READING AND REPETITION: INDIVIDUAL DIFFERENCES IN ADULT READING SKILL

BY

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ABSTRACT

Within the last decade, the study of individual differences in reading skill has become an active area of investigation. Much of this research has been conducted with children, and has focused on selected processes hypothesized to underlie proficient reading skill. Relatively less attention has been directed toward evaluating the effects of experience in contributing to skill differences.

The experiments reported in the thesis were designed to examine multiple dimensions of reading skill, and to evaluate the effects of repeated experience in two groups of readers selected on the basis of their comprehension skill. The results indicated that differences between skilled and less-skilled readers were apparent on all measures of reading. Despite these overall group differences, the less-skilled readers were at least as able to benefit from repeated experience as were their more skilled peers.

The results of the first experiment indicated that the less-skilled readers were poorer at word-level processing, particularly in processing unfamiliar lexical items. The second experiment examined whether this poorer processing reflected an inability to benefit from experience over repeated trials. The results indicated that the performance of both skilled and less-skilled readers improved with repeated experience. Moreover, similar gains were observed after repetition with text in Experiment 3. The results of Experiment 4 further indicated that, although the less-skilled readers appeared less sensitive to higher-order dimensions of text structure when reading for meaning, their performance across specific transfer conditions indicated that they were able to use higher order information to facilitate comprehension.

The results of these experiments suggest that investigation of the role of repeated experience in contributing to individual differences may clarify factors critical to the acquisition of proficient reading skills. The implications of these findings for models of reading and for future research are discussed.

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Introduction

Current research on reading has been conducted within the framework of three types of models. These models can be characterized by the emphasis that is placed on selected processes hypothesized to be critical to proficient reading. Data-driven, or bottom-up, processing models focus primarily on processes which are hypothesized to underlie word identification; processing of meaning occurs only after word-level processing has been completed (e.g., Gough, 1972; LaBerge & Samuels, 1974). In contrast, conceptually-driven, or top-down, processing models emphasize the readers' comprehension skills, and how these skills determine the way in which printed material is processed (e.g., Smith, 1971; Goodman, 1967). Interactive models, as the name suggests, emphasize both data-driven and conceptually-driven processing, and focus on how these processes act in parallel to effect efficient comprehension of written material. These models were generally developed to account for reading skills in the proficient adult reader, but the models have been applied to the investigation of children learning to read and to individual differences in reading skill.

Despite the major differences in these models of reading, a feature common to all of them is the static account they provide of the processes underlying reading. In general, these models were proposed to account for reading on a single trial; no formal mechanisms were proposed to account for how processing would be expected to change after experience with print. While specific features of some models are exceptions to this general statement, there has been relatively little empirical focus on the effect of repeated experience in facilitating proficient reading skill.

This emphasis on the invariant components hypothesized to underlie successful reading is paralleled in research on reading acquisition, particularly in the investigation of how individuals differ in the development of proficient reading skills. The history of individual-difference research (e.g., Wiederholt, 1974) has been characterized by attempts to specify what factors intrinsic to a group of individuals underlie their poorer reading skills. In current cognitive research, the goal has been to specify those hypothetical component processes which differentiate individuals who have achieved different levels of reading proficiency. There has been relatively little emphasis on the dynamic aspects of reading acquisition, and the role of experience with specific material. Rather, inferences about reading acquisition have been based on different patterns of performance demonstrated across selected ages and levels of reading skill. Whether individual differences in reading skill are accompanied by differences in the rate of acquisition or in the ability to take advantage of specific experience has received relatively little attention within psychological research.

The research reported in the thesis was designed to examine the effects of repeated experience in reading, and to determine whether these effects differ between groups of individuals varying in their level of attained reading skill. Specifically, this research examined whether experience with selected materials facilitated later reading of the same, or similar, material in order to determine whether readers at different skill levels could be discriminated by their ability to benefit from such repetition.

The thesis includes eight chapters. In the first chapter, the three types of models of proficient reading are described. That chapter provides a theoretical background for the review of research examining individual differences in reading skill which is contained in Chapter 2. Chapter 3 describes the subject sample, and the criteria for differentiating groups of individuals on the basis of reading skill. The experiments that form the basis of the thesis are reported in Chapters 4 to 7, and a general discussion of the results and directions for future research are presented in the final chapter.

CHAPTER 1

Models of Fluent Reading

The study of reading within psychology has had a history that reflects the prominence of the study of mind within the discipline itself. Early investigations of reading were conducted in Wundt's founding psychological laboratory (Cattell, 1885) and continued until the publication of Huey's classic The Psychology and Pedagogy of Reading in 1908 (Tzeng, 1981). Subsequently, with the rise of behaviourism and its emphasis on the relationship between observable environmental and behavioural events, the investigation of reading, and of mental events in general, declined. Throughout the next 50 years, reading continued to be of interest to psychologists concerned with educational applications, but the concern was focused primarily on the development and standardization of psychometric instruments for use in evaluating levels of reading achievement (Venezky, 1977).

However, developments in information theory from communications engineering, computer science, and linguistics heavily influenced the later interests of psychologists and resulted in a re-emergence of mental events as a focus for empirical and theoretical work (Lachman, Lachman &

Butterfield, 1979). By applying constructs from information theory and computer science, the concept of an information processing system which mediated between input (stimuli) and output (responses) became a prominent and influential framework for considering mental events. Central to this approach was the notion that information could be transformed over a series of stages, resulting ultimately in the creation of new knowledge. The time course of these inferred component processes, capacity limitations of the processing systems, and the representation of knowledge became important issues of concern (Lachman et al., 1979). Concurrent and related developments in the field of linguistics, and the emergence of the field of psycholinguistics, also served to focus the interests of psychologists on mentalistic events. The influence of linguistics, particularly with the introduction of Chomsky's work by Miller (1962; 1965) into psychology, resulted in an interest in linguistic knowledge, including syntax and semantics.

These trends, which culminated in the newly-defined field of cognitive psychology, resulted in a return to research on reading (Venezky, 1977; Williams, 1979). The early research in this period of resurgent interest was largely empirical in nature, and focused on investigating hypothesized components of reading skill. By the early 1970's, however, reading theorists became involved in modelling processes underlying reading. In general, these models were designed to account for skilled adult reading, but the models have been applied to both young children acquiring reading skill, and to individual differences in reading acquisition.

In essence, models of reading can be categorized into three types, depending on what components are considered to be of primary importance in initiating reading and how these components influence later processing. Bottom-up processing models (e.g., Gough, 1972; LaBerge & Samuels, 1974) focus primarily on how printed material is transformed over a series of stages to meaning, while top-down processing models (e.g., Goodman, 1967; Smith, 1971) emphasize the importance of semantic and syntactic dimensions of language and how knowledge of these dimensions determines the way in which printed material is processed. Interactive models (e.g., Rumelhart, 1977) focus on the relationship between bottom-up and top-down processing during reading.

These models were designed to capture the complexity of processes involved in reading, rather than to focus on specific components such as letter or word recognition, and comprehension. Many of the processes underlying specific components of reading skill, particularly those involved in comprehension, are deliberately vaguely specified. Common to all of these models is the postulation of pre-existing cognitive units, or structures, onto which a reading episode is mapped. Moreover, these models are typically static in nature: they were generally developed to account for reading on a single trial or episode. While some consideration is given to how practice with specific material may facilitate the development of reading skill, this remains a topic for empirical and theoretical work and is further explored in the experiments reported in the thesis.

The three classes of models of proficient reading skill will be presented in more detail in the remainder of this chapter in order to provide background for consideration of individual differences in reading skill.

Bottom-Up Processing Models of Reading

The bottom up, or data-driven, processing models of ~~reading~~ were developed within the general framework of information processing: reading is viewed as involving the transformation of information over a series of invariant processing stages. These models take the printed message as their initial focus, and posit a sequence of processes which result in eventual understanding of the printed words or text. In general, the sequence of stages posited in bottom-up processing models are invariant, and individual stages cannot be bypassed. Moreover, higher-level processes, and knowledge already acquired by the reader, cannot influence earlier stages of processing.

An early bottom-up processing model of fluent reading was proposed by Gough (1972) to account for processing which occurred during the first second of reading. A schematic diagram of the model is presented in Figure 1. In this model, the printed text is hypothesized to be processed initially through the visual system, registering on the icon as a brief image. This image is then scanned by pattern recognition routes, resulting in letter identification. Letters are identified serially, and placed in the character register, where they are mapped onto their corresponding phonemes by a decoder. The resulting output from this processing stage (the phonemic tape) is then passed to the librarian. At this stage, the

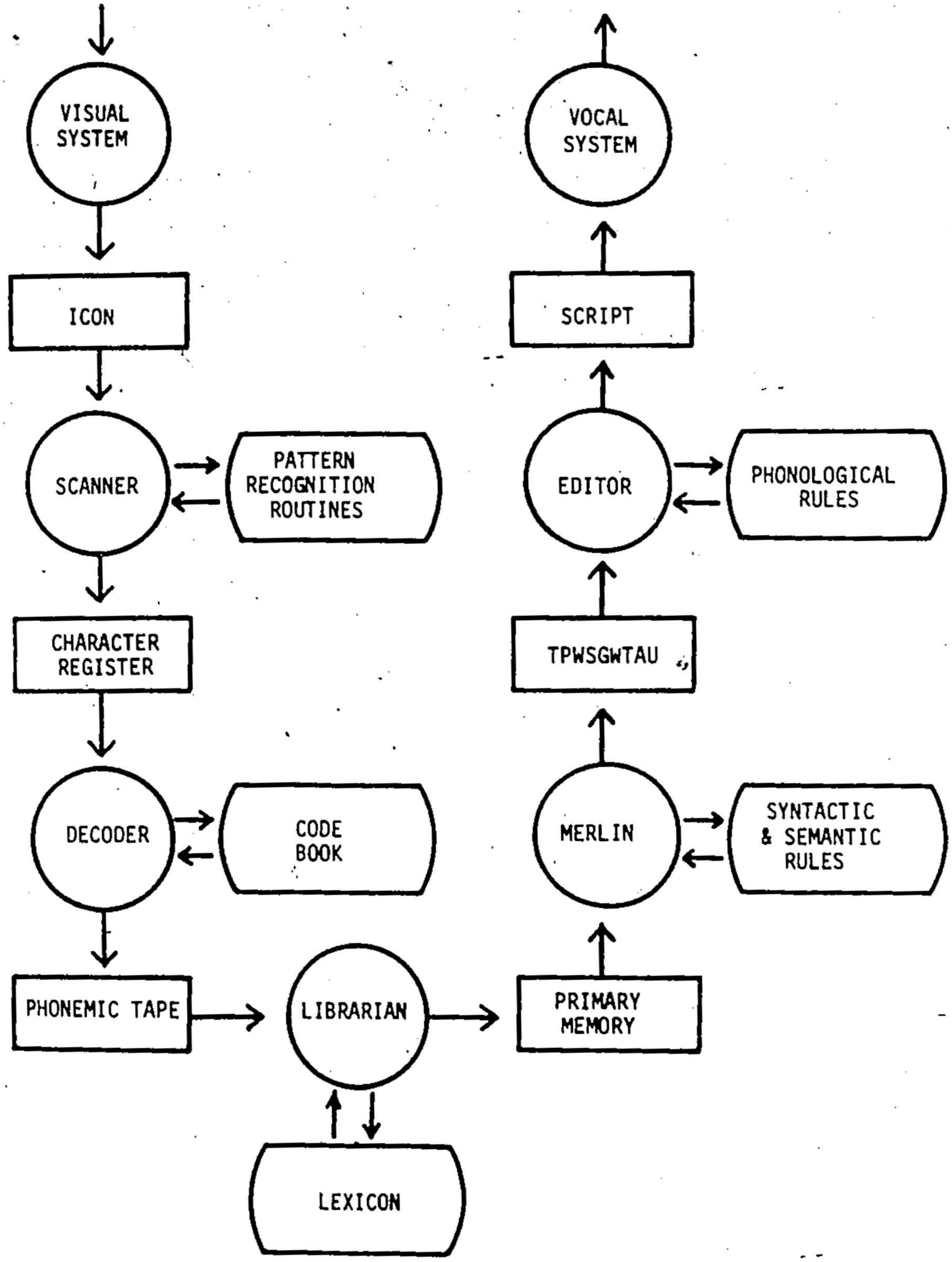

Figure 1: Gough's Model of Reading

phonemic features are matched with phonemic information in the lexicon, resulting in word identification. Each word, as well as semantic and syntactic features associated with it in the lexicon, are sent to be further processed in primary memory. In Gough's (1972) formulation, primary memory provides a temporary buffer where a limited number of words, and their associated attributes, are stored and operated on by a comprehension device. In that the mechanisms underlying comprehension were poorly understood, Gough labelled the comprehension device "Merlin"; subsequent storage occurred in "The Place Where Sentences Go When They Are Understood" (TPWSGWTAU). Further processing, including the application of what Gough terms phonological rules, resulted in oral reading of the message.

While Gough's model was proposed to account for proficient reading, Gough suggested an application to the acquisition of reading skill in young children. In that the beginning reader possesses fairly well-developed language skills, the primary task facing the child is to develop early data-driven processes related to analyzing print. More specifically, Gough proposes that the character recognition device must be developed in order to recognize letters, as well as their transformation into phonemes by a decoder; the input from these stages can then be transferred to already existing phonemic and comprehension devices.

