COMPREHENSION PERFORMANCE AS A FUNCTION

OF ADOLESCENT READER TYPE

by

Janice Lynette Eastman

B.A., University of Tasmania, 1968

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ABSTRACT

Name: Janice Lynette Eastman

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Examining Committee

    Chairperson: R. W. Marx

_____   _____

                        B. Wong
                        Senior Supervisor

_____

                        J. Kendall
                        Associate Professor

_____   _____   _____

                        D. D. Deshler
                        Department of Special Education
                        University of Kansas
                        External Examiner

                            Date approved $\mathcal{S}$1/$\mathcal{O}$1/84

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Author:

        (signature)

        Janice Lynette Eastman

        (name)

        January 31, 1984

        (date)

ABSTRACT

Research in reading strongly indicates that skilled readers differ from less skilled readers in many components of the reading process. However, despite much research and theorizing, the causes of reading failure at both the word recognition and comprehension levels are not readily known. Recent research on interactive models of reading offers a promising approach to studying reading processes and individual differences in these processes. Specifically, an interactive model of reading provides two contrasting views of reading failure: Conceptually based data may not be sufficiently available or sufficiently used; coding of graphically based information (i.e. word decoding and identification) may not be sufficiently fluent.

Based on the literature related to interactive models of reading and types of poor readers, the study attempted to differentiate four types of adolescent readers from an initial sample population of 110 grade eight students in Langley, British Columbia. The four types of readers categorized on the basis of their performance on the Word Identification and Passage Comprehension subtests of the Woodcock Reading Mastery Tests were: Good readers, having adequate word recognition and comprehension skills; Difference readers, having adequate word recognition skills, but poor comprehension skills; Deficit readers, possessing poor word recognition and poor

comprehension skills; and Compensator readers, having adequate comprehension skills despite poor word recognition skills.

The Difference reader group was subsequently dropped from the study because only four subjects could be reliably categorized on an "a priori" raw score level of performance on the word recognition and comprehension tests. An additional 34 subjects could not be categorized as Good, Deficit or Compensator readers and were dropped from the study. The remaining sample of 72 consisted of 34 Good readers, 14 Deficit readers, and 24 Compensator readers. The subjects were then administered four prose passages, and comprehension performance on factual and inferential questions was analyzed in terms of reader type.

The results indicated that the majority of hypotheses, related to reader group type and comprehension performance on factual and inferential questions, were substantiated. The results thus support the usefulness of analyzing reading comprehension performance in terms of reader group differences. The educational and research implications of these findings are discussed.

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CHAPTER I

INTRODUCTION AND REVIEW OF LITERATURE

Context of the Problem

Researchers in reading have long agreed with the evidence that reading is a very complex activity (Gibson & Levin, 1975; Goodman, 1976; Huey, 1908, 1968; Lesgold & Perfetti, 1981). Previous research has tended to investigate each aspect of the reading process as a separate research problem, resulting in a number of theories and typologies of reading and reading disorders. Despite abundant research and theorizing, causes of reading failure both at the word recognition and comprehension levels are not readily known. To understand why the majority of inadequate readers, those who do not possess severe and diagnosable mental or physical problems, experience reading problems, we need to understand the overall reading process sufficiently in order to pinpoint its areas of vulnerability. Given that reading involves a magnitude of "perceptual, linguistic and cognitive processes" (Adams, 1980, p. 11), and that reading processes and skills, and the experiential base that results in learning to read are both complex (Gibson & Levin, 1975; Huey, 1908, 1968; Lesgold & Perfetti, 1981), it is all the more important that reading processes and problems be viewed in the context of a theory of reading that can account for fluent reading, beginning reading and reading problems of young children, adolescents and adults. Recently, renewed interest

into the investigation of reading comprehension by professionals in many fields makes it apparent that we may be moving rapidly toward that goal (Wong, 1982).

Many research fields have contributed significantly to the present theoretical and empirical endeavours on the study of reading comprehension, namely, cognitive psychology, information-processing models of learning, linguistics and psycholinguistics, and developments in artificial intelligence. Some of the recent developments which have influenced current research include: reaffirmation of the active and constructive role of the learner in processing information (Neisser, 1967; Wittrock, 1979) the idea of a limit on the amount of conscious mental processing in which a person can engage at one time (Atkinson & Shiffrin, 1968); the psycholinguistic view of reading as a complex language processing activity in which grapho-phonic, semantic and syntactic information all play a part (Goodman, 1976); and the plausibility of the information-processing model of reading disability, in particular, verbal processing (Morrison, Nagy & Giordani, 1977; Vellutino, Steger, Moyer, Harding and Miles, 1977). As a result of these recent contributions, professionals in cognitive, developmental and educational psychology, as well as those in the fields of learning disabilities and reading, have turned their attention toward understanding the special problems of the disabled reader, especially the problems of the poor comprehender.

Review of the Literature

Several important theoretical approaches to the study of reading processes appear particularly germane to understanding the problems of disabled readers, specifically bottom-up processing, top-down processing and interactive models of reading (Adams, 1980; Lesgold & Perfetti, 1978, 1981; Perfetti & Roth, 1981; Rummelhart, 1977; Stanovich, 1980). These models help to account for individual differences in reading ability.

Bottom-up processing is analytic in so far as the reader analyzes the visual array in order to recognize words, letter by letter, using grapheme-phoneme correspondences which are then formed into phonological representations (Gough, 1972; Rozin & Gleitman, 1977). Top-down processing is synthetic in so far as the reader sets up expectations or hypotheses for word meanings, and seeks confirmation by sampling selectively from the visual cues. Thus top-down processing relies on context to aid word recognition and to gain sentence and passage meaning (Goodman, 1976; Rozin & Gleitman, 1977; Smith, 1971; Wildman & Kling, 1978-79).

An interactive model of reading comprehension takes into account the interactions between these "top-down" and "bottom-up" processes; different processes are responsible for providing data and sharing the data with other processes (Rummelhart, 1977; Perfetti & Roth, 1981), so that "a pattern is synthesized based on information provided simultaneously from several knowledge sources [such as] feature

extraction, orthographic knowledge, lexical knowledge, syntactic knowledge, semantic knowledge" (Stanovich, 1980, p. 35).

Interactive models appear to differ from top-down and bottom-up models primarily in terms of the independence of processes at different levels. Bottom-up models (e.g. Gough, 1972; LaBerge & Samuels, 1974) posit strictly serial stage processing, with processing at each level being completed before processing at the next level is initiated. In top-down models (Goodman, 1976; Smith, 1971) semantic processes are assumed to direct lower-level processes. Criticisms of both models are frequently expressed in the literature (see Rummelhart, 1977; Stanovich, 1982a, 1982b; and Wildman & Kling, 1978-79). The main criticism of bottom-up models is that they fail to account for findings in the empirical research for the effects of prior semantic context and syntactic context in on-going reading. Top-down or hypothesis-test models have been criticized for vagueness of conceptualization. For example, Goodman (1976) doesn't make clear how the reader reaches the stage of adeptness at "selecting the fewest, most productive cues necessary to produce guesses which are right the first time" (p. 498). However, criticisms of top-down models have mainly been directed at the inherent assumptions about the relative speeds of the processes involved. As Samuels, Dahl and Archwamety (1974) have argued, fluent readers can recognize words on purely visual information faster than they can generate hypotheses about upcoming words.

Contrary to Smith's (1971) notion, that the more fluent the reader, the more top-down processing is employed, it now appears that fluent readers are more likely to engage in bottom-up processing (Juel, 1980; Lesgold & Perfetti, 1981; Stanovich, 1982b). However, these two models do not sufficiently allow for individual differences in reading skills, nor do they provide for a compensatory assumption by which readers may overcome deficiencies in reading skill.

For the skilled reader, the processes are so well learned and integrated (Golinkoff, 1975-76; Guthrie, 1973a that written information can flow almost automatically from sensation to meaning (Adams, 1980). Skilled readers appear to be superior to unskilled readers in many components of the reading process. The former are thought to use bottom-up and top-down processing simultaneously at all levels of analysis, thereby making optimal use of the information on the page, the redundancy of the language and the contextual environment, all with minimal effort (Adams, 1980; Rummelhart, 1977; Wildman & Kling, 1978-79). A "triggering event" (Brown, 1980) alerts them to comprehension failure, at which time they slow down and allot more processing capacity to the problem area.

Moreover, an interactive framework provides a focus for two contrasting views of reading failure: 1. Conceptually based data may not be sufficiently available or sufficiently used; 2. coding of graphically based information (i.e. word decoding and identification) may not be sufficiently fluent (Perfetti & Roth, 1981). Few theorists

today would advocate either purely bottom-up or purely top-down models
of reading (Juel, 1980; Wildman & Kling, 1978-79). However, one would
expect that the reader who adopts only bottom-up or top-down
processing would experience reading difficulty (Adams, 1980; Kolers,
1975).

Stanovich (1980, in press) presents an interactive model that
assumes also that the various component subskills of reading can
operate in a compensatory manner. That is, the model described by
Stanovich allows for higher-level processes to compensate for
deficiencies in lower-level processing in reading performance. In a
discussion of studies of orthographic structure effects, sentence
context effects, and automatic and attentional context effects, he
argues convincingly that an interactive-compensatory model may help to
account for individual differences in reading and, further, to explain
many research findings that "had seemed paradoxical" (Stanovich, 1980,
p. 36).

Levy (1981) also recognizes the viability of an interactive model
which accounts for the flexibility displayed by readers. She points
out that "comprehension could be achieved through strong top-down
support, with only weak bottom-up support or vice-versa, so long as
the total strength was above some value" (p. 3), this value being
unspecified at the present time. She concurs with Rummelhart (1977)
that interactive models need further elaboration in order to specify
the "how", in fact, "which mechanisms do what" (Levy, 1981, p. 3).

Many good and poor readers undoubtedly differ from each other at the level of word processing. Use of the terms "word recognition", "decoding", "word identification" varies in the literature. For the purposes of this review, the terms are used interchangeably and are taken to mean the process of "extracting enough information from word units so that a location in the mental lexicon is activated, thus resulting in semantic information becoming available to consciousness" via the use of visual or phonological information (Stanovich, 1982a, p. 486).

While the goal of fluent reading is obviously comprehension, fast and accurate decoding is a necessary prerequisite. But by itself, accurate decoding is not a sufficient condition for reading comprehension to occur. In order for comprehension to occur, the two components of word recognition, accuracy and speed, must develop. The speed of word recognition is related to comprehension (McCormick & Samuels, 1979) in so far as "less skilled reading may be in part due to a failure to develop automaticity, thereby causing a deficit in the amount of attention available for comprehension" (Curtis, 1980, p. 656). Latency is the usual indicator of automaticity in word recognition.

It is well substantiated that individuals who are classified as poor readers read more slowly (Biemiller, 1970; Curtis, 1980; Katz & Wicklund, 1971; Kolers, 1970, 1975; Lesgold & Curtis, 1981; McCormick & Samuels, 1979; Perfetti & Hogaboam, 1975; Samuels, Begy, & Chen,

1975-76; Shankweiler & Liberman, 1972). These differences are apparent at the earliest stages of reading acquisition, and also with adult populations (Cromer, 1970; Jackson & McClelland, 1975; Mason, 1978). These studies demonstrate a correlation rather than a causal relationship between word recognition and comprehension, and as McClelland and Jackson (1978) point out, "a difference between fast and slow readers on one particular visual component of the complex reading process is not sufficient to demonstrate that individual differences actually arise from that component itself" (p. 192). However, Stanovich (1982a) cites findings that suggest that increased word recognition skill leads to improved comprehension rather than the reverse.

