test 4 score minus ($-$) 88.26. The phoneme awareness tests 5—10 can be used for additional testing or for training purposes. Mean is 34.5; SD = 2.8.

TABLE V

Phoneme awareness test II (Rosner and Simon, 1971): phoneme deletion task

Instruction: Say *cowboy.* Now say it again without *boy*: (*cow*).
Let's try one more. Say *birthday.* Can you say it without *day*?: (*birth*). Now I am going to say words like these and ask you to repeat them. Then I want you to say them again without the sound I will tell you. OK?

Note to examiner: The examiner first tells the word and the child repeats the word. Subsequently the examiner tells the phoneme that is to be deleted. The examiner utters the phonemic value of the letter or the syllable to be omitted and *not the name of the letter* or letters. You may stop testing at the following levels: Kindergarten, word no. 10; grade 1, word no. 20; grade 2, word no. 25; grade 3, word no. 30; grade 4, word no. 35.

1. birth(day)	21. (sh)rug
2. (car)pet	22. g(l)ow
3. bel(t)	23. cr(e)ate
4. (m)an	24. (st)rain
5. (b)lock	25. s(m)ell
6. to(ne)	26. Es(ki)mo
7. (s)our	27. de(s)k
8. (p)lay	28. Ger(ma)ny
9. stea(k)	29. st(r)eam
10. (l)end	30. auto(mo)bile
11. (s)mile	31. re(pro)duce
12. plea(se)	32. s(m)ack
13. (g)ate	33. phi(lo)sophy
14. (c)lip	34. s(k)in
15. ti(me)	35. lo(ca)tion
16. (sc)old	36. cont(in)ent
17. (b)reak	37. s(w)ing
18. ro(de)	38. car(pen)ter
19. (w)ill	39. c(l)utter
20. (t)rail	40. off(er)ing

AUTHOR INDEX

SUBJECT INDEX