A second, and influential, bottom-up processing model of reading was formulated by LaBerge & Samuels (1974). Like the Gough model, LaBerge & Samuels proposed that the processing of print proceeds through a sequence of stages from visual analysis to comprehension (see Figure 2). In this

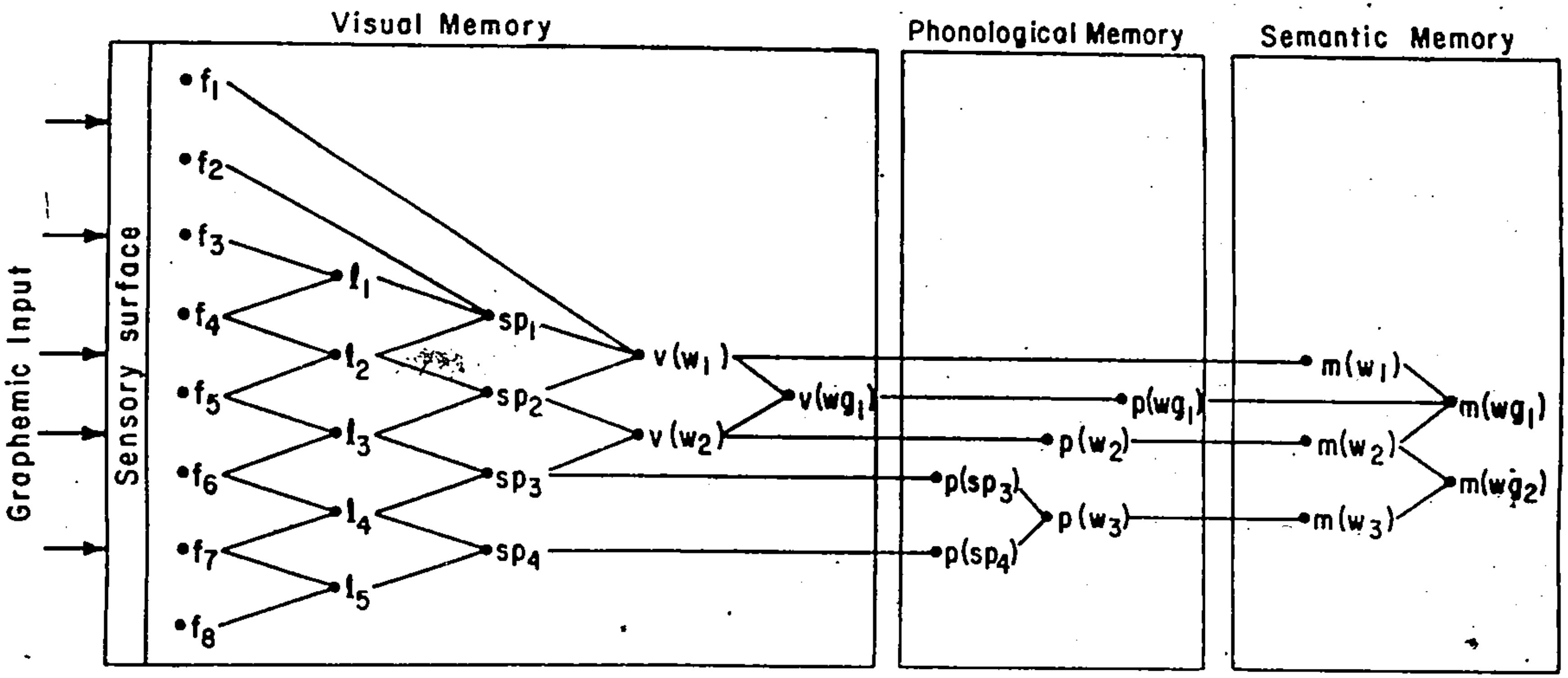

Figure 2: LaBerge & Samuels' Model of Reading

model, the visual input is analyzed by feature detectors; the results of this analysis are organized, or unitized, and then activate letter codes. These letter codes may subsequently activate spelling pattern codes, that in turn activate word codes. After these letter and word codes have been accessed from visual memory, the phonological code for the word is then activated from phonological memory. The meaning associated with the word is subsequently activated in semantic memory; comprehension results from the organization of two or more words within semantic memory.

Like the Gough model, the model of LaBerge and Samuels focuses on the initial, or data-driven, stages of processing the written stimuli. Moreover, in general form both models posit a series of stages where information is processed, and the results of this processing are then passed to the next stage for further processing. Both models posit that initially, letter codes are activated from the visual input through the processing of feature detectors. The LaBerge and Samuels model differs from the Gough model in that for some material, stages may be bypassed. For example, Gough posited that it was necessary for features to be transformed to a phonologically-based representation (the phonemic tape) prior to accessing words and their associated semantic and syntactic attributes in memory. While LaBerge & Samuels posit a similar process of pre-lexical phonological coding, they also propose that visual features may activate spelling, word or even meaning codes directly.

In addition, LaBerge and Samuels propose that processing of material may change with the development of expertise in reading. For example, at early stages of reading or when the word is unfamiliar, they suggest that a visual stimulus, as well as its associated meaning and pronunciation, may be represented as specific event in memory. With repeated exposure to the word, processing proceeds through visual and phonological memory, but the memory for the initial episode (episodic trace) may remain as a back-up. For LaBerge and Samuels, repeated experience with print acts to facilitate the activation and organization at each processing stage, and is important in the development of proficient reading skill.

LaBerge & Samuels suggest that repetition, or practice, is important in developing automaticity, which they propose to be a critical feature of proficient reading. This concept of automaticity allows some flexibility in their model of reading: if processing at early stages can be completed automatically, attention can be directed elsewhere. Consequently, the task confronting the child learning to read includes the development of automatic (i.e., without attention) processing at all early stages; attention may then be directed toward organizing the meaning of the printed material. In the proficient reader, attention may be directed to lower-level processes, such as those underlying word identification. However, this redirection of attention to early data-driven stages disrupts processing at later stages, and results in attenuated comprehension. This concept of automatized components of reading skill has been influential in investigations of reading acquisition (e.g., Ehri & Wilce, 1983) and reading disability (e.g., Lovett, 1984).

While the Gough and the LaBerge and Samuels models differ in several respects, both models focus on hypothesized processes underlying transformation of print to meaning. These transformations are generally serial: processing is completed at one stage and then passed to the next stage for further processing. As is characteristic of bottom-up processing models, no mechanism is proposed by which conceptually-driven processes interact with earlier data-driven processes during reading.

Top-Down Processing Models of Reading

In contrast to the bottom-up, or data- driven, processing models of reading, top-down processing models focus on the prior knowledge of the reader, and how this knowledge influences reading. These models were heavily influenced by developments in linguistics and psycholinguistics, and hypothesize that the readers' semantic and syntactic knowledge direct lower-level visual processes. In the framework of top-down processing models, reading is a "psycholinguistic guessing game" (Goodman, 1967); readers use higher-level linguistic processes to sample printed text, predicting and testing their ongoing construction of its meaning. These models do not propose that the visual input is largely ignored under all conditions, but hypothesize that when higher-order knowledge is available to the reader, it will be used at the expense of lower-level visual and phonological processes. Under optimal conditions the direction of information processing proposed by top-down processing models is in direct opposition to that proposed by bottom-up processing models.

According to top-down processing models, the proficient reader goes directly from print to meaning; meaning is derived optimally from a group of words, rather than from a single word or smaller unit. Like the data-driven model, how comprehension is effected is not well specified, but a heavy emphasis is placed on the redundancy inherent in language. According to Smith (1971), knowledge and use of this redundancy overcomes the capacity limitations imposed by short-term memory on data-driven processing, and consequently can account for the fast reading rate of the proficient reader.

In Smith's (1971) model, redundancy occurs at the text, word and letter levels. In reading text, redundancy is given by the finite number of semantic and syntactic relationships in the language. In English, for example, the word "the" can be followed by only a subset of the words in the language. Knowledge of these linguistic constraints reduces the number of possible alternatives and facilitates reading directly from print to meaning. If this "immediate" form of deriving meaning does not occur, comprehension may then be mediated by identification at the single word level.

Redundancy at the word level comes from at least two sources of knowledge: (1) orthographic regularities and constraints are present in the language (e.g., in English, the combination "th" is acceptable at the beginning of a word; "ht" is not), and (2) words may be discriminated by distinctive features (e.g., "hot" can be discriminated from "not" by a set of features distinctive to "h" and "n"). When reading is at the word level, meaning may be derived directly from the visual features (immediate identification) or mediated by internal feature lists which then make contact with visual, acoustic, and semantic representations in memory. If meaning cannot be derived at the word level, then processing at the letter level occurs, either directly or by the analysis of each letter. In Smith's (1971) model, then, optimal processing occurs at the meaning level; processing at lower levels occurs only when the visual features cannot access meaning directly.

Similarly, Goodman (e.g., 1965; 1967) proposes that optimal processing during reading is at higher levels; extensive analysis at lower levels occurs only when higher-order processing cannot be accomplished. The Goodman model proposes that such higher-order processing is strategic: higher-order processes actually select the visual input to be processed. In this model, the proficient reader first scans and fixates on a portion of the printed text. Predictions are then generated based on the reader's prior knowledge of semantic and syntactic relationships as well as from knowledge acquired during reading. On the basis of these predictions, visual information is selected and processed by ~~the~~ visual system. Subsequently, long term memory is searched for phonological, semantic and syntactic information associated with the visual input. Tentative predictions are made on the basis of this processing and tested at semantic and syntactic levels. If these predictions are disconfirmed, a regressive eye movement is made and predictions are generated and tested through visual and phonological processing at the word level.

While there are differences between the top-down processing models of Smith and Goodman, both emphasize the importance of higher-order linguistic knowledge in reading. Extensive analysis at the lower levels occurs only when these higher-order processes fail to result in comprehension, or when such higher-order processing cannot be employed. The proficient reader is hypothesized to engage in extensive higher-order processing but the young reader, because of less well-developed linguistic knowledge, relies more heavily on analyses at lower levels. With further linguistic experience, however, the young reader is better able to use conceptually-driven processes in reading. Thus, while both conceptually- and data-driven models predict that the early reader relies more on visual input, the two types of models give very different accounts of proficient reading skill.

The hypothesis that conceptually-driven processes influence data-driven processes is consistent with findings in a number of areas within the study of cognition. Several findings in speech perception, for example, have indicated that listeners are insensitive to lower-level stimulus attributes in the presence of a syntactically regular, meaningful message. For example, when a phoneme is deleted from a spoken message, individuals report actually having heard the phoneme (e.g., Warren, 1970). Similarly, pauses in spoken language can be readily detected in the perceiver's native language despite the fact that there is no objective evidence for such pauses on a speech spectograph (e.g., Glass, Holyoak & Santa, 1979). In contrast, pauses are not perceived when the listener is unfamiliar with the language. These findings suggest that the linguistic knowledge acquired by individuals influence their perception of lower-level stimuli.

Similarly, several findings in the early reading literature suggest the importance of conceptually-driven processing in reading. For example,

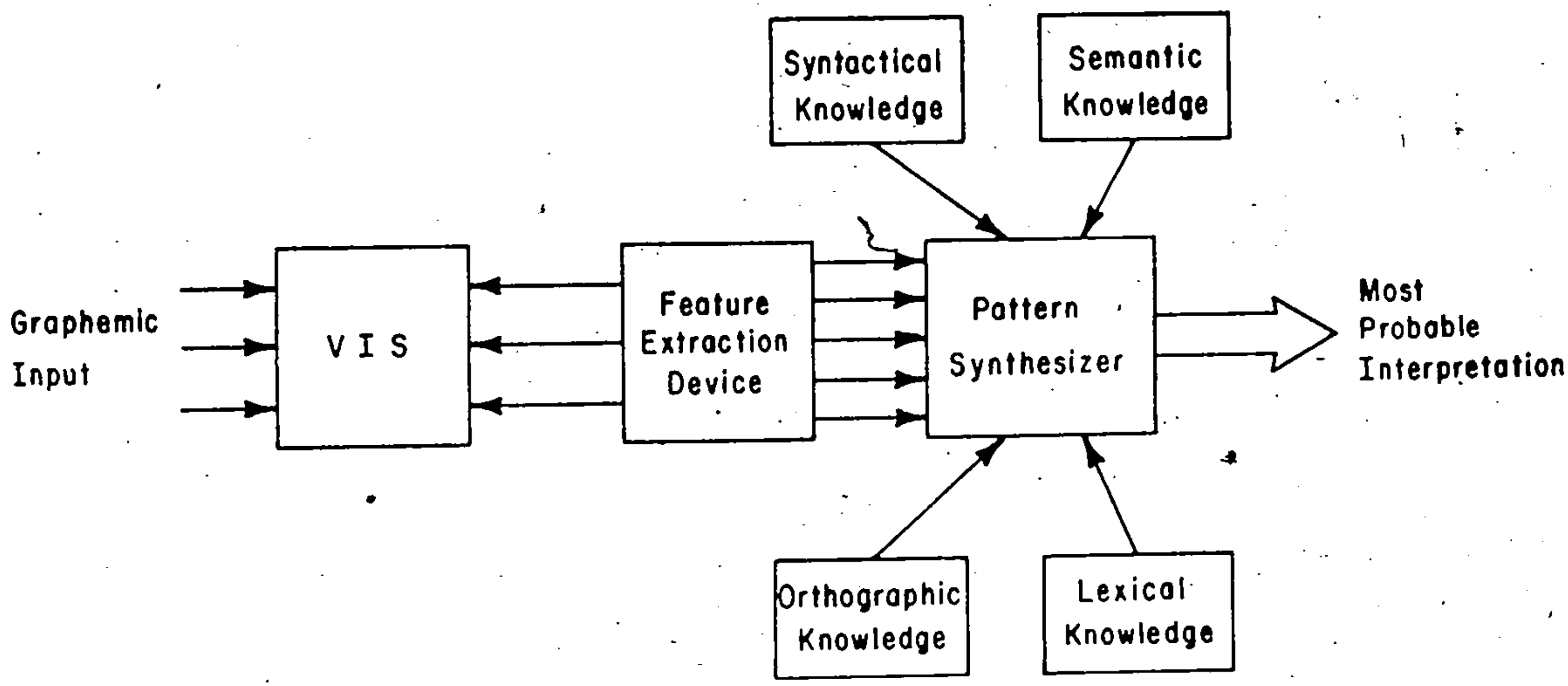

Figure 3: Rumelhart's Model of Reading

Cattell (1885) demonstrated that letters could be more easily identified when presented in a word than when presented in isolation. Such a finding is clearly inconsistent with data-driven models which posit that letters are processed sequentially and subsequently combined into words (e.g., Gough, 1972). Similarly, higher-order processing effects have been noted beyond the word level. Cattell (1885) also demonstrated that reading times were faster when sentences were presented within a semantically and syntactically regular text than when the words in the text were reordered, producing an agrammatical and semantically anomalous passage. These findings, and similar more recent findings, indicate that it is necessary to account for how linguistic knowledge already acquired by the reader influences ongoing processing during reading.