Studies on the speed of verbal processing further indicate that the less skilled reader is slower in executing phonological coding (Lesgold & Curtis, 1981; Lesgold & Perfetti, 1978; Perfetti, Finger, & Hogaboam, 1978; Perfetti & Lesgold, 1979) and that difficulties of the poor decoder reside at the phonological level of processing (Barron, 1981; Shankweiler, Liberman, Mark, Fowler & Fischer, 1979; Snowling, 1980).

According to the theory of automatic information processing in reading of LaBerge and Samuels (1974), skilled reading involves several stages of information processing. The reader can selectively attend to any subprocess but only at the expense of some other component, or at the expense of overall performance if the capacity of

attention is exceeded. The same cognitive processes underlie coding and comprehension. Unless coding is automatic, phonological decoding involves more work for the less skilled reader. Slow, inaccurate, or incomplete decoding will demand attention to the structure of the words, the visual aspect of the array, and will detract from comprehension. Also, if it takes too long to read a given word, or if word attack is initiated too frequently, rapid temporal decay in primary memory may result in the preceding words being forgotten before a phrase or sentence is completed, and ideas recently gathered by the reader may also be forgotten (Beck, 1977; Gough, 1972; LaBerge & Samuels, 1974; Perfetti & Lesgold, 1979). Thus, working memory may operate as a potential "bottleneck" in reading comprehension (Perfetti & Lesgold, 1979). Additionally, the poor comprehender who appears to have intact word recognition skills may, in fact, be a "laborious decoder" (Adams, 1980), and therefore, "observed deficiencies in reading comprehension are partly due to unobserved deficiencies in the extent to which decoding uses an excessive share of the resources" (Perfetti & Lesgold, 1979, p. 60).

In an attempt to provide empirical support for the relationship between decoding and comprehension conceptualized by Perfetti and Lesgold (1979), Fleisher, Jenkins and Pany (1979) trained poor readers in decoding of single words and phrases. They found that the training significantly increased the decoding speed of single words. However, comprehension performance was not improved. It is interesting to note

that after the single word training, the poor readers increased in reading speed and decreased on errors of single word decoding to approximately the level of the good readers, but the good readers read significantly more words per minute in context. Fleisher et al. took this to mean that good readers take more advantage of syntactic and semantic information inherent in context than less skilled readers. Fleisher et al. concluded that the results of their experiments challenge the decoding-sufficiency or bottleneck hypothesis of Perfetti and Lesgold (1979), as training succeeded in increasing the single word decoding speed of poor readers to a level comparable to that of good readers, while comprehension scores remained unaffected. However, Blanchard and McNinch (1980) question whether the Fleisher et al. experiments are, in fact, a test of the decoding-sufficiency hypothesis. They present criticisms of the methodology used in the first experiment, and state that "the findings are limited to an interpretation that there exists a rate transfer effect between single-word decoding training and contextual reading rate" (p. 563). Furthermore, they claim that "the second experiment did not test the decoding-sufficiency hypothesis because it failed to establish a rate transfer effect to contextual reading rate and, hence, to comprehension performance" (p. 563).

Research reviewed to this point strongly supports a correlational relationship, which is possibly causal (Stanovich, 1982a), between fast and accurate word recognition and comprehension. Furthermore,

there is increasing evidence in the literature that younger and poorer readers may rely on the use of contextual information to facilitate word recognition and to compensate for deficiencies at the word recognition level (Allington & Fleming, 1978; Biemiller, 1970, 1977-78, 1979; Guttentag & Haith, 1978; Juel, 1980; Kolers, 1975; Perfetti, Goldman & Hogaboam, 1979; Perfetti & Roth, 1981; Schvaneveldt, Ackerman & Semlear, 1977; Schwantes, 1981, 1982; Schwartz & Stanovich, 1981; Simpson & Lorsbach, 1983; Stanovich, 1980, 1981, 1982b, in press; Stanovich & West, 1979; West & Stanovich, 1978). It appears that context may influence processing in a variety of ways, and that there is no single form of context effects (Levy, 1981).

There is evidence that context effects appear early. Guttentag and Haith (1978) found that third grade poor decoders and normal children with only nine months of reading instruction were able to extract meaning from familiar printed words automatically. In a longitudinal study of grade one subjects' oral reading errors, Biemiller (1970) found stages of development when errors were analyzed in terms of contextual and graphic constraints. The first was characterized by a predominant use of contextual information. He suggests that this early stage represents an attempt to avoid using graphic information. In the second stage the proportion of non-responses and graphically constrained errors increased markedly and the third stage is one in which the oral reading errors are both

contextually and graphically constrained. A large proportion of the errors of even the least fluent readers were contextually appropriate. Weber (1970) found that approximately 90 percent of the oral reading errors of grade one students were grammatically acceptable and that the percentage of grammatically acceptable errors produced did not distinguish between good and poor readers.

Other studies of oral reading errors indicate context effects displayed by poor readers. Allington and Fleming (1978) found that the poor readers approximated the good readers in the use of context. The grade four poor readers in their study took almost twice as long as the good readers, although accuracy did not differ between the two groups. Kolers (1975) used geometrically transformed text to analyze the oral reading errors of his grade seven good and poor readers. He found a similar pattern of substitution errors for good and poor readers, and his results further may suggest that older poor readers may overrely on top-down processing to avoid decoding (Adams, 1980). Juel (1980) studied word identification strategies of grade two and three children with varying context, word type and readers skill. She concluded that as readers become more skilled they read in a predominantly text-driven fashion, stating that "it may be more efficient for good readers, with well developed decoding skills, to directly identify words in a text-driven manner than to 'predict' words based on context" (p. 375). The most able readers in Biemiller's (1979) study made proportionately more non-responses and

graphic substitution errors as passages increased in difficulty, indicating that able readers do not make less use of graphic information than less able readers.

Perfetti and Roth (1981) also suggest that skilled readers may be "not less sensitive to context but less dependent upon it" while the slower data-based processes of the less skilled readers make them more context dependent (p. 277). In support of their view they cite results of the Perfetti, Goldman and Hogaboam (1979) study in which discourse context reduced identification latencies for the less skilled as well as the skilled readers, but only the less skilled readers' identification latencies were affected by word length and word frequency when the word appeared in context. Perfetti and Roth then investigated what happens when conceptually derived data fail to be useful. Expectations that skilled readers would be as capable in identifying words in "semantically surprising contexts" as in contexts of low predictability, that is, at a rate set by the data-based identification process, were confirmed. Also confirmed was the expectation that less skilled readers would perform more slowly because slow identification processes would allow the contextual processes to activate.

West and Stanovich (1978) found similar results when subjects of three different age groups (grade four, grade six and adults) named a target word that was preceded by either a congruous, incongruous or no-sentence context. Congruous contexts were found to facilitate the

reading times of all three groups, but only the adults were unaffected
by the anomalous contexts. These results are also consistent with
those found by Biemiller (1977-78) and Schvaneveldt et al. (1977).
Biemiller found that all children and adults read words in context
faster than words out of context, and no differences in the effects of
context were observed as a function of age or achievement level.
Younger and less able children took longer to read letters, words out
of context, and text, than did older or abler children and adults.
Thus contextual structure facilitated identification speed, although
Biemiller found no evidence for the development of the use of
contextual structure from second grade on.

It is interesting to note that the good readers made more errors

Not all studies provide support for contextual facilitation of
word identification by poor readers. Steiner, Weiner and Cromer
(1971) attempted to investigate the relationship of comprehension
training (providing contextual information) to identification
("saying" words). Fifth grade poor readers showed no improvement in
identification after being given contextual information. They also
failed to utilize contextual and syntactic cues in the material.
Steiner et al. describe the poor readers as seeming to treat words as
unrelated items in a list.

It is interesting to note that the good readers made more errors
with comprehension training, and on the paragraph mode of
presentation. Apparently the training interfered with, rather than
aided, the reading process for these good readers. Steiner et al.

note that the errors were all "good" or anticipation errors, most of which were spontaneously corrected.

There does appear to be, however, sufficient evidence from oral reading studies (Biemiller, 1970), single word semantic context on lexical-decision time (Schvaneveldt et al., 1977), full sentence contexts (Perfetti et al., 1979; West & Stanovich, 1978), and from target words embedded in a meaningful story context (Schwantes, 1981, 1982; Schwartz & Stanovich, 1981) to indicate that younger and poor readers can and do use context to facilitate word recognition and to compensate for deficiencies at the word recognition level (Kolers, 1975; Perfetti & Roth, 1981; Stanovich, 1982b). Furthermore, the research suggests that these context facilitation effects may be automatic or attentional (Posner & Snyder, 1975; Stanovich & West, 1979), that the automatic activation process is evident at an early stage (Guttentag & Haith, 1978; Golinkoff & Rosinski, 1976), and that the conscious allocation of attention increases with age (Simpson & Lorsbach, 1983). There is strong evidence to suggest that as readers increase in the ability to use graphic data, they rely less on context (Juel, 1980; Perfetti & Roth, 1981; West & Stanovich, 1978).

Because reading remains one of the main sources of acquiring information in our society, and especially in the schools (Olson, 1977), it is essential that we investigate the existence of various types of readers so that we can optimize their learning. If different types of readers do exist, it is further incumbent upon us to separate

these groups for appropriate instruction. Additionally, for those students experiencing reading difficulties, it is crucial that we have an accurate understanding of the nature of the reading difficulty in order to provide suitable instructional strategies in the schools.

Recently, several researchers have attempted to address the issue of types of disabled readers. Cromer (1970), was the first to address empirically the issue of separating homogeneous groups of poor readers. Based on the theoretical model devised by Wiener and Cromer (1967), he attempted to single out two kinds of poor readers, a "deficit" reader group, which lacked vocabulary skills and therefore did poorly on comprehension, and a "difference" reader group which did poorly on comprehension despite adequate vocabulary skills. Both groups of poor readers were matched with good reader control groups. Cromer's deficit readers had both poorer vocabulary and comprehension than the good readers; the difference readers' vocabulary skills were similar to their good reader controls and it was assumed that their comprehension problems stemmed from word-by-word reading or sentence organization difficulties. Tasks involving reading stories and answering multiple choice questions were presented to subjects under four conditions: regular sentences, meaningful phrases, fragmented phrases and single words. Cromer predicted that the difference group would perform like good readers in terms of comprehension under the phrase condition, while performing as they usually did on the single word mode of presentation, which was assumed to parallel their typical

pattern of responding, that is, word-by-word reading. Phrase mode presentation was not expected to facilitate comprehension for deficit or good readers, while single word presentation was expected to adversely affect comprehension of deficit and good readers because it was thought to discourage meaningful organization. All subjects were proficient at word identification.

The difference group did perform as well as the good readers under the meaningful phrases condition. The deficit readers' comprehension was poor under all conditions; they performed best on the single word mode but worse than any group under any condition. The deficit group also took the most time to answer the least number of questions correctly, while the other three groups could not be distinguished from each other in terms of the rate with which they read stories and answered questions. The deficit group also took longer to identify words although there were no differences in accuracy between the deficit and difference readers. Overall, poor readers made more oral reading errors than did good readers. Since mastery of decoding skills requires both speed and accuracy, the time scores are relevant in assessing the deficit group's performance. The good readers matched to the deficit readers scored best overall, unsurprisingly.

However, Cromer's findings appeared to be limited by methodological problems. Calfee (1976), Kendall and Hood (1979) and Kleiman (1982) have raised serious questions about the method Cromer

used to categorize his poor readers and match them to difference and deficit good comprehender control groups. As reading and vocabulary measures are highly correlated, selecting subjects who are high in one and low in the other (Cromer's difference poor readers) may result in a high error of measurement (Kleiman, 1982, p. 31). Indeed, in the regular sentence condition, six of the 16 difference poor readers had higher comprehension scores than their matched controls. Cromer reassigned these subjects and reanalyzed the data. As Calfee (1976) notes, "The Deficit and Deficit-controls are poor and good readers, respectively. The Difference and Difference-controls are two groups of moderately poor readers, not different from one another." (p. 32).