Interactive Models of Reading

The empirical work demonstrating that both data-driven and conceptually-driven processes influence reading led to formulations of how these processes interact in proficient reading skill (e.g., Rumelhart, 1977). In general form, Rumelhart's (1977) model specifies how multiple sources of processing can influence ongoing reading. In this model, a set of parallel, independent processes and independent knowledge sources interact at the level of the message center (see Figure 3). The model includes data-driven processes: information is first registered in a Visual Information Store (VIS), where it is operated on by a feature extraction device. Critical features extracted at this stage are then passed on to a pattern synthesizer. In contrast to the predominant assumption in bottom-up processing models, Rumelhart proposes that processing at lower stages need not be completed before processing at other levels begins; this allows for the interaction of higher-order processing with the partially processed visual input.

In Rumelhart's model, several sources of knowledge are proposed to operate independently. These knowledge sources include processing at the feature, letter and letter cluster, lexical, syntactic and semantic levels. The results of ongoing processing from all knowledge sources are sent to the message center. It is here that hypotheses based on input from the knowledge sources are evaluated. While multiple hypotheses are evaluated concurrently, Rumelhart proposed that the strength of any one hypothesis was the result of a multiplicative relationship between direct data-driven evidence and contextual, knowledge-based evidence. When the strength of any one hypothesis reached some critical level, this hypothesis would be accepted, and processing would be terminated.

The models of reading outlined in this chapter can be characterized by their focus on different processes that are hypothesized to be critical in determining proficient reading skill. As a result, research derived from these models differs in the dimension of reading that is examined. Research conducted within the framework of bottom-up processing models has tended to focus on processes underlying the identification of single words, and the implications of slower word-level processing for comprehension. Research derived from top-down processing models, in contrast, has tended to focus on reading of text, although some research has been focused on how higher-order knowledge facilitates the identification of single words. Interactive models have been influential in stimulating further research investigating how higher-order knowledge interacts with word-level processing in reading text, as well as in stimulating research which addresses the interrelationship between multiple dimensions of reading and language. These classes of models differ not only only in how reading is conceptualized, but also in what aspects of reading are selected for investigation.

In Chapter 2, research which has examined individual differences in reading skill will be presented with reference to the models from which the research was derived.

CHAPTER 2

Individual Differences in Reading Skill

The models of proficient reading presented in Chapter 1 are departures from earlier conceptualizations in that they represent an attempt to account for multiple aspects of reading, rather than being restricted to a single component, such as word or letter identification. As a result, these models were necessarily vague in specifying many of the processes underlying reading skill. The development of these models did, however, have an important impact in generating research into various aspects of reading.

With the development of models of proficient reading skill, the study of reading skills in individuals who differ in their level of achievement has become an active area of investigation. While it has long been recognized that considerable variability exists in reading skill, until the last decade little systematic examination of how such differences in reading are manifested had been conducted. This, in part, is attributable to the lack of models available to facilitate such an examination. Moreover, the major focus of early research in individual differences had been directed toward severely disabled readers, particularly in attempting to identify a physiological basis for their extreme difficulty in learning to read (Manis & Morrison, 1985).

Cases of severely disabled reading were first documented late in the nineteenth century by Morgan (1896) and Hinshelwood (e.g., 1900). Their reports presented evidence of a perplexing inability to acquire reading skills in children who apparently demonstrated normal development in other respects. This reading disorder was identified as "congenital word blindness", analogous to the "word blind" syndrome in adults who had lost the ability to read after cerebral insult. Like the adult syndrome, the congenital form was considered to be central, or brain-based, in origin rather than a peripheral sensory deficit, and was characterized as a selective impairment in the recognition of letters and words. Subsequently, Orton (1937) emphasized the occurrence of reversals in letters (e.g., "p" for "d") and words (e.g., "was" for "saw"); this emphasis led him to hypothesize that disabled (or "strephosymbolic") reading was a consequence of incomplete development of cerebral specialization, rather than selective cerebral pathology.

The early recognition of individual differences, then, was a result of the identification of children who were severely impaired, relative to their peers, in the acquisition of reading skills. The major theoretical focus was in identifying the physiological basis underlying the disorder, and the neurologically-based constructs and remedial programs in use throughout the next several decades reflected the impact of this focus (Wiederholt, 1974). Surprisingly absent during this period was an emphasis on reading skills which were apparent, or which could be learned by these children.

With more recent research, a wider range of individual differences has been incorporated into the study of variation in reading skill. This includes not only the severely disabled, or dyslexic, [1] reader but also those children scoring in the lower part of the distribution of reading skill. Whether severely disabled reading represents a clinical entity qualitatively distinct from the underachieving reader remains a controversial definitional issue in research into developmental dyslexia (e.g., Benton, & Pearl, 1978; Taylor, Satz & Friel, 1979). In practice, however, it is frequently the case that the same reading criteria are employed to select both "poor" or "dyslexic" readers. Typically, reader groups are defined on the basis of performance on a standardized reading test, where performance is expressed in relation to a distribution of individuals of the same age or grade level. For example, the criteria of 2 or more years behind expected grade level is frequently employed to select less-skilled readers, and whether this group is labelled as a dyslexic or poor reader group may depend upon the bias of the investigator. For this reason, reader groups selected in this manner will be referred to subsequently as "less-skilled" readers, thus avoiding the theoretical implications of other nomenclatures.[2]

The renewed interest in reading within cognitive psychology and the later development of models of reading resulted in the application of theoretical constructs and methods of investigation to the study of individual differences. In a general form, the models discussed in the previous chapter have provided a framework within which this individual difference research has been conducted. Bottom-up processing models have been particularly influential in stimulating research ~~in word~~ identification, and in attempts to identify processes which contribute to poor word recognition. Moreover, difficulties in processing at the word level have been hypothesized to limit comprehension, and remedial techniques focused at the word level have been advocated on the basis of this model (Samuels, 1979). Top-down processing models, while less influential in stimulating research, have been inflential because of their focus on reading of meaningful text. Moreover, these models make predictions concerning how individual differences are manifested in the use of semantic and syntactic knowledge during reading. The interactive model has been important in stimulating research investigating how context acts to facilitate word recognition in skilled and less-skilled readers. This framework more generally has been extended to encompass a wider investigation of the sources of knowledge which readers bring to the task of reading, and how knowledge at multiple levels influences processing for different levels of reading skill.

In the remainder of the chapter, research which has examined individual differences in reading skill will be reviewed with reference to these models.

A. Individual Differences and Data-Driven Processing

Bottom-up models of proficient reading skill have been particularly influential in stimulating research in the area of individual differences;

this research has indicated that a major source of individual differences is observed at the level of the word, or in processes hypothesized to underlie accurate and rapid word identification (Stanovich, 1982a). The research strategy employed has been to compare the performance of reader groups on data-driven processes delineated in bottom-up processing models. Particular emphasis has been placed on how differences in initial processing stages, particularly visual and phonological processes, underlie isolated word identification. Poorer word identification, in turn, is hypothesized to result in less efficient processing at later stages, resulting in impoverished comprehension of text.

(1) Visual Processing

A long-standing assumption has been that less-skilled readers, particularly disabled readers, have difficulty in processing visual information. While this assumption may have been influenced by Orton's (1937) emphasis on reversal errors, subsequent research has indicated that such errors are relatively infrequent (Fischer, Liberman & Shankweiler, 1978; Liberman, Shankweiler, Liberman, Orlando, Harris & Bell Berti, 1971). While the basis of these errors is still unclear, their occurrence may be an epiphenomenon of reading skill rather than a reliable diagnostic sign (Cornell, 1985; Stanovich, 1985).

Direct investigation of visual processing has indicated that there are no significant reader group differences on many measures. For example, children differing in reading skill do not differ in their performance on figure-ground discrimination (Goetzinger, Dirks & Baer, 1960), visual-sequential memory or three dimensional visualization (Stanley, 1976; Symmes & Rapoport, 1972). Moreover, the ability of less-skilled readers to correctly match both letters and nonverbal stimuli on the basis of physical identity is equivalent to skilled readers in childhood (e.g., Ellis, 1981) and in university populations (e.g., Jackson, 1980; Mason, Pilkington & Brandau, 1981). In general, memory for nonverbal visual designs does not differentiate skilled and less-skilled readers (Lovett, in press; Vellutino, Steger & Kandel, 1972; Vellutino, 1977) unless there is a verbal component to the visual memory task. However, Lyle and Goyen (1975) reported that less-skilled readers were impaired, relative to skilled readers, when visual stimuli were presented for brief intervals of 500 msec; Lyle and Goyen (1975) suggested that this difference for brief presentation rates may indicate that less-skilled readers are slower in processing information in visual form.

This hypothesis has also been proposed on the basis of performance on more sensitive visual information processing tasks. Two types of tasks have been employed in the investigation of individual differences. In backward masking tasks, presentation of a visual stimulus is followed by a patterned visual mask; the time between the onset of the first (test) stimulus and the mask, coupled with accurate identification of the test stimulus, is regarded as an index of the rate of visual processing. Temporal integration tasks, on the other hand, provide an index of the time course of a visual image by measuring the duration of the interval between two successive stimuli which is required to perceive the stimuli as separate events. In general, research employing these paradigms have yielded inconclusive results. Less-skilled readers have demonstrated slower visual processing rates than their skilled peers in some masking studies (DiLollo, Hansen & MacIntyre, 1983; Lovegrove & Brown, 1978; Stanley & Hall, 1973) although not in others (Arnett & DiLollo, 1979; Jackson & McClelland, 1975). Similarly, longer visual persistence times have been found for less-skilled readers (DiLollo et al., 1983; Lovegrove & Brown, 1978; Stanley, 1975; Stanley & Hall, 1973) but not consistently (Arnett & DiLollo, 1979; DiLollo et al., 1983). While these inconclusive results may be due to differences in the subject samples across studies, DiLollo et al. (1983) have hypothesized that less-skilled readers demonstrate slower visual processing only when the task entails repeated stimulation of the same retinal locations.

The results from investigations of visual processing indicate that less-skilled readers do not differ from skilled readers when relatively gross measures of visual processing are examined. When presentation times are relatively brief (Lyle & Goyen, 1975), however, and possibly involve repeated retinal stimulation (DiLollo et al., 1983), the less-skilled reader may demonstrate slower rates in processing visual material. The hypothesis that slower rates of visual information processing characterize the less-skilled reader, however, is in need of further empirical evaluation. Moreover, the relationship between deficits which may be observed under specific conditions and reading skill has not been clearly specified. According to bottom-up processing models, slow processing at this early stage would be expected to influence all later processing stages

-- either because information is lost during processing, or because the results of incomplete processing are passed to the next stage. How these hypothesized visual processing differences would be expected to influence performance in reading and how skill differences are manifested remain to be explored.

(2) Phonological Processing

While the young child beginning to read already possesses a fairly well-developed knowledge of language, a major task confronting the young reader is in recognizing that the speech stream, which is continuous in nature, may be represented as discrete units in written form (Gleitman & Rozin, 1977; Liberman, Shankweiler, Liberman, Fowler & Fischer, 1977). Historically, written languages have evolved from using symbols for representing concepts, to logographies for representing single words, to syllabaries, to the use of alphabetic symbols (Gleitman & Rozin, 1977). In general, alphabetic languages map symbols onto speech at the level of the phoneme, although in English morphology is also represented (Hung & Tzeng, 1981). The alphabetic nature of the relationship between oral language and its written form suggests that it is necessary for the beginning reader to become sensitive to the underlying structural dimensions of the language. Young preschool children appear to acquire the ability to segment words into syllabic units prior to learning to segment into phonemes (Liberman, Shankweiler, Fischer & Carter, 1974), a development which parallels the historical evolution of the components of written language (Gleitman &

Rozin, 1977).

The ability to discriminate the phonemic elements of spoken language appears to be critically related to reading acquisition in the early school years. Phonemic awareness, as measured by the ability to segment and blend phonemes, is highly correlated with early reading achievement, particularly when reading is measured as the ability to name single words (e.g., Calfee, Lindamood & Lindamood, 1973; Rosner, 1973; Liberman, 1973; Share, Jorm, Maclean & Matthews, 1984; Zifcak, 1981). In fact, Stanovich, Cunningham & Cramer (1984) have found that tasks measuring phonological skills are more highly correlated with reading than is intelligence. Moreover, phonemic awareness at school entry continues to predict reading skill at least two years later (e.g., Helfgott, 1976; Share et al., 1984; Tunmer & Nesdale, 1985). While good phonological skills may be a consequence of experience with print, there is some evidence to suggest that training of segmentation and blending skills facilitates learning of word-like forms (Fox & Routh, 1984).

Given the relationship between phonological skill and reading acquisition, difficulty in acquiring such phonological skills would be expected to be related to poor reading skills. Less-skilled readers are poorer in spoken language tasks which require rhyming (e.g., Bradley & Bryant, 1978; 1983; Savin, 1972) and have difficulty in repeating multisyllabic pseudowords which have been spoken aloud (Snowling, 1981). Tasks measuring phonemic analysis and synthesis ability differentiate skilled and less-skilled readers (Beech & Harding, 1984; Bradley & Bryant, 1978; 1983; Fox & Routh, 1980; Liberman et al., 1974) as well as precocious and average readers (Backman, 1983). The poorer phonological skills observed in less-skilled readers are typically seen in the early school years; even severely disabled readers have demonstrated adequate analysis and synthesis skills when re-tested several years later (Fox & Routh, 1983).

The development of an understanding of the underlying phonemic structure of oral language is hypothesized to be an important prerequisite in learning to read. This knowledge then allows the reader to take advantage of the alphabetic representation of language in print. The precise nature of the relationship between the transformation of a word in its visual form to the derivation of its meaning remains controversial. Gough (1972), for example, proposed that it was necessary to convert a word into its phonological representation; this representation was then used to access its corresponding phonological representation in the lexicon. LaBerge & Samuels (1974) posited a similar process of transforming visual information via phonological processing, although the conversion to phonological form was not hypothesized to be a necessary stage. More recent conceptualizations of word identification, however, have suggested that it is not always necessary for the results of visual processing to be recoded into a phonological form. Instead, both visual and phonological processes are hypothesized to act in parallel, with visual processing typically assumed to occur more rapidly and prior to the activation of phonological processing (McCusker, Hillinger & Bias, 1981).

The chief advantage of phonological processing at the word level is that it allows an unfamiliar, or novel, word to be identified (e.g., Gleitman & Rozin, 1977; Liberman et al., 1977), and consequently provides a means by which individuals can learn to identify new words without specific instruction (Jorm and Share, 1983). Phonological analysis may also provide a basis for generating cues which allow retrieval of a word. On the other hand, words which are encountered frequently in print may be read rapidly either because there has been a shift from phonological to visual processing (McCusker et al., 1981), or because both types of processing have become more efficient with repeated experience (Jorm & Share, 1983).

While the way in which children learn to identify words in the initial stages of reading is not well understood, research in individual differences in reading has examined how factors known to affect proficient readers' word identification differentiate between readers differing in skill level.

(3) Word Identification

If a major advantage of an alphabetic system is that it allows identification of unfamiliar words, it would be expected that word familiarity (operationally defined as word frequency) would influence a reader's ability to pronounce individual words. Across a variety of grade levels, less-skilled readers appear to be more affected by word frequency than are their more skilled peers: while they are slower and less accurate in naming individual words of high frequency, greater differences between reader groups are observed for low-frequency words (e.g., Frederiksen, 1978, 1981; Mason, 1978; Perfetti & Hogaboam, 1975; Waters, Seidenburg &

Bruck, 1984). Similarly, a consistent finding has been that less-skilled readers across a variety of ages are differentially poorer in identifying unfamiliar pseudowords than are skilled readers of their own age (e.g., Backman, Bruck & Hebert & Seidenburg, 1984; Barron, 1978; Kochnower, Richardson & DiBenedetto, 1983; Mason, 1978; Perfetti & Hogaboam, 1975).

Moreover, Frederiksen (1978) has found different relationships between word types for skilled and less-skilled readers. For the less-skilled readers, naming latencies for pseudowords were highly correlated with latencies to name low-frequency words. In contrast, the latencies to name pseudowords and high-frequency words were uncorrelated. For the skilled readers, similar correlations were found between pseudowords and words of high and low frequency. The different pattern of correlations between the two groups suggests that frequency is influencing the less-skilled readers' performance in a way which is different than that of the skilled readers. For the less-skilled readers, processing of low-frequency words is similar to that of pseudowords, which by definition are unfamiliar, and less similar to their processing of more frequently encountered words. Whether this pattern of performance (one which was not demonstrated by the skilled readers) reflects relatively less experience with print, or a relative inability to take advantage of such experience, cannot be ascertained from the data.

The poorer performance of less-skilled readers does not appear to be a function of word naming skill more generally, because less-skilled readers are typically slower and less accurate in naming pseudowords when compared to younger skilled readers who have achieved the same absolute level of word identification skill (e.g., Manis & Morrison, 1985; Snowling, 1981). They may, however, demonstrate equivalent performance when the pseudowords are simpler monosyllabic stimuli (Beech & Harding, 1984; Treiman & Hirsh-Pasek, 1985). This may indicate that less-skilled readers are generally less able to identify words and pseudowords which require a greater reliance on phonological processing. Increments in both word length and the number of syllables, which would be expected to increase the demand for phonological processing skills, increase differences in naming accuracy and speed between reader groups (e.g., Snowling, 1981; Mason, 1978).

The advantage of an alphabetic system would be expected to accrue primarily for those words with regular orthographic patterns. Early research investigating differences in word identification skill compared the perfomance on regular and exception words. Regular words were defined as having pronunciations which conformed to rules of grapheme-phoneme correspondences in English (e.g., gave). Exception words, on the other hand, could not be derived by the application of these rules (e.g., have). While skilled readers in the third grade have been found to be faster and more accurate in responding to regular than exception words in a lexical decision task, less-skilled readers demonstrated no difference between these two types of words (Barron, 1980). This finding suggested that the less-skilled readers were less able to take advantage of the rules which could be employed to combine phonemes in regular orthographic configurations. This interpretation was consistent with difficulties in phonological processing observed in less-skilled readers more generally.

In view of this difficulty in phonological processing, the less-skilled readers were hypothesized to be more reliant on visual processing of the words.

In contrast, in research conducted with a sample of university students, neither skilled nor less-skilled readers demonstrated differences in naming times to regular and exception words (Mason, 1978). On the basis of these data, Mason (1978) suggested that both groups of adult readers relied on visual, rather than phonological, processing when naming individual words: the less-skilled readers' reliance on visual processing was hypothesized to be a result of their poorer phonological skills, while the skilled readers relied on visual processing because it was most efficient. The different results observed between children in grade 3 (Barron, 1978) and university students (Mason, 1978) may be related to the differences in age and skill level of the subject samples, or to differences between the naming and lexical decision paradigms. However, subsequent research has indicated that differences between regular and exception words are not reliably found across lexical decision studies employing skilled readers (e.g., Coltheart, Besner, Jonasson, & Davelaar, 1979; Stanovich & Bauer, 1978). This unreliability may, in part, be due to differences in the items employed across different studies (Stanovich & Bauer, 1978).

More recently, the consistency with which an orthographic pattern is associated with a single pronunciation has been hypothesized to be an important additional factor in influencing word identification (Glushko, 1979; Seidenburg, Waters, Barnes & Tannenhaus, 1984). For example, although the word "gave" conforms to regular grapheme-phoneme correspondence rules, its orthographic pattern is inconsistent because there exists a nonrhyming word "have" with the same orthography. Using these dual criteria (orthographic consistency and the regularity of sound-symbol correspondences), several recent studies have found that children demonstrate a regular word advantage. Both skilled and less-skilled readers are more accurate in naming regular consistent words than words which are inconsistent or exceptions to regular sound-symbol correspondences (Backman et al., 1984; Lovett, in press; Waters et al., 1984). Moreover, while less-skilled readers are slower and less accurate than their skilled peers, their overall performance appears similar to that of younger, skilled readers (e.g., Backman et al., 1984; Beech & Harding, 1984).

Despite the fact that less-skilled readers, like skilled readers, demonstrate a regular word advantage, their pattern of errors suggests that their use of sound-symbol relationships is not as well-developed as that of the skilled readers. Backman et al. (1984) noted that most of the errors made to exception and inconsistent words were regularized pronunciations (e.g., "have" read to rhyme with "gave"); the less-skilled readers, however, made proportionally fewer errors of this type.

In addition to less-developed knowledge of regular sound-symbol correspondences the less-skilled readers, like the skilled readers, have more difficulty with words which have inconsistently-pronounced orthographic patterns, as well as irregular (e.g., "aisle", "ache") and ambiguous (e.g., "clown", "blown") spelling patterns (Backman et al., 1984;

Waters et al., 1984). The differences between reader groups have been observed in children up to grade 4 (Backman et al., 1984; Waters et al., 1984) and in a disabled reader population ranging in age from 8 to 13 years (Lovett, in press). Whether inconsistent orthographic patterns continue to pose difficulty for less-skilled readers at later stages in reading has not been addressed, and was investigated in the first study of the thesis.

Differences between skill groups in orthographic knowledge has also been demonstrated on tasks other than word naming. Steinheiser & Guthrie (1978) compared skilled and less-skilled readers' performance in matching vowel combinations of word pairs on the basis of either physical (e.g., h<u>ea</u>t/h<u>ea</u>d) or sound (e.g., h<u>ea</u>t/f<u>ee</u>t) similarity.
Less-skilled readers were both slower and less accurate on both tasks when compared to skilled readers. When compared to younger children matched for reading level, however, the less-skilled readers were both slower and less accurate only when required to match on the basis of sound. The results of this study suggest that the less-skilled readers have particular difficulty with sound-symbol matching; in that their performance was worse than reading-matched younger children, their difficulty does not appear to be attributable to their attained level of reading. Similar findings have been reported by Snowling (1980) in visual-auditory matching.

Examination of skill-group differences has indicated that less-skilled readers demonstrate poorer performance along a number of dimensions related to reading individual words. They demonstrate poorer phonological processing skills during the early school years. These poorer phonological skills are hypothesized to be related to early reading skills, particularly in identifying novel and less familiar words. In fact, tasks measuring phonological processing abilities are correlated with reading in the early school years, particularly with reading individual words. Moreover, less-skilled readers have particular difficulty with unfamiliar and low-frequency words, and with words containing inconsistent or irregular orthographic patterns.

In addition to their poorer accuracy in naming individual words, less-skilled readers are also slower in pronouncing those words which they are able to name accurately. Although their naming speed is particularly slow for less frequent words, this effect is still apparent for familiar high-frequency words. Less-skilled readers' relative slowness in naming does not appear to be specific to words, however. Although less-skilled readers are as fast as skilled readers on physical matching tasks, they respond more slowly when required to match on the basis of the same name (Eg. Aa; Ellis, 1981; Jackson, 1980; Jackson & McClelland, 1979). In fact, speed of naming colours, pictures, letters and numbers has been found to discriminate skilled and less-skilled readers (Bouma & Legein, 1980; Denckla & Rudel, 1976; Lovett, in press; Spring & Capps, 1974; but see Perfetti, Finger & Hogaboam, 1978). Moreover, speed of naming pictures and letters in kindergarten predicts reading achievement at the end of grade 1 (Share et al., 1984). The fact that naming speed is related to reading skill suggests that some portion of the less-skilled readers' slower word naming may be attributable to a slower rate in accessing or in producing a verbal label for a given symbol.

The slower naming demonstrated by less-skilled readers may reflect their more general difficulty on verbally-based tasks (Perfetti, 1985). For example, less-skilled readers are not only slower on name matching tasks, but also on tasks which require matching on the basis of category membership (Jackson, 1980; Jackson & McClelland, 1979). Whether individual differences are a result of differences in processing which are specific to linguistic material remains to be determined. As noted earlier, less-skilled readers may also demonstrate slower visual processing under some conditions: this suggests that slower processing more generally may be characteristic of the less-skilled reader.

The differences observed between skilled and less-skilled readers indicate that, even when reading skill is defined by comprehension ability, between-group differences are apparent at the word or subword level. According to bottom-up processing models of proficient reading, poorer data-driven processes would be expected to affect all later processing stages. Correlational studies suggest that there is a significant relationship between word-level processing and processing beyond the word. For example, a typical finding (e.g., Shankweiler & Liberman, 1972) is that reading of word lists is highly correlated with reading text. Moreover, at least in the early school years, the accuracy and speed with which words are pronounced is highly correlated with reading comprehension (e.g., Curtis, 1980; Stevenson, Parker, Wilkinson, Hegion & Fish, 1976). These data have been taken to indicate that processes at the word or subword level are a major source of individual differences and contribute to differences in comprehension (e.g., Stanovich, 1982a; Perfetti & Hogaboam, 1975).

(4) Comprehension

According to bottom-up processing models, once a word and its associated meaning have been derived from the lexicon, the results of this processing are then transferred to short-term memory. In short-term memory, this information is temporarily held so that processing for meaning beyond the single word may occur. Because processing is hypothesized to occur in a serial word-by-word fashion, word order as well as information derived from the lexicon are important components of short-term storage (Liberman et al., 1977; Perfetti & McCutcheon, 1982).

Hypotheses of individual differences in short-term memory are focused on two components of processing; these components are not necessarily independent of each other. One source of differences between reader groups is hypothesized to be the actual processing involved in short-term memory; less-skilled readers are hypothesized to be less efficient in processing information transferred to short-term storage. In addition, individual differences in short-term memory are also hypothesized to be a consequence of the serial nature of bottom-up processing: as earlier processes are slower and less accurate, processing at subsequent stages is carried out on information which is impoverished.

Whether skill differences exist in short-term memory independent of prior processing differences is difficult to ascertain. In general, skill differences may be observed in a variety of short-term memory tasks, but frequently the relationship between the memory measure and reading skill is not readily apparent.

One source of individual differences which has been related to reading is the use of phonological coding in short-term memory; phonology is thought to provide a relatively stable code which allows integration of the meaning of a series of words (e.g., Jorm & Share, 1983; Liberman et al., 1977; Perfetti & McCutcheon, 1982; Shankweiler, Liberman, Mark, Fowler & Fischer, 1979). The research reviewed in the previous section indicated that less-skilled readers perform poorly on phonological tasks hypothesized to be related to word identification. If comprehension is mediated by a phonologically-based short-term store, it would be expected that poor phonological skills would also adversely affect comprehension. Research conducted by I.Y. Liberman and her colleagues has focused on the nature of children's errors in short term memory: this research has suggested that less-skilled readers in the second grade are not as reliant on phonological codes as are their more skilled peers. For example, Shankweiler et al. (1979) presented children with rhyming and nonrhyming lists of letters to be remembered: highly skilled readers demonstrated poorer recall when the lists were phonetically similar (e.g., b,g,d) than when the lists were different (e.g., f,k,n). In contrast, less-skilled readers were not affected by the phonetic confusability of the rhyming lists; their recall did not differ between the two conditions. These results were subsequently extended to paradigms employing words (Mark, Shankweiler, Liberman & Fowler, 1977) and sentences (Mann, Liberman & Shankweiler, 1980) which suggested that the less-skilled readers' limited use of phonological coding was related to their difficulty in reading.

However, subsequent research has indicated that the insensitivity to phonetic interference is characteristic of less-skilled readers only at younger ages; older children do demonstrate phonetic interference effects (Bisanz, Das & Mancini, 1984; Olson, Davidson, Kliegl & Davies, 1984; Siegel & Linder, 1984), although the overall performance of the less-skilled readers is lower. The results from these short-term memory tasks, then, indicate that an insensitivity to phonetic interference is apparent in the less-skilled reader when young. While older less-skilled readers demonstrate sensitivity to the phonemic dimensions of the task, it is not clear whether their use of a phonological code is equivalent to that employed by skilled readers.

The major difference in memory, however, is proposed to be a consequence of the inefficiency of less-skilled readers' data-driven processes (Baddeley, Logie, Nimmo-Smith & Brereton, 1985; Daneman & Carpenter, 1980; Perfetti & Lesgold, 1977; 1979). Because lower-level processes are slow and may result in the transfer of impoverished information, less capacity is available for "functional" short-term (Perfetti & Lesgold, 1977) or working memory (Baddeley et al., 1985; Daneman & Carpenter, 1980). In effect, this less efficient processing is hypothesized to result in a "bottleneck" in short-term memory (Perfetti & Lesgold, 1977; 1978). One consequence of such a bottleneck would be expected to be the loss of specific word information in a passage. Perfetti & Goldman (1976) have found that less-skilled readers demonstrated poorer probed recall of words within specific sentences than did skilled readers, despite equivalent performance on a memory task (digit recall) that did not require reading. Similarly, Waller (1976) found that more false recognition errors are made by less-skilled readers when selected changes in wording are made.