Results of further studies by Cromer and his associates (Oaken, Wiener & Cromer, 1971; Steiner, Wiener & Cromer, 1971) and by others (Guthrie, 1973b; Kendall & Hood, 1979; and Levin, 1973) suggest some support for the Wiener and Cromer (1967) model, and do indicate that there may well be two types of disabled readers, and that there appears to be more involved in comprehending text than the existence of adequate word recognition skills. Some factors leading to poor comprehension skills may be an inability to use syntactic and semantic cues to gain meaning from text, or a lack of appropriate strategies in terms of planfulness, purpose, and monitoring of meaning gained (Baker, 1982; Garner & Reis, 1981; Golinkoff, 1975-76; Markman, 1977; Sullivan, 1978; Torgeson, 1982; Wong, in press); an inadequate understanding of the goal of reading; an inability to recognize main

ideas or the importance of thematic units (Brown & Smiley, 1977; Eamon, 1978-79; Smiley, Oakley, Worthen, Campione & Brown, 1977); or a "production deficiency" in terms of using strategies that are within an individual's repertoire (Flavel, 1971).

It seems apparent from the aforementioned studies as well as studies by Garner (1980), Meyer, Brandt and Bluth (1980), and Palincsar (1982), that poor comprehenders possessing adequate word recognition skills are to be found. Further empirical research on "difference" readers is obviously warranted.

The first step in investigating comprehension performance must be to determine if various types of readers exist. Given that the vast majority of research has concerned itself with young or, to a lesser extent, adult populations, it would be important to the educational system to focus on the adolescent age group.

Typically, poor readers are given group or individual reading tests, and their performance is noted in terms of years below grade level. Older poor readers are generally exposed to similar remedial material as younger poor readers on the assumption that such material may help them to acquire more efficient processing strategies. In British Columbia, it was first thought that setting up Learning Assistance Centres in the elementary schools would solve the problems of the older poor reader; that early identification and remediation of young poor readers would prevent development of more intransigent forms of reading disability. Such an assumption has not been borne

out. It has since been found necessary to set up similar centres in the secondary schools.

In addition to "good", "difference" and "deficit" reader types, this researcher believes that there may be a further subgroup of readers, namely "compensators". "Compensator" refers to those students whose ability to comprehend text is not commensurate with measures of their decoding skill, in so far as they comprehend at a much greater level than may usually be expected. These readers may overrely on top-down processing (Kolers, 1975), and by making sufficient use of contextual cues and "scan for meaning" (Golinkoff, 1975-76) strategies, commensurate for poor or non-automatic decoding of single words (Schvaneveldt et al., 1977; Stanovich, 1980, in press; West & Stanovich, 1978).

<u>Statement of the Problem</u>

The present study, then, attempted to differentiate four groups of readers into specific categories: "Good" readers: readers having adequate word recognition and comprehension skills; "Difference" readers: readers having adequate word recognition skills, but not comprehension skills, "Deficit" readers: readers having inadequate word recognition and comprehension skills; and "Compensator" readers: readers having adequate comprehension, but poor word recognition skills. To avoid problems of categorization of readers based on comparative measures (c.f. Cromer, 1970), readers were grouped "a

priori" on a predefined raw score level of performance on the word recognition and comprehension tests administered.

Description of the Reader Groups

Because categorization of reader groups was conceptualized "a priori", the groups are described below as well as in the Method section.

Good Readers:

These readers are able to use bottom-up and top-down processing simultaneously at all levels of analysis. Because word recognition processes are automatic (LaBerge & Samuels, 1974: Perfetti & Lesgold, 1979), attention can be directed entirely at constructing meaning (Adams, 1980; Brown, 1980; Doctorow, Wittrock & Marks, 1978).

Difference Readers:

These readers appear to have the word recognition and vocabulary skills necessary to comprehend, but have poor comprehension. They may lack contextual utilization or text organization skills necessary to process meaning at deeper levels of analysis (Condon & Hoffman, 1979; Cromer, 1970; Juel, 1980: Steiner et al., 1971). They appear to be unable to gain meaning from text, are insensitive to idea importance (Smiley et al., 1977) and consequently are less able to comprehend inferential material.

Difference readers may also be laborious decoders, slow but accurate (Adams, 1980; Perfetti & Lesgold, 1979), and the burden slow decoding places on short term memory may prevent the deeper processing necessary for comprehending at an inferential level (c.f. "bottleneck" hypothesis of Perfetti & Lesgold, 1979).

Deficit Readers:

Because of slow and inaccurate decoding, these readers are "slaves to the printed word" (Golinkoff, 1975-76). Poor readers have been shown to take longer to name a printed word than more skilled readers (Perfetti & Hogaboam, 1975). Phonetic or visual features demand most of the readers' attention due to lack of facile verbal coding. These readers will typically be reliant on bottom-up processing, and comprehension and recall will decrease as a result.

Compensator Readers:

These readers appear to have adequate comprehension skills despite poor word recognition skills. These readers may over-rely on top-down processing in an attempt to gain meaning and to avoid decoding (Schvaneveldt et al., 1977; Stanovich, 1980, in press; West & Stanovich, 1978). As processing demands increase with inferential questions, the ability of the Compensator reader may break down.

Hypotheses

The following predictions were made:

Hypothesis 1. In performance on both total factual and total inferential questions, the predicted order of performance is: Good readers better than Compensator readers, Compensator readers better than Deficit readers.

Hypothesis 2. The Compensator reader group will perform better than the Deficit reader group on each set of factual questions but not on any set of inferential questions.

Hypothesis 3. The Good reader group will perform better than the Deficit reader group on each set of factual and inferential questions.

Hypothesis 4. The Good reader group will perform better than the Compensator reader group on each set of inferential questions but not on any set of factual questions.

Hypothesis 5. (a) The Compensator reader group will perform better on the total sets of factual questions than on the total sets of inferential questions; (b) The Compensator reader group will perform better on each set of factual questions than on each set of inferential questions.

Hypothesis 6. The Good reader will perform better than both the Deficit and Compensator reader groups on oral reading passages, and the Deficit and Compensator reader groups will not differ from each other.

If these predictions were substantiated, then instructional programs should incorporate strategies and materials appropriate to the type of adolescent disabled reader. Additionally, the study should contribute to current interactive theory in light of the recognition presently being given to interactive models of reading (Adams, 1980; Lesgold & Perfetti, 1978, 1981; Perfetti & Roth, 1981; Rummelhart, 1977; Stanovich, 1980; Wildman & Kling, 1978-79), and the differentiation of types of poor readers (Cromer, 1970; Kendall & Hood, 1979; Levin, 1973; Palincsar, 1982).

CHAPTER II

Method

Subjects

All subjects were drawn from the grade eight population in three secondary schools located in similar socio-economic areas in the school district of Langley, British Columbia, Canada. Selection criteria, general and specific, were as follows:

General Selection Criteria

It was initially requested that students from both grades eight and nine be allowed to participate in the study. However, the school board would permit only one grade to be used; grade eight was selected.

Age. All subjects were between the ages of 13 years, 3 months and 15 years, 1 month (Mean Age: 14 years, 0 months, S.D.: 5 months). The reasons for selecting this age range include: (1) Excepting those for whom basic decoding skills pose a problem, most students have mastered these skills by this age; (2) differential mastery of context to facilitate word recognition and comprehension is established by this age; (3) average or below average reading ability should be more discernable at this age range than at an earlier age.

Intelligence. To insure that the adolescents participating in the study were all of adequate intelligence, Standard Age Scores of the Verbal and Nonverbal Batteries of the Canadian Cognitive Abilities Test (CCAT; Thorndike, Hagen & Wright, 1971, 1974, 1977, Form 1, Level F, Grades 8 - 9) were used to obtain an I.Q. score. Students who scored between 90 and 120 on a composite score of the Verbal and Nonverbal Batteries were then included as potential subjects for the study. The available CCAT scores were used because the school board involved in the study discouraged lengthy intelligence testing as entailed by the Wechsler Intelligence Scale for Children Revised (WISC-R, 1974), and the CCAT had recently been administered to all grade eight students in the district. Test scores were at most six months old at the commencement of data-gathering. Because of the verbal nature of the test items on the Verbal Battery, and because each testee has to read the instructions as it is a group-administered test, it was expected that disabled readers as a group would score lower than the good readers of similar intelligence. Thus the Verbal and Nonverbal Battery scores were averaged. The mean score for the pool of 110 potential subjects was 102.54 (S.D. 7.48). Table 1 presents respective means and standard deviations of Good, Deficit and Compensator readers.

Monolingual background. As a control for the possible effects of bilingualism on reading, students whose school records indicated that

Table 1

Mean Performance of Good, Deficit, and Compensator Reader Groups

on the Canadian Cognitive Abilities Test Scores (CCAT)

and the Woodcock Reading Mastery Tests

Canadian Cognitive Abilities Test (CCAT)

Group	n	Range	Mean	S.D.
Good	34	91-119	106.74	8.24
Deficit	14	92-105	98.29	4.60
Compensator	24	92-116	102.13	5.45

Woodcock Reading Mastery Tests (WRMT)

Group	n	Range	Mean	S.D.
		Word Identification		
Good	34	135-148	138.94	3.27
Deficit	14	89-130	119.86	12.00
Compensator	24	110-130	123.38	5.75
		Passage Comprehension		
Good	34	65-80	70.82	4.37
Deficit	14	53-60	57.29	5.58
Compensator	24	65-73	68.25	2.71

a second language was spoken at home were excluded from the study.

Emotional adjustment. Students known from clinical records to be emotionally disturbed were excluded from the study.

Sensory and physical problems. Students whose school records showed them to be in poor physical health or to have uncorrected sensory impairments were excluded from the study.

Specific Selection Criteria and Reader Group Formation

In accordance with the conceptual and theoretical reasons detailed in the Introduction and Review of the Literature, groups were categorized on achievement differences in word recognition and comprehension, as measured by the Word Identification and Passage Comprehension subtests of the Woodcock Reading Mastery Tests (WRMT, Woodcock, 1973). Raw scores used in the categorization of reader groups are presented in Table 2.

Empirically, four groups were formed based on their performance on the Word Identification and Passage Comprehension subtests of the WRMT. Thirty-four subjects could not be categorized as Good, Difference, Deficit or Compensator readers. Because only four subjects out of a sample population of 110 fit the difference model of reader difficulty, this group was subsequently dropped from the study. Table 3 shows the distribution of subjects into groups.

Table 2

Raw Scores Used in Categorization of Reader Groups
Woodcock Reading Mastery Tests (WRMT)

Group	Raw Score
Word Identification	
Good	135 or more
Difference	135 or more
Deficit	132 or less
Compensator	132 or less
Passage Comprehension	
Good	65 or more
Difference	62 or less
Deficit	62 or less
Compensator	65 or more

Note. A raw score of 135 on the Word Identification subtest of the WRMT corresponds to a grade score of 8.8; a raw score of 132 corresponds to a grade score of 7.8. The raw scores of 65 and 62 correspond to grade scores of 8.8 and 7.8 respectively, on the Passage

Table 3

Reader Groups

Group	n[a]	Males	Females
Good	34	17	17
Difference	4		
Deficit	14	11	3
Compensator	24	16	8

[a]n = 76

Distribution of scores as measured by the CCAT and the WRMT are presented in Table 1.

A one-way analysis of variance and multiple range test using Newman-Keuls procedure was run to ensure the veracity of the categorization procedures. On the word recognition variable, Good readers differed significantly from both Deficit and Compensator readers, as expected. On the variable of passage comprehension all three groups differed significantly from each other. However, it is noted that the difference between the means of the Good readers (70.82) and the Compensator readers (68.25) just reached significance at the 0.05 level. The critical difference for comparing the means was 2.55 and the difference between the means was 2.57.