Because of the linear nature of bottom-up processing models, a bottleneck in memory would be expected to limit higher-order processing involved in comprehension. Demonstrations that less-skilled readers are less sensitive to sentential and phrasal constraints in recall (Goldman, Hogaboam, Bell & Perfetti, 1980) provide support for this view of differences between reader groups. Moreover, investigation of the extent to which text structure influences recall has suggested that less-skilled readers are not as sensitive to this higher-order dimension of meaning in processing text (e.g., Meyer, Brandt & Bluth, 1980; Rahman & Bisanz, in press).

B. Individual Differences and Conceptually-Driven Processing

The central premise in top-down processing models is that proficient reading is characterized by the use of higher-order linguistic knowledge, which guides processing of lower-level visual information. In contrast, the less-skilled reader is proposed to be impaired in the use of linguistic knowledge, and consequently, does not benefit from redundancy inherent in language to the same extent as does the skilled reader. At the level of the single word, the less-skilled reader is hypothesized to be less able to take advantage of orthographic redundancy to guide single word identification. Similarly, in reading text, the less-skilled reader is hypothesized to be less able to use syntactic and semantic information in order to generate predictions about subsequent text. As a consequence, the less-skilled reader is proposed to be more reliant on the graphic features of individual words -- in effect, reading in a "word-by-word" fashion.

(1) Use of Orthographic Redundancy at the Word Level

The evidence reviewed in the previous section indicated that less-skilled readers' knowledge of orthography was less well developed than that of their skilled peers. The critical comparison needed to address the prediction derived from top down models of reading skill, however, is whether the less-skilled readers are less able to use their knowledge of orthographic constraints in word identification than are skilled readers (Stanovich, 1980). The most frequently employed index of orthographic redundancy is that of positional frequency, which provides a measure of the frequency that letters, or letter combinations, occur in specific positions within words. The effect of positional frequency has been investigated using both the word search and word naming paradigms.

In the word search paradigm, subjects are asked to indicate whether a previously presented target letter is present in a word or pseudoword. The comparison of performance between search items with different positional frequencies may indicate the extent to which readers are sensitive to that dimension. Mason (1975) has reported that while skilled and less-skilled readers demonstrated equivalent performance when the search field consists of items with low positional frequency, the skilled readers demonstrated greater sensitivity (i.e. more errors) with items of high positional frequency. This finding suggests that the skilled readers are influenced more by the positional frequency of the search items than are the less-skilled readers. However, in a subsequent study, Mason and Katz (1976) demonstrated similar positional frequency effects when nonlinguistic stimuli were used. These results suggest that the effects observed in the letter search tasks may not reflect specific use of linguistic knowledge, but reflect lower-level perceptual differences (Mason et al., 1981).

When reading is examined directly, the effect of positional frequency suggests that, in contrast to the prediction derived from top-down processing models, it is the less-skilled readers who are more influenced by positional frequency than are skilled readers, as would be predicted by top-down processing models. Barron (1980) found that less-skilled readers in grade three responded to words with high positional frequency faster than those of low positional frequency; skilled readers, however, did not differentiate between words with different values of positional frequency. Similarly, Mason (1978) found redundancy effects differed for university readers of different skill: the less-skilled readers demonstrated greater effects than did the skilled readers. Moreover, less-skilled readers in adolescence have been found to be differentially slower in identifying letter pairs in low, rather than high, frequency positions (Frederiksen, 1978). These results suggest that it is the less-skilled readers who make greater use of orthographic redundancy in word identification. However, this effect may be due to differential familiarity with the word items. For example, Mason (1978) found effects of positional frequency primarily for pseudowords; it may be that redundancy effects were less for words because of the subjects' greater familiarity with them.

The results from experiments investigating the use of redundancy at the word level, then, suggest that it is the less-skilled readers, rather than the skilled readers, who are more reliant on this redundancy in reading. These findings do not support predictions from top-down processing models: according to these models, the less-skilled readers are impaired in the use of higher-order linguistic processing.

(2) Use of Redundancy in Reading Text

In contrast to much of the research examining data-driven processing in reading, research generated by top-down processing models of reading has focused to a large extent on the use of text material. This focus has consisted primarily of examining oral reading errors; in fact, Goodman (e.g. 1969; 1973; Goodman & Goodman, 1977) used reading errors (or miscues) to demonstrate the influence of semantic and syntactic knowledge in reading. In early work, Goodman (1965) demonstrated that grade 1 readers achieved more accurate identification of words in text than when the same words were presented singly, suggesting that the young reader was using semantic and syntactic aspects of the passage to facilitate word recognition. Moreover, many errors were semantically or syntactically consistent with text, although they did not appear to be constrained by graphic information. The hypothesis derived from the top-down model provided a theoretical rationale for a method which had previously been largely descriptive in nature, and employed primarily as an aid in determining reading level (Leu, 1982; Weber, 1968). A major assumption in employing this method to examine the contribution of conceptually-driven processes was that the processes underlying reading errors were the same as those underlying accurate reading. Consequently, inferences about underlying processes during reading could be made from incorrectly identified words (Leu, 1982).

Subsequent research in oral reading errors, however, has suggested that less-skilled readers demonstrate sensitivity to higher-order linguistic information in text to the same extent as do skilled readers. For example, although the absolute number of errors made by the less-skilled readers is greater, there is no difference in the proportion of semantically or syntactically consistent errors made by skilled and less-skilled readers in early school years (Clay, 1968; Weber, 1970). However, Weber (1970) found that where the reader groups did differ was in their tendency to correct such errors: whereas the skilled readers generally corrected only syntactically unacceptable errors, the less-skilled readers corrected both acceptable and unacceptable errors to the same extent. This finding suggests that skill differences are manifested in comprehension monitoring, rather than in actually predicting subsequent text (Stanovich, 1980).

Skill differences have also been observed when the syntactic structure and meaning of text are manipulated. Allington (1978) compared differences between skill groups in reading normal, meaningful text with reading text in which the words had been randomly rearranged. If the less-skilled readers were using a word-by-word strategy rather than making use of higher-order linguistic information, it would be expected that their reading times for the two types of text would be similar. This hypothesis, however, was not supported by the results. While the skilled readers' accuracy was not influenced by the type of text, the less-skilled readers made more errors in reading scrambled, compared to normal, text. The semantic and syntactic content of the passages appeared to influence the less-skilled readers' accuracy, but not that of the skilled readers. In contrast, both groups demonstrated differences in reading times between the two types of text: the scrambled text was read more slowly than the normal, meaningful text. The reading rates of both groups appeared to be adversely affected when syntactic and semantic constraints were not present, but the proportional increase in time to read the scrambled text was greater for the less-skilled group. The results of this experiment provide no support for the hypothesis that less-skilled readers make less use of semantic and syntactic information while reading; they appear to rely on this information to a greater extent than do their skilled peers.

Moreover, it appears that it is the skilled readers, rather than the less-skilled readers who make more use of graphemic information in oral reading. Biemiller (1970) has demonstrated that while high- and low-ability groups do not differ in the proportion of contextually appropriate errors, the number of graphically constrained errors made during the first school year increased for skilled readers, but remained fairly constant for those less-skilled in reading. Kolers (1972) also reported that adolescent groups of readers made similar patterns of errors in reading transformed text, but that the errors of skilled readers were more constrained by graphemic information. Direct manipulation of graphemic cues was performed in an experiment by Allington & Strange (1977): specific words in text material were altered by changing a single letter to a visually similar letter. This alteration resulted in a word which rendered the meaning and syntax of the sentence anomalous (e.g. "He leaned too <u>fan</u> over the edge of the well"). Both skilled and less-skilled readers read the altered words as they had originally appeared 56% of the time; however, the skilled readers demonstrated a greater (but only marginally significant) tendency to read words in their altered form.

Taken together, research investigating use of higher-order linguistic information does not support the hypothesis that skilled readers are more reliant in using semantic and syntactic context when reading text than are less-skilled readers. Moreover, there is no support for the hypothesis that less-skilled readers are more dependent on graphemic cues when reading text: when between-group differences are observed, it is the skilled readers who make greater use of graphemic information.

C. Individual Differences and Interactive Processing

As reviewed in previous sections, research derived from bottom-up processing models of proficient reading has suggested that less-skilled readers are less efficient in data-driven processing. These less efficient data-driven processing skills are assumed to underlie the less-skilled readers' slower and less accurate performance in word identification, and to limit the amount of higher-order processing available for comprehension. In contrast, top-down processing models predict that less-skilled readers are poorer at comprehension because poorer language skills limit the amount of conceptually-driven processing in which they can engage. Both bottom-up and top-down processing models, then, predict that the less-skilled reader makes less use of higher-order linguistic processes when reading, although the bases for the prediction are very different. While less-skilled readers do demonstrate poorer performance on tasks tapping a number of dimensions of language skill (Stanovich, 1982b), the critical comparison is the extent to which these language skills are used in ongoing reading: research reviewed in the previous section suggested that it is the less-skilled reader who makes greater use of higher-order linguistic processes in ongoing reading.

In order to account for the less-skilled readers' greater reliance on the results of conceptually-driven processing, Stanovich (1980) has proposed a compensatory-interactive model of individual differences. In the presence of less efficient processing abilities at the data-driven level, Stanovich proposes that less-skilled readers rely more heavily on higher-order processing in ongoing reading. These conceptually-driven processes compensate for the less efficient data-driven processes. Stanovich distinguishes between two types of compensatory processes: (1) obligatory compensatory effects, which are a property of the processing system, and which operate quickly and automatically to facilitate word recognition, and (2) optional compensatory effects, which are slower and involve conscious expectancies under the individual's control. When identifying individual words in text, less-skilled readers are hypothesized to use both automatic and optional mechanisms; skilled readers, on the other hand, rely more on automatic processes alone, thus allowing faster word recognition, and freeing optional processes more for comprehension processing. In effect, skilled readers use the linguistic context to facilitate comprehension, while less-skilled readers use it for word identification.

One hypothesis derived from an interactive model would predict that when reading words in text, less-skilled readers would be more reliant on the semantic and syntactic structure of the text to aid word identification than the skilled reader. A set of experiments reported by Perfetti, Goldman & Hogaboam (1979) provide support for this hypothesis. In these experiments, grade 4 children were presented with either single words, or words in context. Both skilled and less-skilled readers' word identification latencies were facilitated when the words were presented in the context of meaningful sentences; the magnitude of the benefit, however, was greater for the less-skilled reader. This finding is consistent with the obligatory/optional compensatory processing effects proposed by Stanovich (1980): the skilled readers' performance in context is determined primarily by their word-level processing skills. Because the word-level processing of the skilled readers is hypothesized to be automatic, they derive less benefit from meaningful context in identifying words. The optional processing mechanisms can then be used in comprehending text. In contrast the less-skilled readers, because of poorer data-driven processing, are hypothesized to use both obligatory (automatic) and optional processes in order to identify words. As a consequence, higher-order processing of context is then allowed to exert effects on word identification.

Both Stanovich (1980) and Perfetti (1985; Perfetti & Roth, 1981) argue that the degree of contextual facilitation depends upon the speed of identifying single words. If word identification is slow -- either because the words themselves are degraded, or because of slower processing skills within an individual -- then context should exert an effect on word-level processing. Perfetti & Roth (1981) have reported that both skilled and less-skilled readers demonstrate a beneficial effect of context when words are degraded (by removing a proportion of the dots comprising the computer-generated letters of each word). As in previous studies, the less-skilled readers demonstrated greater effects of context. Compared to words presented in isolation, ~~words~~ presented in the context of a story were identified faster and more accurately by both groups of readers. The relative benefit derived from context, however, was greater for the less-skilled readers.

The results of investigations of higher-order linguistic processing, then, suggest that the less-skilled reader is more reliant on such processing than is the skilled reader. These between-group differences are based on relative increments: typically the overall performance of the less-skilled reader is poorer. Moreover, the less-skilled reader appears more likely to use higher-order linguistic knowledge to facilitate processing at lower levels, which is consistent with predictions derived from interactive models of reading (Stanovich, 1980). These results are inconsistent with predictions derived from both top-down and bottom-up processing models: the prediction that it is the skilled reader, rather than the less-skilled reader, who benefits most from context receives no support.

Reading and Repetition

While the models that have been discussed differ substantially in several respects, common to all of them is that the accounts of reading are essentially static in nature. With the exception of aspects of the LaBerge and Samuels (1974) model, each was proposed to account for processes underlying reading on a single trial; these processes are viewed as stable cognitive systems. These models more generally fall within the abstractionist framework which has dominated traditional research within cognitive psychology (Jacoby and Brooks, 1984). In such a traditional view, the stability of processing across different materials and experimental situations has been emphasized with a corresponding focus on theoretical constructs which incorporate characteristics of these invariant processes.

In contrast, recent theoretical and empirical work has emphasized the importance of changes in processing across repeated experience with the same or similar materials. The examination of such changes as a focus of interest has been advocated in such diverse areas as memory and concept formation (e.g., Jacoby & Brooks, 1984; Roediger & Blaxton, 1985), and reading fluency (e.g., Kolers, 1985; Levy, 1983) as well as intelligence testing (Estes, 1972), and other areas of traditional mental abilities measurement (Glaser, 1981). The advantage of incorporating repeated trials into such investigations is that it allows greater experimental control of the amount and quality of experience that individuals have with specific materials, and consequently the impact of that experience on subsequent performance can be more accurately evaluated. Examining the effect of experience with selected material, then, allows inferences about the effect of such experience on later re-processing of the same or similar material. Depending on the specific experimental manipulation, one can evaluate the effect of prior processing on later performance to the same material or transfer to selectively changed material.

An additional advantage of examining the effect of repetition on reading is that it allows direct investigation of the rate of acquisition, and has the potential of making contact with educational practice. Currently, little is known about the processes involved in reading acquisition (Lovett, 1981); how less-skilled readers differ from their normally achieving peers in their learning of relevant reading skills remains an open empirical question. With respect to accurate word learning, recent evidence suggests that the learning of poor readers may be dependent upon item characteristics, specific educational input, and the difficulties in transferring to new materials. Savage (1983), for example, examined whether the relationship within a set of items influenced skill differences in learning word-symbol correspondences. This experiment included two conditions. The consistent condition contained pairs of symbols differing in only one element; this element denoted an opposite relationship (e.g., good/bad). In the inconsistent condition, half of the items maintained the same opposite relationship while the remainder corresponded to unrelated words (e.g., new/hot). While there were no group differences in learning a unique one-to-one relationship between a symbol and its corresponding word, less-skilled readers performed less well when the symbols were related to each other. This between-group difference was particularly apparent when the relationship within the set of symbols was inconsistent. This finding suggests that the difficulties experienced by children when confronted with inconsistent or exception sound-symbol correspondences (Backman et al., 1984; Morrison, 1985) may be attributable to general difficulties inherent in learning inconsistent relationships.

This difficulty, however, may be readily amenable to specific remedial input. Lovett, Ransby, Hardwick & Johns (in press) have found that dyslexic children demonstrated greater post-treatment gains on exception, rather than regular, words. Rather than being specific to the type of words tested, this difference was attributed to the type of remedial intervention: while regular words were taught as instances of word families, exception words were drilled as unique individual instances. Moreover, the gains achieved by these children appeared to be specific to lexical items which were explicitly taught, suggesting that a difficulty in generalizing to new items may be characteristic of the reading-disabled population.

Other studies examining speeded performance of less extremely differentiated reading groups suggest that high- and low-skilled groups differ in the eventual level of performance after repeated trials. Ehri & Wilce (1983) have found that less-skilled readers, unlike their skilled peers, failed to reach automatized levels of performance (defined as speed of naming nonlexical visual items such as digits, letters or pictures) after word drills. Moreover, less-skilled readers fail to reach the same level of performance as better readers with repeated naming trials (Hogaboam & Perfetti, 1978; Ehri & Wilce, 1983), a finding which has been attributed to poorer quality decoding (Hogaboam & Perfetti, 1978) and to the slower development of unitized processing speed (Ehri & Wilce, 1983) in less-skilled readers.

In fact, Jackson (1980) has suggested that less-skilled adults' slower word naming skills are attributable to more generally slower naming of all visual stimuli; this slower naming is proposed to be independent of practice. In Jackson's (1980) study, skilled and less-skilled university students learned an association between a nonverbal visual stimulus and a pseudoword label. After repeated learning trials, the skilled readers were faster at naming the stimuli than were the less-skilled readers. This result is puzzling, however, in that over the course of the learning trials, the two reader groups did not differ in naming times. Moreover, Mason, Pilkington & Brandau (1981) have found no differences between university-level reading groups in either the speed or trials to criterion in a paired associate learning task similar to that employed by Jackson (1980).

Whether individual differences in performance are apparent across repeated experience with print remains a subject for further examination. Moreover, the effect of repeated experience with different types of material, and the extent of transfer to new material has not been extensively investigated. In particular, the relative benefit of repeated performance at the word and text levels has not been addressed. The purpose of the thesis was to investigate skill differences in selected dimensions of reading, and to evaluate whether there are individual differences in the benefit derived from repetition for different dimensions of reading.

CHAPTER 3

Individual Differences in Adults and Description of the Subject Sample

Most of the research in individual differences, which was reviewed in Chapter 2, has been conducted with children, with a particular emphasis on children in the elementary school grades. In contrast, most of the models of reading outlined in the first chapter have been developed to account for the proficient reading demonstrated in adulthood by university students. Relatively less research has focused on individual differences in reading during adulthood. Studies examining the adult performance of children who had earlier been identified as severely disabled readers, for example, have indicated that outcome is extremely variable (e.g., Herjanic & Penick, 1972). However, individuals who continue to engage in extensive academic pursuits demonstrate considerably better reading than matched peers who do not (Bruck, 1985), suggesting that for the disabled reader, continued experience with print is an important component in successful reading development. In outcome studies generally, however, the focus has been on level of reading achievement (ie. grade level), rather than a more intensive examination of multiple dimensions of reading.

In contrast, individual difference studies of reading in university students has paralleled recent research conducted with children. Given the nature of the sample more generally, these university samples are likely to be more homogeneous than those consisting of children in the earlier school years. Investigations of university populations do have an advantage in that these adults have more highly developed skills in reading; consequently, multiple dimensions of reading, particularly those that are hypothesized to be related to proficient comprehension, may be evaluated.

The research which has been conducted on reading in university students suggests that the factors which differentiate skilled from less-skilled readers are similar to those observed with children. Jackson & McClelland (1979), for example, found that fast and average readers were differentiated on a variety of matching tasks, as well as on auditory short-term memory and listening comprehension. Moreover, in subsequent regression analyses, listening comprehension accounted for a large proportion of the variance in effective reading speed (defined as speed X comprehension). A second factor which accounted for a lesser amount of the variance in effective reading speed was attributable to performance on reaction time tasks; this performance was effectively predicted by subjects' performance on name matching tasks (e.g., Aa). A third, and less significant predictor of effective reading speed was subjects' performance in matching homonyms (e.g., dough - doe) on the basis of pronunciation.

The high correlations between reading and listening comprehension suggested by the results of Jackson & McClelland (1979) for two groups of readers have subsequently been demonstrated across the range of reading comprehension skill observed in university populations (Jackson, 1980; Palmer, Macleod, Hunt & Davidson, 1985). This finding parallels that observed with children: beyond the initial 2 to 3 years of schooling, listening comprehension becomes the best predictor of reading comprehension (e.g., Curtis, 1980).

While the Jackson & McClelland (1979) study employed a combined measure of reading comprehension and speed as the dependent measure, a recent study by Palmer et al. (1985) suggests that the relationship between information processing measures and reading differs for the comprehension and speed components. While the relationship between listening comprehension and reading times were significant, it was lower than that observed between listening and reading comprehension (see also Jackson, 1980). Moreover, tasks measuring processing at the word level were related more to reading speed than to reading comprehension.

The review of individual difference research in Chapter 2 indicated that the hypothesis that word-level differences are a major source of differences in reading skill has received strong support (e.g., Stanovich, 1980a). In university students, Graesser, Hoffman & Clark (1980) have demonstrated through regression analyses that the speed of processing at the word level differentiates between fast and slow readers. In contrast, higher-order processing of complex semantic and syntactic relationships does not differentiate between groups of readers. This work is confounded, however, by the fact that readers were differentiated on the basis of their performance on the dependent variable of interest. More directly, Mason (1978) has found that skilled and less-skilled readers, defined on the basis of a standardized comprehension score, can also be differentiated on their performance in naming isolated words and pseudowords. In parallel with the results observed in younger populations, less-skilled readers were slower in naming words and pseudowords than were their more skilled peers.

The basis for individual differences at the word level and their relationship to comprehension of meaningful text is in need of further clarification. Based on their finding that letter naming is a secondary predictor of effective reading speed, Jackson & McClelland (1979) have proposed that the speed of accessing verbal codes in memory represents a source of individual differences underlying reading skill, a source which is independent of experience (Jackson, 1980). However, as noted in the previous chapter, individual differences in the ability to benefit from experience with print have not been extensively investigated. The experiments reported in the thesis were designed to examine individual differences along multiple dimensions of reading, as well as to determine whether less-skilled readers differ from skilled readers in their improvement across repeated trials. These experiments were designed to compare differences between skilled and less-skilled readers on selected components of reading, and to evaluate whether repetition at each of these levels had different effects for the two groups.

The population of interest in these studies was the young adult reader in university. This population was selected because, compared to children, these individuals have achieved relatively high levels of reading proficiency; as a consequence, multiple levels of reading could be examined. Moreover, students in a university population have already had extensive experience with print. Examination of their performance not only allows comparison with more diverse samples of younger children, but also allows examination of the effect of repeated experience with different types of material on more highly developed dimensions of reading. It may be the case, for example, that less-skilled readers have relatively less experience with print than their more skilled peers; providing repeated trials might indicate that with the benefit of such experience, they demonstrate performance levels similar to more skilled readers. On the other hand, if less-skilled readers are characterized by slower rates of acquisition, it would be expected that they would benefit less from repeated experience than would skilled readers.

All subjects who participated in the experiments reported here were selected from a larger group of Introductory Psychology students who received the comprehension subtest of the Nelson-Denny (Form F) Reading Test (Brown, Bennett & Hanna, 1981). This subtest consists of a set of passages to be read silently; each passage is followed by multiple choice questions based on information contained in that passage. The first passage of the test is approximately 600 words in length followed by 8 questions, while the remaining 7 passages are each approximately 200 words long and are followed by 4 questions. The time allotted for administration of the test is 20 minutes, during which a maximum of 36 questions may be answered. The comprehension measure is based on the number of questions which are answered correctly. In addition to comprehension, the test also provides a measure of reading rate. After the first minute of test administration, the number of words read from the first passage is recorded by the subject.

Both the comprehension and reading rate measures have been standardized with reference to the performance of individuals with an educational history of 9 to 16 years. Preliminary investigation of reading scores in a sample of Introductory Psychology students similar to that from which the subjects in the research were selected indicated that the distribution of their scores did not differ from that of the sample on which the test norms were based.[3]

Individuals were asked to participate in the experiments if their comprehension score met the criterion for either the skilled or less-skilled reader group. The less-skilled group was composed of readers scoring below the 25th percentile; the skilled group consisted of individuals who scored between the 61st and 88th percentiles. All subjects in the experiments were between 17 and 30 years of age, and were fluent speakers of English. The number of subjects participating in each experiment depended on the design requirements (see Table 1). Subjects received either course credit or payment for their participation.

The mean Nelson-Denny comprehension scores for individuals in each experiment are presented in Table 1. As the groups were selected on this comprehension measure, the difference between the skilled and less-skilled reader groups is highly significant (all p's $< .001$). In addition to the comprehension measure, differences between the groups were examined on the standardized measure of rate included in the test. The passage which subjects read to obtain this measure is at the grade 8 to 9 reading level (Brown et al., 1981). The mean reading rates for each group, expressed in

Table 1: Nelson-Denny Comprehension Scores for Skill Groups in Experiments 1 to 4 (maximum = 36)

	Skill Group	N	Score	F	df	p <
Experiment 1	Less-skilled	36	18.33	436.38	1,70	.001
	Skilled	36	29.89			
Experiment 2	Less-skilled	25	17.44	270.94	1,48	.001
	Skilled	25	29.96			
Experiment 3	Less-skilled	32	17.69	516.22	1,62	.001
	Skilled	32	29.97			
Experiment 4	Less-skilled	36	18.31	419.30	1,70	.001
	Skilled	36	29.89			

words per minute, are presented in Table 2. Evaluation of the groups' performance on this reading rate measure indicated that in all studies, there were significant differences between the skilled and less-skilled reader groups. This finding supports earlier research (Biemiller, 1977-1978), which indicated that when the comprehension measure includes a time component, between-group differences in reading rate are also apparent.

This finding also suggested that the major difference between the skill groups could have been primarily due to differences in reading rate. Because of slower rates, the less-skilled readers might be hypothesized to achieve lower comprehension scores because fewer questions were attempted, rather than because their understanding of the passages which they had read was markedly inferior. In order to determine whether the differences between the groups in comprehension could be accounted for primarily by differences in reading speed, a subsequent analysis attempted to separate the comprehension from rate components of the comprehension measure. This analysis was conducted on the number of correctly answered questions as a proportion of all questions attempted by each individual. The mean scores for each reader group are presented in Table 3: in all experiments, the differences between the skilled and less-skilled reader groups remain highly significant (all p's $< .001$).

In summary, subjects in the two reader groups selected for the experiments in the thesis were individually chosen on the basis of their comprehension score on a reading test which had been standardized on University populations. These groups comprised the first quartile (below

Table 2: Nelson-Denny Rate Scores for Skill Groups in Experiments 1 to 4 (words per minute)

	Skill Group	N	Rate	F	df	p <
Experiment 1	Less-skilled	36	207.25	16.08	1,70	.001
	Skilled	36	257.39			
Experiment 2	Less-skilled	25	226.16	5.16	1,48	.03
	Skilled	25	270.12			
Experiment 3	Less-skilled	32	234.59	7.74	1,62	.007
	Skilled	32	288.44			
Experiment 4	Less-skilled	36	206.17	18.50	1,70	.0001
	Skilled	36	257.39			

Table 3: Nelson-Denny Comprehension Scores for Questions Attempted by Each Skill Group in Experiments 1 to 4 (percent)

	Skill Group	N	Score	F	df	p <
Experiment 1	Less-skilled	36	69.81	54.98	1,70	.001
	Skilled	36	87.15			
Experiment 2	Less-skilled	25	65.97	58.16	1,48	.001
	Skilled	25	87.90			
Experiment 3	Less-skilled	32	66.95	104.18	1,62	.001
	Skilled	32	88.96			
Experiment 4	Less-skilled	36	70.31	50.62	1,70	.001
	Skilled	36	87.15			

25th percentile) and slightly above the third quartile (61st to 88th percentile) of the distribution of reading comprehension scores in similar populations. As well as differing from skilled readers in their attained comprehension score, the less-skilled readers read less quickly and demonstrated poorer comprehension when this measure included the number of comprehension questions attempted by the subjects.

CHAPTER 4

Experiment 1: Individual Differences in Processing at the Word Level

The research reviewed in Chapter 2 has indicated that individual differences in reading skill are readily apparent in processing at the word level: across a range of ages, less-skilled readers are slower and less accurate in naming individual words. Moreover, groups of less-skilled readers are particularly poor at naming pseudowords. Because pseudowords are, by definition, unfamiliar, this poorer performance has been attributed to the poorer phonological processing required to analyze and synthesize segments of these unknown words.

The extent to which phonological processing underlies reading of words more generally, however, remains unspecified. The traditional view, exemplified by the LaBerge and Samuels model as well as other dual access models, posited that word identification could be accomplished by either a visual or a phonological "route". An exception word was hypothesized to be accessed by the visual route, because it could not be accurately identified by the application of grapheme-phoneme correspondence rules. Regular words, in contrast, could be accessed by either a phonological or a visual route. Pseudowords, because they are unfamiliar, were assumed to be pronounced after phonological analysis of the individual components of the item.