Instruments

Canadian Cognitive Abilities Test (CCAT) (Thorndike, Hagen and Wright, 1971, 1974). The CCAT multi-level edition for use with grades three to nine was developed from the Lorge-Thorndike Intelligence Test series, which were modified and standardized in Canada as the Canadian Lorge-Thorndike Intelligence Tests. The present CCAT contains ten subtests assembled into three separate batteries: Verbal, Quantitative and Nonverbal, each intended to be homogeneous in the function that is measured. Each battery is group-administered. Raw scores are first converted to Universal Scale Scores, which are normalized standard scores. These scores may then be converted to Standard Age Scores (SAS), which allow for comparison of an individual's performance with those of others in his/her chronological age group. The SAS is a normalized score scale (Thorndike, Hagen and Wright, 1974, p. 45) in which the average score for each age group on each test battery is set at 100 and the standard deviation is set at 16.

No reliability and validity statistics have been published for the CCAT. The test-makers refer the user to the Cognitive Abilities Test (CAT, Thorndike and Hagen, 1974) for information on reliability and validity. For Level F (grades 8 and 9) Kuder-Richardson Formula #20, reliability estimates are .95 for the Verbal Battery, and .93 for the Nonverbal Battery. The average standard errors of measurement in SAS Units as a function of raw score level are reported as 3.6 for a

score of 15, 4.6 for a score of 85 on the Verbal Battery, and as 4.2

for a score of 25 and 7.0 for a score of 75 on the Nonverbal Battery.

In addition to content validity descriptions, criterion-related

and construct validity are reported. Concurrent correlations of CAT

subtests with Iowa Tests of Basic Skills (ITBS), grades 3 to 8, or

Tests of Academic Progress (TAP), grades 9 to 12, are high. The

predictive validity coefficients for midyear CAT subtests with

end-of-year teachers' marks show correlations ranging from .50 to .65.

Correlations of the CAT with the Stanford-Binet Intelligence Scale are

reported as .77 (S.D. 19.2) for the 12 to 14 age group on the Verbal

Battery, and as .68 (S.D. 18.5) for this age group on the Nonverbal

Battery.

Woodcock Reading Mastery Tests (WRMT) (Woodcock, 1973). The WRMT

comprise a battery of five individually administered reading tests,

for use with Kindergarten through Grade 12. The five tests include:

Letter Identification, Word Identification, Word Attack, Word

Comprehension, and Passage Comprehension. A total reading score can

be obtained by combining performances on the five separate tests.

Derived scores in these six areas include scores at each of four

levels: easy reading (96% mastery), reading grade score (90%

mastery), failure reading level (75% mastery), and relative mastery

grade level. The tests are handscored; two parallel forms are

available, and total testing time is quoted as 20 to 30 minutes. The

WRMT have as one of their objectives precision of skill measurement in each test area.

The Word Identification Test consists of 150 single words in isolation. These words cover a range of difficulty (e.g., "go" to "facetious"), and items include irregularly pronounced words as well as those which may be correctly pronounced through applications of pronunciation generalizations. As is the case with each of the subtests, a basal and ceiling format is utilized, and reduction and extension of the basal-ceiling rule criterion (3 or 8 passes/failures instead of 5) is included to provide for shorter administration time or greater precision. Time and standard error of measurement increase or decrease is reported. Split-half reliabilities for the Word Identification test for grade 7.9 for a mean score of 132.2 and a S.D. of 11.8 are reported as $r = .97$, with a standard error of measurement of 2.0. Test-Retest Alternate-Form reliabilities for the Word Identification test are reported as .93 for grade 7.9.

The Passage Comprehension Test consists of 85 items which the subject reads silently. Passages begin at first grade level and extend to college level. This subtest uses a modified cloze procedure, that is, key words or nonspecified words are deleted, and the reader must supply the missing word. Split-half reliabilities for the passage comprehension test for grade 7.9 for a mean score of 63.5 and a S.D. of 10.3 are reported as $r = .93$, with a standard error of measurement of 2.7. Test-Retest Alternate Form reliabilities for this

test are reported as .78 for grade 7.9.

Validity of the WRMT is discussed in the Manual in terms of content validity, predictive validity, a multitrait-multimethod matrix analysis, and intercorrelation data. The multitrait-multimethod matrix gives validity coefficients of .93 for Word Identification and .78 for Passage Comprehension. However, alternate forms of the test were used rather than different methods. The predictive validity study outlined in the Manual also may indicate alternate form reliability rather than validity because the prediction of scores on one form is made from performance on the other. That is, no external criteria were used.

Gray Oral Reading Tests (Gray, 1963, 1967). The Gray Oral Reading Tests consist of 13 passages of increasing difficulty designed to objectively measure growth in oral reading from early first grade to college, and to aid in the diagnosis of oral reading difficulties. Four forms of the test are available. The test is administered individually; time taken to orally read each passage, and total number and types of errors are recorded. A passage score (0 - 9) is derived from the number of errors and the reading time. These passage scores are added to obtain a total passage score. Grade equivalent (G.E.) norms and standard errors of measurement are provided in the Manual for each form and separately for boys and girls. Average standard errors of measurement for total passage scores for boys and girls on

Forms A and B range from .42 for a passage score of 0, G.E. 1.1, to 1.70 for a passage score of 72, G.E. 12.0 for boys on Form B.

The difficulty of each passage in the Gray Oral Reading Tests was increased by means of vocabulary, range and density of the vocabulary (percentage of different words among the total number of running words), syllabic length of words, length and complexity of the structure of the sentences and the material of the concepts (Gray Oral Reading Test Manual, 1963, 1967, p. 3). The Spache (1953) formula was used to analyze the readability of passages one to five and the Dale-Chall (Dale & Chall, 1948) formula was used to analyze the readability of passages six to thirteen. The average subject is expected to read at least five or more passages to allow for adequate sampling. The Gray Oral Reading Tests are not designed to measure comprehension, although four comprehension questions calling for literal meaning are included for each passage. Total number of errors and time taken to read each passage determine the grade equivalent score obtained. Types of errors to be recorded are listed as: Aid, gross mispronunciation, partial mispronunciation, omission of a word or group of words, insertion of a word or group of words, substitution of one meaningful word or several for others, repetition of one or more word(s), inverting or changing word order (c.f. Gray, 1963, 1967, pp. 5-6).

Coefficients of intercorrelations among grade scores on each of the four forms of the Gray Oral Reading Tests at each grade level of

the standardization sample range from .973 to .982. The standard error of measurement is used as a second estimate of the reliability of the Gray Oral Reading Tests. The Manual states that a standard error of measurement "of less than 4.00 points may be expected in the total passage score for any pupil 68 per cent of the time" (Gray Oral Reading Tests Manual, 1963, 1967, p. 30). The test-maker bases validity claims on the procedures used in test construction. Details of test construction are described in the Manual on pages 25 to 29.

Procedure

Selection procedure. Parental consent was obtained for all subjects meeting the general criteria. A total of 110 subjects was then categorized as Good, Difference, Deficit or Compensator reader on the specific criteria described earlier.

The Word Identification of the Woodcock Reading Mastery Tests (WRMT) was administered individually in a private room. The Passage Comprehension subtest of the WRMT was administered to groups of 15 subjects at one time. There were two reasons for this administration procedure: (1) Tuinman, Kinzer and Muhtadi (1980) studied the feasibility of administering the Passage Comprehension test as a written rather than as an oral test to grade eight students. They found nearly identical results between a group administered the test orally and the written-test group. The product-moment correlation between the oral and written scores was .82, with a reliability of

approximately .80, and a standard error of measurement of four.
(2) Total WRMT administration time is suggested as being 20 to 30
minutes. The amount of time allowed in testing is unrealistic for
poor readers, in that they have insufficient time to respond, and that
"the poorer a decoder a subject is, relative to the norming group, the
more the test becomes a measure of word attack rather than
comprehension skills" (Tuinman, 1978, p. 1307). The Passage
Comprehension test administration in written form took approximately
25 minutes, compared to 13 minutes for oral administration. The
written tests were scored as if they were oral tests. That is, a
basal level was established in terms of the first five consecutive
correct answers, and a ceiling level was established in terms of five
consecutive incorrect answers. This scoring method was used to make
scores on the written form comparable to those on the oral form.

All tests were administered by the investigator or one of two
research assistants. All tests were scored by the investigator. All
testing took place during May and June of 1979. Categorization into
reader groups on specific criteria has already been described.

Only two passages of the Gray Oral Reading Tests were
administered individually to all subjects in the study at the same
time that the Word Identification subtest of the WRMT was
administered. These were passage number seven of both Forms A and B.
This passage is reported to be at a grade 5 reading level. The
purpose of administering the two forms of this passage was to compare

the reader groups on a post hoc basis on time in oral reading and total error scores (words correctly read per minute). These data are included in the analysis and are presented and discussed in Chapters III and IV of the thesis.

Stimuli. Four expository passages from Wong & Winne's (1981) study were used. The passages shared a common theme and were entitled respectively Ecology, Energy in the Ecosystem, The Flow of Energy in the Ecosystem and Matter in the Ecosystem. The shortest passage was 857 words in length and the longest passage was 1445 words in length. The average passage length was 1153.65 words. The passages were at approximately a grade 5 level of difficulty (Fry Readability Formula, Fry, 1968). Each passage was typed, double-spaced, on single sheets of 8 1/2 x 11 inch paper. Each passage was followed by 12 questions, 6 factual and 6 inferential, on separate sheets of paper. Three independent raters judged the questions to be either factual or inferential. In order to ensure complete inter-rater reliability, two questions were subsequently dropped from each passage. Thus each passage was then followed by 10 questions, 5 factual and 5 inferential questions. These questions served as the dependent variables.

Procedure. All subjects were administered passages one, two, three and four in groups of 15 in a self-contained classroom by the investigator or one of two research assistants on consecutive

occasions.   Subjects were told the purpose of the study, namely to find out more about how people read so that instruction and materials could be improved.   They were reminded that scores obtained would have no bearing on grades or promotion.   They were asked to do the best they could.   Each group was then given the following instructions:

> I want you to read this passage silently and to answer·
> the questions that follow it.   The question sheet looks
> like this (show question sheet).   Read the story to
> understand it as best you can so that you can answer
> the questions about it.   You may take as long as you
> need and you may look back to the story in order to
> answer a question.   You may ask me for help on a
> difficult or unknown word.   When you have finished,
> give the passage and your question sheet to me and
> return to your class.   Are there any questions?   Okay,
> start when you are ready.

CHAPTER III

Results

It is recalled that one of the selection criteria for all subjects was a CCAT score of between 90 and 120. To test for possible differences among the Good, Deficit and Compensator groups on this intelligence measure, a one-way analysis of variance (ANOVA) was performed on the mean CCAT scores.

The results of the one-way ANOVA on CCAT mean scores indicated a significant difference between Good and Deficit reader groups [F (2.69) = 8.45, p< .0005). No reliable differences occurred between the means of the Good and Compensator groups, or between the means of the Compensator and Deficit reader groups. The respective means on the CCAT of Good, Deficit and Compensator readers were 106.74 (S.D. 8.24), 98.29 (S.D. 4.60) and 102.13 (S.D. 5.45). The finding of a significant difference on the CCAT means between Good and Deficit readers places a constraint on data interpretations of the performance differences between these two reader groups.

To examine hypothesis one, that the order in performance of the total factual and total inferential questions correctly answered will be Good better than Compensator, and Compensator better than Deficit readers, two one-way ANOVA's were carried out, one to analyze the Good, Deficit and Compensator reader groups' performances on the total factual questions (20) correctly answered, and one to analyze the

reader groups' performances on the total inferential questions (20) correctly answered. These results indicated reliable differences among the three groups for total factual questions and for total inferential questions correctly answered, [F's (2,69) = 8.35; 7.91, respectively, p < .001].

Post hoc multiple comparisons of the means using Newman-Keuls procedure (see Table 4) indicated significant differences between the Good and Deficit readers on both the total factual and total inferential question variables (p < .05). The Compensator reader group performed significantly better than the Deficit reader group on total factual questions, and no differently from them on total inferential questions, as expected. Furthermore, the Compensator readers did not differ in performance from the Good readers on total factual questions. However, there were no differences between Compensator and Good reader performances on total inferential questions. The mean difference between the Good and Compensator reader groups on the variable of total inferential questions (1.76) was close to reaching significance (critical difference = 1.80). Hence hypothesis one was partially supported.

Before hypotheses two, three and four could be specifically examined, it was necessary to carry out a one-way multivariate analysis of variance (MANOVA) and follow-up univariate analyses of variance of the performances on the eight sets of questions (four sets of factual and four sets of inferential questions). The results of

Table 4

Comparison of Reader Group Means on Performance of Total Factual
and Inferential Question Sets Using Newman-Keuls Procedure

Variable	Group	Mean	Critical Difference	p
Factual Questions	Good	15.59	2.07	*
	Deficit	11.79		
	Good	15.59	2.07	
	Compensator	14.54		
	Compensator	14.54	2.07	*
	Deficit	11.79		
Inferential Questions	Good	14.09	1.80	*
	Deficit	11.07		
	Good	14.09	1.80	
	Compensator	12.33		
	Compensator	12.33	1.80	
	Deficit	11.07		

*$p < .05$

the MANOVA indicated reliable differences among the three groups on the eight sets of questions, $F(16,123) = 2.42$, $p < .01$. To locate the exact source of variance, results from the univariate analyses of variance were examined. The results showed that reliable differences occurred among the three groups for each of the four sets of factual questions and for sets one and two of the inferential questions, F's $(2,69) = 5.77$; 4.17; 4.75; 3.05; 3.65; and 7.58, respectively, $p < .05$.

To examine hypothesis two, that the Compensator reader group will perform better than the Deficit reader group on each set of factual questions, but not on any set of inferential questions, Newman-Keuls post hoc multiple comparisons of the means of the Compensator and Deficit reader groups were used (see Table 5). The post hoc multiple comparisons of means indicated that the Compensators performed significantly better than the Deficit group on factual questions sets one and three only. As expected, there were no differences between Compensator and Deficit readers' performances on inferential questions sets. Partial support for hypothesis two was thus obtained.

Hypothesis three, that the Good reader group will perform better than the Deficit reader group on each set of factual and inferential questions, was mainly supported. Post hoc multiple comparisons of the means of the Good and Deficit reader groups indicated that significant differences in performance between Good and Deficit readers occurred on all four sets of factual questions and on the first two sets of

Table 5

Multiple Comparisons of Group Means for Factual and Inferential
Question Sets using Newman-Keuls Procedure

	Variable	Mean	Mean	Critical Difference	
Groups					
		Good	Deficit		
Factual Questions	Set 1	4.03	3.14	0.62	*
	Set 2	4.12	3.14	0.80	*
	Set 3	3.91	2.86	0.77	*
	Set 4	3.53	2.64	0.80	*
		Compensator	Deficit		
	Set 1	4.04	3.14	0.62	*
	Set 2	3.54	3.14	0.80	
	Set 3	3.71	2.86	0.77	●
	Set 4	3.25	2.64	0.80	
		Good	Compensator		
	Set 1	4.03	4.04	0.62	
	Set 2	4.12	3.54	0.80	
	Set 3	3.91	3.71	0.77	
	Set 4	3.53	3.25	0.80	

*$p < .05$

Table 5 (Continued)

	Variable	Mean	Mean	Critical Difference	
		Good	Deficit		
	Set 1	4.24	3.29	0.79	*
	Set 2	3.94	2.79	0.69	*
Inferential	Set 3	2.76	2.71	0.75	
Questions	Set 4	3.15	2.29	0.86	
		Compensator	Deficit		
	Set 1	3.88	3.29	0.79	
	Set 2	3.33	2.79	0.69	
	Set 3	2.38	2.71	0.75	
	Set 4	2.75	2.29	0.86	
		Good	Compensator		
	Set 1	4.24	3.88	0.79	
	Set 2	3.94	3.33	0.69	
	Set 3	2.76	2.38	0.75	
	Set 4	3.15	2.75	0.86	

*$p < .05$

inferential questions.

Hypothesis four, that the Good reader group will perform significantly better than the Compensator reader group on each set of inferential questions, but not on any set of factual questions, was partially substantiated. Post hoc comparisons showed that there were no significant differences between Good and Compensator readers on any set of questions, factual or inferential.

Taken as a group, hypotheses two, three and four suggest that the Compensator reader group's performance appears to parallel that of the Good readers. However, analyses of factual sets of questions reveal that a superior performance by Compensator readers in comparison to Deficit readers occurred on sets one and three only, whereas the Good readers performed better than the Deficit readers on all four sets of factual questions. Furthermore, the Compensator group's performance did not differ from Good readers or from Deficit reader group's performance on any of the sets of inferential questions. As expected, the worst performance was given by the Deficit readers.

To test the first part of hypothesis five, that the Compensator reader group will perform better on the total sets of factual questions than on the total sets of inferential questions, pairwise comparisons of the means of the total factual and total inferential questions correctly answered by the Compensator reader group was carried out, using one dependent t-test. This prediction was substantiated [t(23) = 3.85, $\underline{p}$ < .0005].

The second part of hypothesis five predicted that the Compensator reader group will perform better on each set of factual questions than on the corresponding set of inferential questions. To test this prediction, a repeated measures MANOVA was carried out, the score on the factual questions of each passage and the score on the inferential questions of each passage being the two dependent variables for each analysis. The results indicated that, overall, the Compensator reader group performed better on factual questions than on inferential questions, multivariate $F_{(4,20)} = 11.54$, $p < .0001$. The repeated measures ANOVA revealed that this group performed better specifically on factual question set three than on inferential question set three, $F_{(1,23)} = 27.77$, $p < .0000$. No reliable differences were observed for the other three sets of questions. The first part of hypothesis five, that the Compensator reader group would perform better on the total sets of factual questions than on the total sets of inferential questions was thus substantiated. However, only marginal support was found for the second part of hypothesis five, that Compensator readers would perform better on each set of factual questions than on each set of inferential questions.

To test hypothesis six, a univariate ANOVA and post hoc multiple comparisons of the means of the three reader groups on words correctly read per minute were performed (see Table 6). Results indicated reliable differences among the groups, $F(2,69) = 66.17$, $p < .0$. It is recalled that both the Deficit and Compensator reader groups possessed

Table 6

Means of Words Correctly Read Per Minute by
Good, Deficit and Compensator Readers

Group	n	Mean	S.D.
Good	34	163.38	29.21
Deficit	13[a]	114.69	41.00
Compensator	24	133.71	26.31

Note. Critical difference = 21.74

[a] One subject was lost from the sample for this variable.

poor word recognition skills as measured by the Word Identification subtest of the Woodcock Reading Mastery Tests (WRMT, Woodcock, 1973), and as compared to the Good readers. These post hoc analyses, then, were expected to differentiate the Good readers from both the Deficit and Compensator readers.

The multiple comparisons indicated a significant difference between the means of words correctly read per minute by Good and Deficit readers (mean difference: 48.69), and between the means of Good and Compensator readers (mean difference: 29.67). Thus the predicted differences between the groups on words correctly read per minute were substantiated.

To summarize the results, Good readers performed better than the Deficit readers on both factual and total inferential questions correctly answered; the Compensators performed better than the Deficit readers on total factual but not on total inferential questions correctly answered; there were no differences between Good and Compensator readers' performances on total factual or on total inferential questions correctly answered. The predicted order in performance of Good, Compensator and Deficit readers was thus partially substantiated.

Analyses of each set of factual and inferential questions indicated that the Compensator readers performed better than the Deficit readers on factual sets one and three, and there were no differences between them on any set of inferential questions.

Hypothesis two was thus partially substantiated. The Good readers performed better than the Deficit readers on all four sets of factual questions and on the first two sets of inferential questions, providing partial support for hypothesis three. Hypothesis four was also partially supported as there were no differences found between Good and Compensator reader groups' performances on any sets of questions, factual or inferential.

Within-group analyzes indicated support for hypothesis five, that the Compensator readers would perform better on the total sets of factual questions than on the total sets of inferential questions. Analyses of Compensator performance on each set of factual questions compared with each set of inferential questions was marginally supported. Finally, as predicted, correct words per minute on oral reading passages did reliably discriminate the Good readers from both the Deficit and Compensator readers.

CHAPTER IV

Discussion

The present study was designed to differentiate four types of adolescent readers: Good, Difference, Deficit and Compensator, on their performance on two dependent variables, factual and inferential comprehension questions. Because an insufficient number of the Difference readers could be categorized on "a priori" criteria, this group was subsequently dropped from the study.

The interpretation of the data revolves around the integration of three issues: top-down, bottom-up and interactive processing in reading performance; types of readers; and differential processing demands of factual and inferential questions. The hypotheses were based on the assumption that factual questions are more straightforward, demand less processing than inferential questions, and that answering inferential questions may require integrating information across sentences and paragraphs, thereby increasing processing demands on the reader. The mean of the total factual questions was therefore expected to be significantly greater than the mean of the total inferential questions. The results of one dependent t-test carried out on the means of the total factual and total inferential questions correctly answered by the entire sample ($n = 72$) indicated support for this assumption [$t (71) = 5.01$, $p < .000$].

Top-down processing, or utilization of conceptually-based

information, and bottom-up processing, or utilization of graphically-
based information, are both types of processing in which a fluent
reader is thought to engage. Because of fluent, facile verbal coding
and the ability to use syntactic and semantic cues, good readers are
able to extract meaning from text. Additionally, they are thought to
employ other general comprehension strategies such as monitoring and
debugging devices, as a result of which they are able to allot extra
processing to a problem area when it occurs. Good readers in this
study were therefore expected to perform well on both factual and
inferential questions. The result clearly indicated the overall
superior performance of the Good readers. Good readers, however, did
perform significantly better on the total sets of factual than on the
total sets of inferential questions [t (33) = 3.38, p < .001]. Two
possible explanations may be proferred to account for the difference
in the Good reader group's performance between factual and inferential
question sets: (1) Level of processing demanded by the inferential
questions may be sufficiently taxing even for Good readers; and
(2) passage difficulty on passages three and four may offer a second
avenue of explanation. It is recalled that there were no main effects
found on the inferential question sets of passages three and four.
This negative finding suggests that difficulty of the last two
question sets may have masked existent performance differences among
the Good, Deficit and Compensator reader groups.

Conversely, Deficit readers, largely as a result of a lack of

facile verbal coding skills, may be more reliant on bottom-up processing, and the amount of attention required to decode was expected to impair their performance at both levels of questioning. The results supported such a prediction in the Deficit readers performed equally poorly on factual and inferential questions.

The data clearly supported the differentiation of Good and Deficit readers in comprehension performance, except for sets three and four of inferential questions, where no main effects were found. The poorer performance of the Deficit readers is thought to reflect their undue reliance on bottom-up processing at the expense of top-down processing. Consequently, they do not process information sufficiently for good comprehension and recall to occur. According to the hypotheses of LaBerge and Samuels (1974), and Perfetti and Lesgold (1979), these readers direct attention primarily at the visual aspects of the text and their laborious decoding causes a "bottleneck" in working memory resulting in impaired comprehension performance.