Glushko (1979), however, has argued that the consistency with which a particular orthographic pattern was pronounced has more psychological validity than the linguistically-based notion of regularity. He proposed that, rather than access through separate routes, multiple sources of knowledge were activated simultaneously in order to identify a lexical item. These knowledge sources include phonology, as well as activation of similar words with the same orthographic pattern. The extent to which these orthographic patterns specified a similar pronunciation was hypothesized to influence the speed with which words were pronounced. The hypothesis that word identification could be accomplished by analogy to words with similar orthography was supported by Glushko's (1979) finding that there was a significant effect of orthographic consistency. Naming latencies were faster to regular consistent words (eg. gaze) than to regular inconsistent (eg. gave) and exception (eg. have) words. Particularly compelling support for the importance of the consistency of pronunciation was provided by the finding that even pseudowords which had an inconsistent orthographic pattern (eg. tave) had longer naming times than pseudowords with a consistent orthography (eg. taze). Consequently, it appears that accurate naming of pseudowords includes activation of items with similar orthography, as well as phonological knowledge.

Subsequent research by Kay & Marcel (1981) has indicated that the particular pronunciation given to an ambiguous pseudoword can be influenced by the prior occurrence of a word with a similar orthographic pattern.

Pseudowords with inconsistent orthographic patterns (eg. yead) tended to be pronounced to rhyme with the corresponding regular pronunciation (as in "bead") when presented under a number of conditions. However, if presentation of the pseudoword was preceded by a word with an irregular or exception pronunciation (eg. dead), there was a substantial increase in the proportion of responses which rhymed with the exception word. Similar effects in response times to regular, but inconsistent words of low frequency have been reported by Seidenburg, Water, Barnes, & Tannenhaus (1984). These demonstrations indicate that naming of word and pseudoword items is influenced by prior processing of items with similar orthography, and suggest that such prior presentations may provide a salient basis for accessing pronunciations by analogy.

Recent research has emphasized the importance of orthographic consistency in influencing children's word identification. As noted in Chapter 2, regular consistent words are pronounced more accurately than exception and inconsistent words by both skilled and less-skilled readers (Backman et al., 1984; Lovett, in press; Waters et al., 1984). Moreover, less-skilled readers have more difficulty with words which have inconsistent and irregular patterns (Backman et al., 1984; Waters et al., 1984).

The finding that orthographic consistency poses particular difficulty for less-skilled readers has been demonstrated in children. In adults, Mason (1978) has found that less-skilled readers, like skilled readers, are equally fast in responding to regular and exception words. However, regularity in this experiment was confounded with the consistency of orthographic patterns. Whether orthographic consistency continues to be a source of individual differences in reading in an adult university population was investigated in Experiment 1.

Method

Materials. The 172 word and pseudoword items used in the study were the same as those employed by Glushko (1979; Experiment 1; see Appendix A). The words were either regular or exception items, and were defined with respect to both the applicability of sound-symbol correspondence rules, and the consistency of the pronunciation of that orthography in English. Regular words were defined as those with pronunciations which could be derived by applying sound-symbol correspondence rules (e.g., plain). In addition, regular words were defined by the consistency of the pronunciation of that orthographic pattern in English: they were selected if other words with the same orthographic pattern have a consistent, or rhyming pronunciation. Exception words, on the other hand, were defined as having pronunciations which could not be generated by applying sound-symbol correspondence rules (e.g., plaid). These words also have inconsistent orthography in that there exist words with the same orthography with nonrhyming, but regular, pronunciations (e.g., maid).

Pseudowords were derived by changing the initial letter of all word items. "Regular" pseudoword (e.g., sust) pronunciations would be considered to be correct if they rhymed with the corresponding English word (e.g., must). "Exception" pseudowords (e.g., bost), in contrast, could rhyme with either the regular (e.g., cost) or exception (e.g., most) pronunciation for that orthography. Across the regular and exception word and pseudoword categories, the items were matched for the initial letters, so that comparisons of the latencies to each category were not confounded by differences in the time to pronounce specific sounds.

Procedure. Each item was presented individually in lower case letters by a slide projector. The onset of each slide activated a Gebrands clock counter which was stopped with the activation of a voice key by the subjects' verbal response. The items were presented in an order which was random with the restrictions that: (1) not more than 2 items from the same Regular and Exception word and pseudoword category were presented successively, (2) no more than three Regular and Exception, or three word or pseudoword items occurred successively; and (3) items could not be followed by another item which had more than 2 letters in common.

Because the order in which words are presented has been demonstrated to contribute to naming latencies (Seidenburg et al., 1984), two different orders were administered. Half of the subjects in each reader group received one order (F); the remaining subjects received the items in the reverse order (R).

Each subject was tested individually. Subjects were informed that they would be presented with words and pronounceable nonsense words. They were instructed to pronounce each item as quickly and as accurately as possible because both speed and accuracy were important to task performance.

Results and Discussion

In order to analyze the data, the first analysis was conducted on the naming latencies for all items pronounced accurately. Subsequent analyses examined both latencies and pronunciation errors in order to further explore effects reflected in the latency data.

The median latencies for those items named correctly were calculated for all regular and exception words and pseudowords.[4] Following Glushko (1979; Experiment 1), the first analysis was based on the criteria employed in that experiment: a response to an exception pseudoword was considered to be correct only if the pronunciation given by the subject was regular (ie. "tave" pronounced to rhyme with "gave"). However, while the majority of exception pseudowords were pronounced as regular items, they received exception pronunciations on approximately 20 per cent of the trials. Consequently, additional analyses were performed on the data from those trials where exception pronunciations were given by the subjects. The results of these analyses will be discussed after presentation of the first analysis.[5]

The latency data were subjected to a 2 (Group) X 2 (Order) X 2 (Word/Pseudoword Item) X 2 (Regular/Exception) analysis of variance, with the Group and Order factors as between-subject effects, and item and regularity as within-in subject measures. The mean latencies for all items pronounced correctly are presented in Table 4. Of interest in this

Table 4: Mean Latencies for Correct Pronunciations of Words and Pseudowords in Experiment 1 (msec)

	WORDS		PSEUDOWORDS	
	Regular	Exception	Regular	Exception
Less-skilled (N=36)	647 (92)	640 (93)	740 (143)	776 (166)
Skilled (N=36)	588 (81)	584 (82)	635 (93)	659 (103)

experiment was whether the less-skilled readers' performance to pseudowords and to items of irregular orthography differed from that of the skilled readers.

There was a significant effect of the word/pseudoword variable, F $(1,68) = 126.93$, $MSe = 4383.77$, $p < .001$, replicating the standard finding that naming times for pseudowords are substantially longer than the time taken to name words. Moreover, there was a significant effect of reader group, F $(1,68) = 11.66$, $MSe = 43940.76$, $p < .002$, as well as a significant interaction of reader group with the Word/Pseudoword effect, F $(1,68) = 12.10$, $MSe = 4383.77$, $p < .002$. Comparisons between the groups on word and pseudoword items were made by testing simple main effects (Keppel, 1982; Kirk, 1968). The less-skilled readers were markedly slower in naming pseudowords, F $(1,68) = 18.53$, $MSe = 24162.27$, $p < .001$, although group differences were also observed in naming times for words, F $(1,68) = 4.88$, $MSe = 24162.27$, $p < .05$. The group effect did not interact with regularity, F $(1,68) < 1.0$, $p > .05$, nor was the group X regularity X word/pseudoword interaction significant, F $(1,68) = 1.21$, $MSe = 732.84$, $p > .05$).

The finding that less-skilled readers are differentially poorer at pseudoword naming when compared with more skilled readers replicates previous findings across a wide range of reading achievement. The finding is consistent with the hypothesis that one source of individual differences is in phonological processing, specifically in the analysis and synthesis of sounds in unknown, or unfamiliar, words. Because the pseudowords were, by definition, unfamiliar to the subjects, their fast and accurate identification relies more on these phonological processing skills than do the more familiar words.

In addition to the difference between words and pseudowords, there was a significant effect of regularity, $F(1,68) = 17.55$, $MSe = 612.09$, $p < .001$, as well as a significant interaction between the word/pseudoword variable and regularity, $F(1,68) = 31.61$, $MSe = 732.84$, $p < .001$. The effects contributing to this interaction were evaluated using Tukey's HSD test (Keppel, 1982; Kirk, 1968). These comparisons indicated that while exception pseudowords took longer to name than regular pseudowords (M difference = 30.15, $p < .01$), there was no difference in naming latencies to regular and exception words (M difference = 5.73; $p > .05$).

The finding that the regular - exception effect is present for pseudowords, but not for words, fails to replicate the results of Glushko's (1979) experiment: in that study, orthographic consistency influenced naming latencies to both types of items. Recent experiments reported by Seidenburg et al. (1984) suggest one basis for this non-replication. The results of these experiments indicated that when word frequency is controlled, regular - exception word effects are found only for words of low frequency. In the present experiment, exception words had higher frequency values than the regular words,[6] suggesting that this difference in frequency may have attenuated any effect of regularity. Moreover, the error rates in the present experiment (see Table 5) are relatively high when compared to other experiments where only words are presented (e.g., Seidenburg et al., 1984). An examination of the errors to exception items

Table 5: Error Rates for Words and Pseudowords in Experiment 1
(percent; maximum raw score = 43)

	WORDS		PSEUDOWORDS	
	Regular	Exception	Regular	Exception
Less-skilled (N=36)	3.0	12.0	9.2	28.7
Skilled (N=36)	1.7	8.0	6.3	23.4

(see Table 6) indicates that the majority are in fact regularized pronunciations (e.g., "pint" read to rhyme with "mint"), rather than actual mispronunciation errors. Similarly, the majority of errors to exception pseudowords are exception pronunciations.

The fact that regular pronunciations are given to a proportion of exception words and pseudowords suggests that the pronunciation of items with inconsistent orthographic patterns may be vulnerable to the effects of other variables within an experimental setting. In the present experiment, two additional significant effects appeared to constrain the results. While these observed effects are tangential to the present investigation of individual differences, they have important implications for the investigation of word identification more generally and, consequently, for its application to the study of individual differences.

As noted in the method section, two orders were administered across subjects: the second order (R) was simply the reverse of the first order (F). While the order in which the individual items were presented was not a significant main effect, $F\ (1,68) < 1.0$, $p > .05$, order interacted with both regularity, $F\ (1,68) = 8.24$, $MSe = 612.09$, $p < .006$, and with the word/pseudoword item effect, $F\ (1,68) = 3.86$, $MSe = 4383.77$, $p = .05$. The third order interaction of order X regularity X word/pseudoword was nonsignificant, $F\ (1,68) < 1.0$, $p > .05$, as was the fourth order interaction with reader group, $F\ (1,68) < 1.0$, $p > .05$.

Given the major purpose of the present experiment -- that of investigating individual differences in reading skill -- the design precluded specification of the precise nature of these interactions with

Table 6: Pronunciation Errors to Exception Items in Experiment 1 (percent; maximum raw score = 43)

	WORDS		PSEUDOWORDS	
	Mispron.	Regular	Mispron.	Exception
Less-skilled (N=36)	2.3	9.6	6.7	22.0
Skilled (N=36)	1.2	6.8	4.3	19.2

order of presentation. However, subsequent analyses of the responses to exception items, combined with these interactions with presentation order, suggest that subjects are responding differently to the exception items in a way which is dependent upon their order of presentation.

Because order interacted with both regularity and item type, further inspection was made of the nonsignificant order X regularity X item interaction. The relevant data, collapsed across reader group, are presented in Table 7. Tukey comparisons of these means require a difference of 20.02 msec for significance at the $p < .05$ level. While there was no difference in the latencies to pronounce regular and exception words ~~in either~~ order, a different pattern of performance was observed in pseudoword latencies. Inspection of these data reveal that the difference between regular and exception pseudowords is highly significant in Order F (M difference = 41.03, $p < .01$), whereas this difference just fails to achieve significance in Order R (M difference = 19.28, $p > .05$). Subjects in Order F, then, responded to regular pseudowords significantly faster than to exception pseudowords; in Order R this difference was attenuated.

A further analysis of the frequency of exception pronunciations in the two orders indicated that the differences in latencies were accompanied by differences in the frequency of exception pronunciations. Following Glushko (1979), latencies to exception pseudowords had been included in the first analysis only if the pronunciations given by the subjects were regular ones. As noted earlier, exception pronunciations to the pseudoword items, however, occurred on approximately 20 per cent of the trials. When

Table 7: Correct Naming Latencies for Regular and Exception Items as a Function of Presentation Order (msec)

	WORDS		PSEUDOWORDS	
	Regular	Exception	Regular	Exception
Order F	622 (100)	622 (100)	674 (123)	715 (149)
Order R	612 (83)	601 (82)	700 (138)	720 (152)

the frequency of exception pronunciations is examined separately[7], significantly more exception pronunciations are given in Order F than to the reverse order, F (1,68) = 4.53, MSe = 8.94, p < .04. Thus, it appears that in Order F, subjects were biased to give exception pronunciations to ambiguous pseudowords, and demonstrated a larger difference between regular and exception pseudowords when their pronunciation was regular.

In contrast, for exception words, there was no effect of order in the number of regularization errors, F (1,68) < 1.0, p > .05.[8] As inspection of these errors had suggested that they appeared most frequently to exception words of lower frequency, the words were divided into equal groups of high and low frequency. The incidence of regularization errors was then compared for each order using a Chi square analysis, as several subjects did not make errors to higher frequency words. The results of this analysis indicated that substantially more errors to lower frequency words were made in Order R than in Order F for both the skilled, χ^2 = 13.12, p < .05, and less-skilled readers, χ^2 = 6.61, p < .05. Subjects in the R order, then, tended to regularize exception words of lower frequency.

The results of the order analyses suggest that subjects responded to the exception items in a way which differed between the two orders. The differences observed between the orders in subjects' responses to regular and exception items may reflect general differences in the subjects' strategies. Relative to subjects in Order R, subjects in Order F may have been biased to give exception pronunciations: their greater number of exception pronunciations to exception pseudowords, and the greater difference in their latencies to name regular and exception pseudowords may reflect this bias. In contrast, subjects in Order A may be characterized by a regularization strategy in that they gave more regular pronunciations to exception pseudowords and exception words of low frequency, and demonstrated an attenuated difference in naming times between regular and exception pseudowords.