Although there is a possibility that the Deficit readers failed to use, or made little use of context to facilitate word recognition and prose comprehension, it is outside the scope of this study to attribute their poor performance to an inability to use contextual cues. There is clear evidence in the literature that less skilled readers can and do use context to facilitate word recognition (Biemiller, 1970; Juel, 1980; Perfetti, Goldman & Hogaboam, 1979; Samuels, Begy & Chen, 1975-76; Schvaneveldt, Ackerman & Semlear, 1977;

West & Stanovich, 1978). Stanovich (1982b) suggests that

> the slow and inaccurate decoding processes of the poor
> reader may in fact degrade the contextual information
> that they receive, rendering it unusable. The
> observation that, under such conditions, poor readers
> rely less on context, is not necessarily an indication
> that they _cannot_ use context to speed word recognition,
> Rather, the finding may be an epiphenomenon of their
> poor decoding skills. (p. 551)

Theoretically, this explanation of processing differences between

the Good and Deficit reader groups is soundly based, However,

findings in support of processing differences between Good and Deficit

readers are constrained by significant difference in CCAT means

between these two groups. Performance differences between Good and

Deficit reader groups on factual and inferential comprehension

questions may therefore be in part due to differences in intelligence.

Both Good and Compensator readers performed significantly better

on the total sets of factual questions than on the total sets of

inferential ones. Furthermore, there were no differences between Good

and Compensator readers on any set of factual or inferential

questions. These results offer support both for the existence of

compensator group readers and for an interactive-compensatory model of

reading (Stanovich, 1980). Compensator readers were presumed to

utilize conceptually-based data, syntactic and semantic cues, in such

a way as to compensate for poor decoding skills. Their performance at

the factual level of questioning was therefore predicted to parallel

that of Good readers and to be superior to that of Deficit readers. In overall performance, this prediction was substantiated.

When Compensators are compared to Good readers and when Compensators are compared to Deficit readers there are some specific findings which are difficult to explain. Post hoc comparisons between Compensator and Good readers indicated that there were no differences between the performances of these two groups on any set of factual or inferential questions. Post hoc comparisons between Compensator and Deficit readers indicated reliable differences on factual sets one and three only. Thus there were no differences between Compensator readers and Good or Deficit readers on factual question sets two and four, and on inferential question sets one and two. The data indicates fuzzy boundaries between the compensator reader group and the others, Good and Deficit reader groups. The Compensator reader group is a fascinating one, but it would appear that methods and stimuli in the present study are not sufficiently sensitive to ascertain exactly what this group is.

Passage differences may provide one possible source for explaining conflicting results. There were perhaps an insufficient number of passages and certainly an insufficient number of questions of both types to provide more conclusive data, especially regarding the Compensator group. Also, greater uniformity in length of both the passages and the paragraphs within the passages, and use of organizational cues such as subheadings may have assisted readers. It

is recalled that the passages used ranged in length from 857 words to 1445 words. Thus a greater number of questions per passage may have afforded more discrimination between each reader group by providing more data, while organizational cues may have made stimuli more sensitive qualitatively.

It is also recalled that subjects were instructed to ask for help on unknown or difficult words; none did so. Moreover, time taken to complete each passage was not measured and subjects were not monitored in terms of looking back at a passage in order to answer a question. They had been instructed to do so if they wished. The negative finding of no main effects for inferential questions on passages three and four also indicates a need to examine these passages closely.

The need for further research is clearly evident, especially regarding the Difference and Compensator readers. Such research may enlighten us on the nature of Compensator readers, a group which is not dependent on bottom-up processing despite poor decoding skills, but which may depend unduly on top-down processing to compensate for a lack of automatic and accurate decoding skills. Further research may also identify Difference readers and perhaps also enlighten us as to whether these readers are, in fact, laborious decoders, possessing accurate but not automatic decoding skills (Perfetti & Lesgold, 1979), or whether they lack text organizational skills (Cromer, 1970).

Given the importance of reading in schools and society generally, and the effects of reading failure on the development of efficient

reading strategies, it is of paramount importance that adolescent poor readers be given appropriate instruction based on a clear understanding of their reading processes and deficiencies. Such instruction should incorporate means of compensating for as well as means of improving deficiencies. This study does provide support for the notion of types of readers and therefore some indication to educators that reading instruction should provide for individual differences and that standardized reading achievement test scores, usually reported in terms of years below grade level, should be interpreted and used with caution. However, the question of whether distinct groups of adolescent readers exist, or whether readers possess a variety of deficiencies in varying abilities and strategies to compensate for deficiencies remains to be answered.

Certainly, the limited capacity models of LaBerge and Samuels (1974) and Perfetti and Lesgold (1979) as well as the interactive models of reading of Rummelhart (1977) and Stanovich (1980) offer viable theoretical frameworks for both the study of reading processes and for the study of individual differences in reading skill. The results of this study are best interpreted in terms of these models, and further indicate the importance of fast and automatic word recognition as a determinant of fluent reading.

APPENDIX A

Stimuli

ECOLOGY

Imagine yourself on a walk through the forests near Squamish. Living things are all around you. Birds fly here and there; squirrels chatter as they gather pine cones. Some trees reach tall for the sun while shrubs squat over large parts of the ground. The warming sun begins to dry away last night's rain. Ants move back into their underground homes as the water seeps deeper into the earth and evaporates into the air. You glimpse a rabbit munching on some clover, but it scurries for cover when a hawk's shadow passes nearby.

There are many beautiful and interesting sights. But there are reasons why you see many of the things you do. For example, we know why some shrubs squat close to the ground while other trees grow tall. We can tell what the rabbits will do if there's too little rain to help the clover grow. These and other topics are our focus in the next few sets of readings.

You have been on an imaginary walk through the ecosystem of the pine forest. Let's look more closely at the word "ecosystem". It can be broken down into two parts - eco and system. "Eco" reminds you of a popular topic today - ecology.

Ecology is a science that studies plants, animals, people, and

parts of the environment like soil, water, and wind. But it examines more than just a collection of these different things. The "system" part of ecosystem gives us a hint. A system is a set of things that are arranged and related to one another. For example, we have a muscle system whose related parts are muscles. It determines how we move. We also have a system of traffic laws that are relations among individual laws. For example, it tells us when to stop or turn right.

An ecosystem is a related collection of living things like plants and animals, and non-living things like soil and weather. The rabbit depends on the clover for food. This is a relation between two parts of the ecosystem. The clover needs rain to grow. The hawk depends on there being enough rabbits so it can have food. All together, these individual relations make up a complex relationship between plants, weather, and animals.

More precisely, ecology is the science that explores these kinds of relationships and systems. Since the relationships between living and non-living things are basic to ecology, a good place to start our study of ecology is to examine some kinds of relationships that we might find. We have already seen several of these relationships in our imaginary walk through the pine forest ecosystem. Let's look at them more closely to see what they are, and how they are similar and dissimilar.

Imagine a rabbit sitting on a hillside munching grass. A hawk flies overhead, and its shadow passes near the rabbit. The rabbit gets frightened and scurries to its hole. The relationship between these two animals is common in nature: one animal is the food that helps the other animal live. We call this kind of relationship a predator-prey relationship. The rabbit is the hawk's prey. It must be killed to feed the predator, that is, the hawk. Another example of a predator-prey relationship is seen when a woodpecker eats insects that live in tree bark.

A second kind of relationship occurs when one living thing depends on another for something, but doesn't do it any harm. For example, plants like mistletoe climb trees to get more sunlight. The mistletoe depends on the tree to help it live, but this kind of dependency does no damage to the tree. This is called a benefit-no difference relationship. Another example of a benefit-no difference relationship can be seen in the way grasses get a better supply of air when there are earthworms in the soil. By burrowing around the roots of the grass, earthworms leave passages for air to flow to the roots of the grass. The grass benefits at no expense to the earthworm.

You probably know that bees carry pollen on their legs as they travel from flower to flower. The flower needs pollen grains from other flowers to make seeds. The bee needs the nectar from the

flowers it visits to make its food called honey. As the bee collects the flower's nectar, its hairy legs pick up pollen. Then the bee flies off to another flower where the pollen is scraped off the bee's legs. This second flower can then make seeds. We label this kind of relationship a mutual benefit relationship because the bee helps the flower by transferring pollen and the flower helps the bee by providing nectar.

Before we talk about other kinds of relationships, notice that each kind of relationship described so far has some similarities. For example, think about a robin that eats a caterpillar. In this relationship, the robin has the part of predator and the caterpillar has the part of prey. As predator, the robin does something to the caterpillar. Another way to say this is that the first actor in the relationship has an effect on the second actor. This happens in all the kinds of relationships in the ecosystem. There are always at least two actors, and one has an effect on the other. This is what makes an ecological relationship a relationship.

Besides the three relationships already described, there are others that are typical in local ecosystems. A squirrel and a chipmunk both like to eat the same food, particularly pine cones. If there were not enough pine cones for both the squirrel and the

chipmunk, then both might begin to starve. This kind of relationship
is called a competitive relationship because two animals fight over or
compete for the same source of food. Animals can compete for other
things besides food, of course. Two kinds of birds may want the same
place to build a nest. Here, the competitive relationship is
concerned with territory.

Another important relationship happens when two or more of the
previous kinds of relationships we have examined are combined into one
larger relationship. We call this more complicated relationship a
combined relationship. Here's an example of a combined relationship.
A robin, a moth and a tree are the actors in this relationship. The
robin nests in the tree. This is a benefit-no difference
relationship. It benefits the robin to nest in the tree because it is
safer there. The tree, on the other hand, neither gains nor loses
anything because the robin is just nesting in it. At the same time,
the moth uses the same tree to hide from the bird because the tree
bark is similar to the color of the moth. Again, the moth benefits
from the relationship, but the tree neither gains nor loses anything
from the moth's presence. This is a second benefit-no difference
relationship. But, the moth is a source of food for the robin. This
is a predator-prey relationship. As you can see, the combined
relationship between the robin, moth and tree is made up of three
simpler relationships -- two benefit-no difference relationships and

one predator-prey relationship.

It is still a relationship in the general sense because it has at least two actors, and one actor has an effect on another of the actors. Earlier, you found out that a system is made up of many different parts that work together. A combined relationship has several parts that are related to each other. The parts in a combined relationship are the simpler relationships. Because of this, a combined relationship can be called a system. A change in one of the simpler relationships that makes up a combined relationship will lead to a change in another part of the combined relationship. For instance, if the moth moves to a different tree, the robin loses its built-in food supply. A change in the benefit-no difference relationship between the moth and the tree produces a change in the predator-prey relationship between the robin and the moth. Perhaps the robin will eat worms instead of moths. So, if one simple relationship in the system changes, we can predict something about what will happen to other simple relationships in the system. When we can predict changes in a system, we have a lawful system. The study of a lawful system is called a science. Since ecology studies lawful ecosystems, ecology is a science.

Ecology_____   Name: _____

Choose one best answer for each of the following questions. Write the
number corresponding to your choice in the blank to the left of that
question.

____   **Why do robins like to nest in trees?**

            1. It is nearer the robin's supply of food than other
                nesting places.
            2. Because birds can be warmer in trees.
            3. There is more safety from predators high in the
                trees.
            4. Because their nests benefit the tree's growth.

____   **When a woodpecker eats grubs in the bark, the grubs**

            1. are a system
            2. are the prey
            3. participate in a benefit-no difference relationship
            4. are a predator

____   **If the benefit-no difference relationship between trees and
            moths is changed, robins may change**

            1. their nesting places to the ground or shrubs
            2. the time when they migrate south for winter
            3. from prey to predators
            4. from eating moths to eating worms

____   **When squirrels carry pine cones far away from the tree to
            store them, some seeds in the pine cone sprout where they
            can get lots of sunlight. Which kind of relationship
            between squirrels and pine trees is this?**

            1. competitive
            2. predator-prey
            3. mutual benefit
            4. combined

____ **Traffic laws form a system because they**

1. always tell drivers to do the same thing
2. make use of different kinds of road signs
3. relate to one another in logical ways
4. apply to trucks as well as cars

____ **Forest trees are tall because they**

1. need direct sunlight
2. have to get away from predators
3. can't participate in benefit-no difference
   relationships if they are short
4. are a source of food for birds

____ **What kind of relationship is it when rabbits and woodchucks try to use the same burrow for their homes?**

1. combined
2. competitive
3. benefit-no difference
4. predator-prey

____ **Relations between which two groups of things make up the science of ecology?**

1. humans and pollution
2. science and technology
3. birds and insects
4. living things and non-living things

____ **What food do rabbits depend on to live?**

1. insects
2. field mice
3. pine cones
4. clover

____ **A silver moth is trying to hide from a hungry robin. Which tree will it choose for hiding?**

1. yellow cedar
2. grey oak
3. brown pine
4. silver birch

ENERGY IN THE ECOSYSTEM

Living things in the ecosystem take part in many kinds of relationships. In each one of these relationships, living things have to do something. For example, to catch a rabbit for food a fox has to run after the rabbit. Even flowers are active because they are growing. What starts and keeps up these activities is energy. Whenever there is activity, there is energy.

Energy is an important idea in the science of ecology. If the fox had no energy, it couldn't chase the rabbit. In fact, it couldn't do anything! Because the energy that a fox or any other living thing has controls what it can do, it also controls the relationships between that living thing and its ecosystem. Therefore, energy is a big influence on the kinds of relationships that we find in an ecosystem. Let's explore this idea further.

Whenever you see an activity, like running or growing, you need to ask where the energy comes from. One source of energy is food. For example, a glass of milk has enough energy to keep you jogging for about half an hour. In the ecosystem of the pine forest, there are lots of different foods that supply energy to all kinds of living things. For example, the squirrel gets energy from eating pine seeds in pine cones. The birds eat insects like moths and worms to give

them energy. Mushrooms often live on decaying leaves. In fact, all living things and many non-living things have energy stored inside them. Even tree bark, which deer sometimes eat, has energy stored in it.

These sources of energy aren't moving. But, we said earlier that energy meant activity -- running, breathing, growing for example. Each of these things involves movement, no matter how slow. But a pine cone that's fallen from the tree doesn't move before the squirrel eats it. It's just lying on the ground. But we know that it has energy stored in it because when squirrels eat pine cones, they can be active -- run and breathe and grow. There seems to be a contradiction here because if energy is the same as movement, then there shouldn't be any energy in the pine cone that just lies on the ground.

We can get rid of the contradiction by having different kinds of energy. One kind of energy means activity. Another kind of energy means that activity is possible sometime later. Energy that we see in things that are active or moving is called kinetic energy. The word kinetic comes from a Greek word for moving. The other kind of energy is stored in living things that aren't moving, like the energy in the pine cone. There is a possibility, or a potential, for activity only if something happens, like when the pine cone is changed to energy after it's eaten and digested by a squirrel. This kind of energy

that's stored in the pine cone is called potential energy. There is a possibility that it will become kinetic energy, but something has to happen to it first.

So far, we have talked about eating food as one way to get energy. Birds eat insects, snakes eat mice, humans eat apples. Like animals and other living things, plants are sources of energy, too. But since plans don't "eat" in the same way as animals, they must get their energy in some other way.

Plants are a special kind of living thing. They are living things that make their own food. They do this by combining chemicals and sunlight to make sugar. They need a part of the air called carbon dioxide, some water, sunlight, and a special chemical called chlorophyll and -- poof -- sugar. The kind of chemical process plants use to make sugar has a special name -- photosynthesis.

Not all plants can photosynthesize to make sugar -- only green plants do. In fact, the green color of these plants comes from the special chemical, chlorophyll. Mushrooms and other plants that aren't green usually live off green plants by "eating" the remains of green plants that have died.

Let's return to the importance of energy as a controller in the

ecosystem. Plants are sources of energy for animals who eat the plants. Because animals eat plants, we call the animals consumers. Since plants make food rather than consume it, we call plants producers. So, we have a basic ecological relationship about energy in the ecosystem. Producers, who are the plants, make energy for the consumers, the animals and non-green plants. Without the plant producers, the animal consumers wouldn't have energy -- they all would die. Therefore, things that effect the world of plants have a big influence on the world of animals. And, this whole relationship is based on how energy gets from one place to another -- from the plant producers to the animal consumers.

Thus producers are the source of all potential energy for consumers. This relationship between producers and consumers is labelled the energy flow because the energy flows in one direction, from producers to consumers. As an example, think of a rabbit that is eating grass. The grass is the producer and the rabbit is the consumer. Once the rabbit eats the grass, the energy in the grass is passed on to the rabbit. The rabbit uses the potential energy in the grass for its own needs. When the rabbit is active, it turns some of the potential energy from the grass into kinetic energy. The energy the rabbit gets from the grass can never be given to the grass. Green plants, the producers, can never get their energy from the consumers. Producers always get their energy from the sun.

<u>Energy in the Ecosystem</u>   Name: _____

Choose one best answer for each of the following questions. Write the
<u>number</u> corresponding to your choice in the blank to the left of that
question.

____   **Before hibernating in winter, a bear eats a lot so that it
              gets very fat. It does this to:**

              1. become a producer
              2. store lots of kinetic energy
              3. store lots of potential energy
              4. use up lots of kinetic energy so it can get to
                  "sleep".

____   **Potential energy is energy that**

              1. is possible after something happens
              2. never gets used
              3. is the same as kinetic energy
              4. can be seen in movement.

____   **Which of the following is a consumer?**

              1. a bee
              2. a mushroom
              3. a dog
              4. all of the above.

____   **Which of the following is a producer?**

              1. rabbits
              2. bees
              3. hawks
              4. corn plants.

____   **Which is the source of energy for producers?**

              1. green plants
              2. the sun
              3. animals
              4. non-green plants.

___ **In which direction does energy move in an ecosystem?**

1. from plants to animals
2. from consumers to producer
3. from animals to the ground
4. from the sun to animals.

___ **Which of the following is a source of energy?**

1. a worm
2. a bird
3. a pine cone
4. all of the above.

___ **Plants make what kind of food?**

1. vitamins
2. minerals
3. potential
4. sugar.

___ **Which plants live off the remains of green plants?**

1. flowers
2. mushrooms
3. algae
4. grasses.

___ **Why do birds eat moths and other insects?**

1. to keep down the population of these living things
2. to provide energy
3. to keep food away from competitors
4. to complete a food chain.

THE FLOW OF ENERGY IN THE ECOSYSTEM

Energy is an essential ingredient for life. Living things need energy for energy influences many of the relationships in an ecosystem. One of the important things which ecologists study is how energy moves from one place in the ecosystem to another. For example, plants like clover use energy from the sun to make sugar. The sugar is stored in the plant. Later it becomes food for animals. But the useful energy that a rabbit gets by eating plant roots is less than all the useful energy the plant received from the sun. When a fox eats the rabbit, the amount of useful energy the fox gets is less than all the useful energy the rabbit had. Let's see why energy is lost at each of these points and what it means for the ecosystem.

Plants use energy from the sun in two ways. First, they make sugar and store it in their leaves, stems, and roots. This is how plants grow. Second, plants use energy to stay alive. This part of the original energy does not get stored, but is lost after it is used. So, the energy stored in the plant is less than all the energy the plant received from the sun because some of the sun's energy was used to keep the plant alive. But the energy that was stored by the plant can be used later by the plant to stay alive or by an animal which eats the plants.

Now let's see what happens to the energy a rabbit gets when it eats clover. The rabbit uses energy from the plants to make muscle, bone, and other living tissues. These body parts are places for energy to be stored in the rabbit. The rabbit also changes some energy from the plant into kinetic energy to stay alive. The rabbit walks around to get to other plants, breathes, sleeps, scratches, and does many other things. Each activity uses some energy. So, when a rabbit is eaten by a fox, the fox gets less energy than the rabbit from eating the clover. Now, the fox uses some energy to digest the body of the rabbit. It also uses energy to run, to reproduce, and so on. By the time something else eats the fox, there is even less energy than can be used for living.

In general, the movement or flow of energy through the ecosystem is like this example. The amount of useful energy gets smaller and smaller at each step in the energy flow. Since the rabbit is the first living thing to get energy from the producer plants, it's called a first-order consumer. Being second in line, the fox is called a second-order consumer. The next animal in line is a third-order consumer.

The way energy flows through the ecosystem involves a principle about energy. Energy that is useful to things in the ecosystem moves in only one direction -- from the sun to producers to first-order

consumers to second-order consumers, and so on down the line. Energy never goes backwards in this flow. We give this characteristic of one-way flow the name unidirectional. Thus, the flow of energy in the ecosystem from producers to first-order consumers to second-order consumers, and so on, is a unidirectional energy flow.

Let's explore some things that happen in the energy flow. We already know that the amount of energy useful to animal consumers gets smaller and smaller at each step in the energy flow. There's something else besides activity whenever kinetic energy is used, however. Any activity results in some heat. You notice heat most when there is a great deal of activity, like when you get warm after running. But heat is given off for little activities, too, like when a plant grows, or when we breathe and digest food. In other words, when kinetic energy is used for life activities, heat is always given off. In our example, when the fox finally ate the rabbit, the fox gets less useful energy from the original food source, the clover, partly because the rabbit has already used some energy from the clover for life activity and partly because some potential energy was given off as heat.

A major characteristic of energy flow is that it follows the principle of conservation of energy. This principle says that the total amount of energy originally in the ecosystem always stays the

same in the ecosystem even though the energy changes forms. Thus, all the energy in an ecosystem is either potential energy or heat. For instance, let's begin with all the potential energy in plants that comes from the sun. Some of these plants are eaten by first-order consumers—animals. Now if we could capture the heat given off by a plant, the energy used by the plant for life activities, the heat given off by the first-order consumer, and the potential energy stored in the first-order consumer, we would have all the energy from the sun that originally went into the plant. The amount stays the same, but the form changes. The original energy of the plants has been conserved in the ecosystem according to the principle of the conservation of energy.

Flow of Energy   Name: _____

Choose one best answer for each of the following. Write the <u>number</u>
corresponding to your choice in the blank to the left of that
question.

_____   A bird eats a mosquito. Last night the mosquitoe bit a cow
               for blood, and the cow had eaten some grass earlier that
               day. The bird can't give all the energy it gets from the
               mosquito to a second mosquito because

               1. energy is conserved in an ecosystem
               2. energy flow is unidirectional
               3. the cow didn't give enough energy to the first
                   mosquito
               4. mosquitoes won't bite birds.

_____   For what do plants use energy from the sun?

               1. to make sugar and stay alive
               2. to stay alive and feed consumers
               3. to feed producers
               4. to store kinetic energy.

_____   When energy flows from a flower to a bee to a bear (when the
               bear eats the bee's honey), where is the energy lost?

               1. in the transfer from flower to bee
               2. in the transfer from bee to bear
               3. in the transfer from flower to bear
               4. all of the above.

_____   The amount of energy stored by a plant is

               1. the same amount as it received from the sun
               2. more than it receives from the sun
               3. less than it received from the sun
               4. either the same as or less than it received from
                   the sun.

____ **When a rabbit breathes, eats, and does other things to stay alive, it**

1. changes heat into kinetic energy
2. stores kinetic energy as potential energy
3. stores heat as potential energy
4. changes potential energy into kinetic energy.

____ **A worm eats some rotting alder leaves. Later a fish eats the worm on a fisherman's hook. Then, the fisherman eats the fish. Who gets the most energy?**

1. the worm
2. the fish
3. the fisherman
4. they all get the same amount of energy.

____ **A caterpillar eats plant leaves. A frog eats the caterpillar, and then the frog is eaten by a fish. You eat the fish for dinner. Who is the third-order consumer?**

1. the frog
2. the fish
3. the caterpillar
4. you.

____ **What does a first-order consumer eat?**

1. it makes its own food, like plants
2. plants
3. second-order consumers
4. all of the above.

____ **In the flow of energy, what category of living things is next in line after first-order consumers?**

1. people
2. plants
3. second-order consumers
4. other first-order consumers.

____ **All the energy that a bean receives from the sun equals the potential energy in the bean plus energy the bean used to grow plus heat lost by the bean. What principle is this?**

1. unidirectional flow of energy principle
2. kinetic energy – heat principle
3. conservation of energy principle
4. consumer ordering principle.

MATTER IN THE ECOSYSTEM

You've probably heard the word recycle many times. We talk about recycling aluminum cans, glass bottles, paper bags, and other things. What we mean by recycle is that we use the things over again -- returnable soda bottles are cleaned and filled with soda again and again. The same thing happens to all the natural materials in an ecosystem. In fact, materials are always recycled in nature. Let's look more closely at some of these materials and the way they are naturally recycled.

Meet Harvey Carbon -- he's a chemical substance that is essential for life. We see him best as coal. But he really gets around more in shapes that are harder to see than coal. Let's go with him on his adventures. We begin in the air.

Air is made up of lots of things -- oxygen, nitrogen, and other gases. Harvey started out as a gas called carbon dioxide. He hung around for a while until a pine tree took him in through its needles. Inside the tree, he was mixed up with some other chemicals in the process of photosynthesis and became organic material, a solid chemical compound. As such he was put to use in making seeds. In a few months he had a nice home inside a ripe pine cone. So, for the first part of Harvey's travels in the ecosystem, we see him changing

from a gas called carbon dioxide into the organic material in a pine
cone.

Next, Harvey and his pine cone fell off the tree's branches. A
hungry squirrel happened along and snatched up the pine cone for
lunch. When the pine cone was digested in the squirrel's stomach,
Harvey Carbon moved into some of the fat the squirrel carried around.
He stayed there for a while until the squirrel died.

After the squirrel died, bacteria began to grow on its dead
flesh. Some of the bacteria gave off gases that contained carbon
dioxide. Harvey was part of these gases, and he became carbon dioxide
in the air again.

As we can see, Harvey Carbon really travelled around -- from the
air to the pine cone to the squirrel and back again to the air. Now
he's ready to be used again by another plant. Much like the soda
bottle that is refilled over and over, Harvey Carbon has been
recycled. But unlike the soda bottle which cannot be recycled if it's
broken, Harvey Carbon is always usable in one form or another.

All of the materials in the ecosystem are recycled. Some are
particularly important in ecological relationships. One of these is
nitrogen. Like carbon, nitrogen is a basic ingredient for life. A

good place to start in the nitrogen cycle is when it is a gas in the air. When it rains, nitrogen sometimes combines chemically with the water and falls to the soil. Here, certain kinds of bacteria called nitrogen-fixing bacteria make the nitrogen into a chemical compound that plants need to grow. These bacteria live in the soil near the roots of plants like clover. After the nitrogen-fixing bacteria change the form of the nitrogen, plants gather up nitrogen and use it to make new stems, roots, and leaves. Animals eat the plants and perhaps other animals eat these first animals. When the animal dies, the nitrogen is given off as a gas into the air from the decomposing flesh. So, it is back into the air as a gas. The nitrogen cycle can involve lots of other living things, too, to make a full cycle from gas to gas.

Each one of the living things that has a part in the carbon or nitrogen cycle can be grouped into a category. For example, plants make organic materials made up of nitrogen, carbon, and other things which other living things use. We call plants producers. Other living things, especially animals, eat the plants to get energy and recycled materials. This group is called consumers -- they consume the organic materials produced by the plants. A third group of actors in the cycle of materials is the group of living things which get the materials out of organic materials and put them back into the soil or the atmosphere. These living things are called decomposers. They

help break down, or decompose, complex organic materials, like bone or leaves, into simple organic materials like nitrogen and carbon. Snails, maggots, fungi, and bacteria are good examples of decomposers.

When we want to speak about the way materials like carbon are recycled in general, we can use the names of these three groups of living things -- producers, consumers, and decomposers. For example, carbon usually is cycled from the environment to producers to consumers to decomposers and back to the environment. But this is only true for most of the time. An important exception would be when a plant dies, its carbon might never get to a consumer. It might go right back into the air as carbon dioxide to be used by another plant. This is still a cycle for carbon, only it's a shorter cycle than we usually find in the ecosystem.

The carbon cycle and the nitrogen cycle are two matter cycles involving producers, consumers, and decomposers. We also mentioned the same kinds of actors in describing the energy flow. There are important similarities and differences between the actors in matter cycles and actors in the flow of energy. First, the general idea of a producer is always the same whether we are talking about matter cycles, or energy flow. A producer always makes something, for example, directly useful for life activities. Plants are both energy producers and matter producers. The idea of the consumer remains the

same, too. The consumer is unable to change sunlight into energy useful for life activities in the energy flow. Therefore, the consumer has to get its energy from plants and other animals. It also is unable to make direct use of matter, like nitrogen in the air, without the matter being changed into a new chemical compound by a matter producer. For example, cows that eat grass are nitrogen consumers. A difference between matter cycles and energy flow occurs when we talk about decomposers. In the energy flow, the decomposers are thought of as the last consumers. This is because energy flow is unidirectional and energy is not recycled. The decomposers are simply the last ones to get energy from dead animals and plants. In the matter cycle, however, we emphasize decomposers because they recycle the matter. They break the matter down into its simpler, original form for re-use by the producers, like the bacteria that help to decompose dead animals to release nitrogen and carbon back into the air.

In different matter cycles, a single living thing may take on different roles. For example, in the nitrogen cycle, nitrogen-fixing bacteria are the producers because plants cannot take nitrogen gas right from the air and use it. Instead, the nitrogen-fixing bacteria change the gas into a solid nitrogen compound that plants can use. Plants, then, are the first-order consumers in the nitrogen cycle, not the nitrogen producers. A rabbit who eats the grass would be a

second-order nitrogen consumer. Finally, other bacteria will
eventually break down the nitrogen that is in the dead rabbit so that
it can return to the air.

Much of what we've been talking about has to do with how energy
and materials move through the ecosystem. A simple predator-prey
relationship like the one between a hawk and a rabbit is an example of
one link in these cycles. We can think of other links too. The
rabbit eats clover. Decomposers live off the decaying flesh of dead
hawks. When we put all this together, we have a food chain that's
made up of several simpler links -- clover to rabbits, rabbits to
hawks, and hawks to decomposers. Both materials and energy are passed
along this food chain.

But we also know that more than one animal eats rabbits to get
organic matter and energy. For example, cats eat rabbits and so do
snakes. Hawks also eat snakes. We are beginning to make the simple
food chain have a lot of complex relationships. When several food
chains are all interconnected, we call the whole set of food chains a
food web. The food web is a way of showing how lots of living things
relate to each other in moving matter and energy through the
ecosystem.

Matter in the Ecosystem   Name: _____

Choose one best answer for each of the following. Write the number
corresponding to your choice in the blank to the left of that
question.

____   **What is the difference between a food chain and a food web?**

          1. Food chains don't transfer energy, while food webs
              do.
          2. A food web is more complex than a food chain.
          3. Food webs are not ways of recycling matter in .
              ecosystems.
          4. None of the above are differences.

____   **What living things first make use of carbon and nitrogen to
          produce organic materials?**

          1. animals
          2. humans
          3. green plants
          4. non-green plants.

____   **By what process does carbon combine with other chemicals to
          become organic material?**

          1. decomposition
          2. oxidation
          3. photosynthesis
          4. recycling.

____   **Where do we begin when tracking how carbon moves through the
          ecosystem?**

          1. water
          2. the air
          3. in living things
          4. the sun.

A plant makes nectar which bees use to make honey. A bear eats honey. Then when it dies, a vulture eats some of the bear's flesh. What does this series of events describe?

1. the carbon cycle
2. the nitrogen cycle
3. a food chain
4. the role of decomposers.

A stalk of corn was left to rot in a farmer's barn where no animals could reach it for food. Which kind of living thing would be the one left out of the usual pattern of recycling chemicals?

1. producers
2. consumers
3. decomposers
4. nitrogen-fixing bacteria.

When a sandwich is left to rot in the woods, how does carbon that it contains move to the next step in its cycle through the ecosystem?

1. Bacteria feeding on the sandwich release the carbon into the air.
2. The carbon drops to the ground.
3. Rain carries the carbon to streams where water plants use it.
4. All of the above.

When a plant dies, its carbon

1. may be consumed by an animal
2. may go directly into the air
3. may be used by nitrogen-fixing bacteria
4. all of the above.

_____ **What group of living things return chemicals to the atmosphere or the soil?**

1. decomposers
2. consumers
3. producers
4. animals.

_____ **How much are the materials in nature recycled?**

1. about 2 or 3 times
2. about 50 to 100 times
3. they are usually recycled
4. they are always recycled.

APPENDIX B

Tables

Means and Standard Deviations of Factual and Inferential
Question Sets Across the Three Reader Groups

	Variable	Mean	S.D.
Factual Questions	Set 1	3.86	0.94
	Set 2	3.74	1.19
	Set 3	3.64	1.14
	Set 4	3.26	1.16
Inferential Questions	Set 1	3.93	1.15
	Set 2	3.51	1.06
	Set 3	2.63	1.05
	Set 4	2.85	1.24

Within-Group Reader Performance on Factual and
Inferential Questions Across Passages

Group	Variable	Mean	S.D.	t	p	
Total (n = 72)	Factual	3.63	0.81	5.01	.000	**
	Inferential	3.23	0.70			
Good (n = 34)	Factual	3.90	0.73	3.38	.001	**
	Inferential	3.52	0.62			
Deficit (n = 14)	Factual	2.95	0.83	1.02	.16	
	Inferential	2.77	0.56			
Compensator (n = 24)	Factual	3.64	0.67	3.85	.0005	**
	Inferential	3.08	0.69			

*p < .05
**p < .001

APPENDIX C

Letter Requesting Parental Consent

Mrs. Jan Eastman
3749 196A Street
Langley, B.C. V3A 4T8
Phone 530 2966

April 30, 1979

Dear Parent:

I am presently conducting a research study in the school which your
child attends. The aim of this study is to find ways of improving
reading comprehension. Specifically, I will attempt to identify what
kinds of comprehension questions present most problems to readers.
The exploration of these issues is central to my Master of Arts
(Education) thesis.

I am conducting the research under the supervision of Dr. Bernice
Wong, Assistant Professor, Faculty of Education, Simon Fraser
University. This research study has been approved by the Langley
School Board and by the principals of the schools involved. Dr. L.
Sampson, Superintendent of Schools, and Dr. S. Rawlyk McBride,
Supervisor of Special Education, are supportive of it.

To achieve the aims of the study, I need to present some short
passages to readers at different levels and have them answer both
factual and inferential questions. A reading comprehension,
vocabulary and word recognition test will also be administered to the
students involved in the study. Any information resulting from the
tests which is of benefit to students will be shared with the student
and school.

Results of the study will be presented to the Langley School Board.
Names of students will not appear in the completed thesis.

I would appreciate it very much if you would allow your child to
participate in this study. Please indicate your approval or
disapproval on the enclosed form and return it to the school by
Friday, May 11, 1979.

I will be pleased to answer any questions you may have.

Thank you in advance for your kind consideration.

                              Yours truly,

                              Jan Eastman

Do you approve of your child participating in the research study outlined?

Yes _____

No   _____

Signature: _____

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