Whether the differences between the two presentation orders reflect such general strategic effects, or are a consequence of selective biasing of specific orthographic patterns cannot be determined from the results of the present experiment. The experiments of Kay and Marcel (1981) and Seidenburg et al. (1984) suggest that selective biasing of pronunciations to inconsistent orthographic patterns can be demonstrated for single items. The extent to which such biasing of individual items may have occurred within the present experiment is not readily apparent from its design. However, the results of the present experiment suggest that specific conditions within a list of items can influence the pronunciation of lexical items, particularly those which are of low frequency or are unfamiliar. The susceptibility of such results to particular processing conditions, demonstrated both in this study and in those of Kay and Marcel (1981) and Seidenburg et al. (1984), have implications for considering results from experiments investigating word-level processing more generally. Many investigators have assumed that the skills under investigation were so stable that they were impervious to the influence of particular conditions of context and processing within an experimental setting. Such an assumption may, in some cases, be unwarranted.

Despite the fact that the order of items within a list influenced all subjects' performance on consistent and inconsistent items, there was no evidence to suggest that inconsistent orthographic patterns posed particular difficulty for the less-skilled readers. Like the skilled readers, their latencies to name inconsistent pseudowords was longer than for the regular, consistent pseudowords, but this difference was not substantially longer. Moreover, there was no difference between the groups in the frequency of exception pronunciations to ambiguous pseudowords, F (1,68) = 3.01, MSe = 8.94, $p > .05$, which provides additional support to indicate that the less-skilled readers do not differ in their response to inconsistent orthography *per se*. The less-skilled readers did, however, make significantly more regularization errors to exception words than did the skilled readers, F (1,68) = 5.91, MSe = 4.34, $p < .02$. While this finding may suggest that the less-skilled readers have greater difficulty processing *words* with ambiguous orthographic patterns, the fact that group differences are confined to words suggests that this difference may be a function of familiarity. Given that less-skilled readers have greater difficulty in processing low frequency words, this finding may be attributable to their relative lack of familiarity with exception words of lower frequency.

The finding that less-skilled readers in a university sample are not differentially affected by pseudowords with inconsistently-pronounced orthographic patterns is in contrast to findings with younger readers (e.g., Backman et al., 1984). While it is tenuous to make inferences across subject samples which differ in age and selection criteria, this finding might indicate that the increased familiarity with a variety of orthographic patterns (which results during development to more advanced levels of reading) overcomes the initial difficulty seen in children.

In contrast, the less-skilled readers in this experiment, like younger less-skilled readers, continue to have particular difficulty with unfamiliar pseudowords. Moreover, less-skilled readers in university continue to demonstrate slower naming of more familiar words. Whether their slower latencies to name individual words reflects their reliance on poorer phonological skills, poorer naming skills more generally (e.g., Jackson, 1980), or their relative inexperience with words cannot be determined from the results of this experiment. One potential basis for this word-level difficulty was explored further in the second experiment.

CHAPTER 5

Experiment 2: Repetition and Processing at the Word Level

The previous study demonstrated that differences in the latencies to name words and pseudowords are found between skilled and less-skilled adult readers, replicating findings from other populations. It is surprising, however, that these differences are maintained in the university population, where the level of comprehension skill greatly surpasses that of the developmentally younger reader. The fact that word-level differences are apparent at this level of reading skill is consistent with the conclusion that word-level processing is a major source of individual differences (e.g., Stanovich, 1980; 1982a), a source which, by the accounts of serial, bottom-up processing models, would limit later processing of printed material.

The differences at the word level which were demonstrated between the reader groups, however, are correlational in nature, and are open to the interpretation that they are a consequence of reading skill rather than a contributing factor. The faster and more accurate word and pseudoword naming demonstrated by the more highly skilled group, for example, may be a consequence of greater experience and familiarity with a wide range of lexical items. It is not unlikely that the better reader, because of more successful experience with print, is more likely to engage in further reading. Such experience would be expected to result in exposure to a wider range of words, as well as to more varied exposure to individual words in different contexts. This exposure, in turn, would be expected to facilitate fast and accurate identification of a range of lexical items. This greater familiarity with a variety of items may in part explain why differences between high and low-skilled readers are greater for low frequency, than for high frequency, words (e.g., Perfetti & Hogaboam, 1975).

It is also possible that word-level differences reflect other aspects of differences in the development of reading skill. Differences demonstrated between skill groups in adulthood may be attributable to differences in the initial acquisition of reading skills. Mason (1978), for example, has speculated that pseudoword naming in adulthood is an epiphenomenon of reading skill: poor readers' slower performance on this task may reflect the initial difficulty which was encountered by this group in learning new words. Such speculation suggests that the less-skilled reader, either because of characteristically slower acquisition, or because of relatively fewer experiences with print, should demonstrate slower, less accurate learning of new lexical items.

To date, there has been no investigation of the effect of repeated experience with printed linguistic material on the subsequent performance of adult readers. If the less-skilled adult reader's performance on isolated word and pseudoword naming tasks is a consequence of their relative inability to benefit from experience with print, it would be expected that this group would demonstrate less facilitation of naming speeds over repeated trials. Experiment 2 was designed to investigate this hypothesis: given the less-skilled readers' differential difficulty with pseudowords, these items were chosen as stimuli. The pseudowords were repeated either once (Rep-1) or three times (Rep-3) in order to evaluate the relative benefit of repeated experience on later naming between the two reader groups.

Of additional interest was whether the effects of repeated experience were dependent upon the visual characteristics of the pseudowords. Recent research has indicated that changes in such characteristics across trials may attenuate the benefits of repetition for some performance measures, but not others. For example, changes in script or typeface may reduce transfer effects in reading inverted text (Kolers, Palef & Stelmach, 1980) and proofreading (Levy, 1983), but not in lexical decision (e.g., Brown, Sharma & Kirsner, 1984). A change from upper- to lower-case may also decrease performance in scanning (Brooks, 1977) and perceptual identification (e.g., Jacoby & Witherspoon, 1983) tasks. Such superficial changes in the visual characteristics of material may be particularly important when subjects have little experience with the material (Jacoby & Brooks, 1984). In order to examine whether changes in visual characteristics affect performance in the naming task, pseudowords were presented in either upper- or lower-case during the first (repetition) phase of the experiment. If the less-skilled readers, because of less experience with lexical items, are more dependent upon superficial characteristics during processing, it was expected that the effects of repetition would be attenuated when case was changed in the test phase.

Method

Materials. The items employed in the experiment consisted of 75 pronounceable pseudowords of 4 to 5 letters in length (see Appendix B). These pseudowords were constructed so that their pronunciations were unambiguous, in that reference to both grapheme-phoneme correspondence rules and to words of similar orthography resulted in the same pronunciation. Pseudohomophones (e.g., "phocks") and pseudowords with inconsistently-pronounced orthographies were excluded.

Sixty pseudowords were presented in Phase 1 of the experiment: 15 upper-case and 15 lower-case items were presented three times (Rep-3), while 15 upper- and 15 lower-case items were presented once (Rep-1). These 60 items, as well as 15 New items, were presented during the test phase so that comparisons were made between these 5 test conditions. Items with the same initial consonant sounds occurred equally often in all conditions, so that any differences in the latency to produce these sounds would not confound comparisons between the repetition conditions. There were 5 different presentation orders across subjects within each reader group so that a set of items occurred in each condition an equal number of times.

In the first phase, the presentation sequence for items in each condition was the same across each of the five presentation orders. For items that were presented three times, the trials were spaced at intervals of between 20 and 30 trials ($\underline{M}$ interval between trials 1 & 2 for UC was 24.73, for LC 24.60; $\underline{M}$ interval between trials 2 & 3 for UC was 24.40, for LC 24.53). The presentation of items in each condition was constrained so that no more than 2 items from each condition were presented consecutively, and no more than three consecutive trials consisted of items from the same case or repetition conditions. The presentation order was additionally constrained so that items were not repeated in the same relative order on the second or third repetition trials.

The test phase consisted of 75 trials: one for each of the 60 items presented in Phase 1 as well as the 15 New items. In contrast to the first phase, each of the individual items were presented in the same order during the test phase. As each pseudoword had been presented in a different condition across each of the counterbalanced lists in Phase 1, this procedure controlled for specific order effects within the test list itself. While items had been presented in either upper- or lower-case during Phase 1, all items were presented in lower case during the test phase.

<u>Procedure</u>. Pseudowords were presented on a monitor screen via an Apple IIe computer. Naming latencies were recorded automatically when the subjects' response activated a voice key. Pronunciation accuracy was recorded by the experimenter.

Each subject participated in an individual testing session. Prior to beginning the first phase, the subject received 8 practice trials in order to provide familiarity with the procedure. Each subject was instructed to read the pseudowords as quickly and as accurately as possible. If a pronunciation error occurred, it was corrected by the experimenter; the subject then repeated the correct pronunciation while re-examining the item on the screen.

Although the repetition and test phases were conceptually discrete, no distinction was made between these phases during the experiment: the test phase followed immediately after the last trial of the study phase. The error correction procedure was not employed during the test phase.

Results and Discussion

The mean number of pronunciation errors, expressed as a percentage of items in each category (i.e., 15) are presented in Table 8. While a majority of both the skilled (84%) and less-skilled (88%) readers made at least one pronunciation error on the first trial, both the number of subjects making at least one error and the mean number of errors per condition declined with repeated experience. Because the error rate was small after repetition, analysis of these data were not performed. It is noteworthy that the decline in errors across repetition conditions is similar to that observed in latencies for each condition.

In order to evaluate the effects of prior presentation on pseudoword naming, three separate analyses were conducted. These analyses were performed on naming latencies for items which had been pronounced correctly on all trials throughout the experiment. All analyses were conducted on subjects' median latencies for each condition.

Table 8: Error Rates in All Conditions in Experiment 2
(percent; maximum raw score = 15)

Condition	NEW	ONE REPETITION		THREE REPETITIONS			
Trial	test	1	test	1	2	3	test
Less-skilled (N=25)	19	19	13	16	11	6	8
Skilled (N=25)	8	11	6	12	6	4	4

Of major interest in this experiment was whether items which had been presented either once or three times during the first phase differed from New items in the test phase. Consequently, performance in the five test conditions was compared for both groups of readers. This analysis was complemented by a further analysis which examined the groups' performance for trials on which items were presented three times in Phase 1.

Prior to examining the test items, a preliminary analysis was conducted in order to confirm that no initial differences existed between the repetition conditions. The mean latencies for correct pronunciations on the first trial of the first phase are presented in Table 9. For this comparison, a 2 (Group) X 2 (Case) X 2 (Repetition Condition) analysis of variance was performed. Only the difference between the reader groups was statistically significant, $F(1,48) = 5.28$, $MSe = 192779.51$, $p <$ .03). No other main effects or interactions were significant, $p > .05$. The significant Group effect indicated that the less-skilled readers were slower in pronouncing pseudowords, a finding which replicates the effect demonstrated in Experiment 1 as well as similar results observed in other populations.

Although the repetition categories did not differ on the first presentation trial, subsequent analyses indicated that differences between these items and New items were apparent in the test phase. Moreover, the absolute benefit derived from repeated experience was greater in the less-skilled reader group. In order to make this comparison, a 2 (Group) X 5 (Test Condition) analysis of variance was conducted on naming latencies in the test phase. This analysis revealed significant effects of both

Table 9: Latencies for Correct Pronunciations of Pseudowords on the first Trial in Phase 1 of Experiment 2 (msec)

	TEST CATEGORY	
	Rep-1	Rep-3
Less-skilled (N=25)	861 (257)	862 (264)
Skilled (N=25)	721 (198)	709 (168)

Group, F (1,48) = 5.50, MSe = 95750.70, p < .03, and Test Condition, F (4,192) = 22.19, MSe = 2949.07, p < .001, which were qualified by a significant interaction, F (4,192) = 2.52, MSe = 2949.07, p < .05. Further analysis of this interaction using Tukey's HSD test indicated that the major difference between the groups was apparent when the New items were compared to those items which had previously been presented in the first phase. There was no effect of case for either repetition condition (Rep-1 difference: 4.04 msec for less-skilled readers; 0.64 msec for skilled readers; Rep-3 difference: 10.24 msec for less-skilled readers, 2.52 msec for skilled readers). The means for each test condition, collapsed across case, are presented in Table 10.

When compared to New items, the less-skilled reader group demonstrated significantly faster latencies to items that had been presented both once (difference = 72.62, critical difference (10,192 = 57.56, p < .01) and three times (difference = 117.42, p < .01) in the first phase. For the skilled readers, however, pronunciation latencies for repeated items were faster than New items only if they had been presented 3 times in the first phase (difference = 59.26, p < .01). The difference between items with one prior presentation and New items was not significant for the skilled readers (difference = 42.80, critical difference (10,192) = 49.52, p > .05).

The results of this analysis indicate that compared to a new test item, both one and three prior presentations facilitated naming latencies for the less-skilled readers. In contrast, for the skilled readers, facilitation of naming latencies was evident only after 3 prior

Table 10: Latencies for Correct Pronunciations of Pseudowords in the Test Phase of Experiment 2 (msec)

	TEST CATEGORY		
	New	Rep-1	Rep-3
Less-skilled (N=25)	801 (203)	728 (143)	685 (109)
Skilled (N=25)	674 (178)	631 (144)	615 (129)

presentations.

This pattern of performance is further demonstrated over trials where the items were presented three times in Phase 1. These response latencies, collapsed across upper- and lower-case, are presented in Table 11. While both the effects of Group, F (1,48) = 5.48, MSe = 166177.02, $p < .03$, and Trials, F (3,144) = 39.80, MSe = 9734.03, $p < .001$, were significant, these main effects were qualified by a significant Group X Trials interaction, F (3,144) = 3.61, MSe = 9734.03 $p < .02$. Tukey comparisons indicated that for the less-skilled readers, the first trial was significantly longer than each subsequent trial (differences > 86.02 = critical difference (8,144), $p < .05$). While latencies continued to decline, the differences between the remaining consecutive trials were not significant. This pattern of performance demonstrated by the less-skilled readers parallels that found for items in the test phase: one prior presentation resulted in significantly faster naming latencies when compared to either a New test item, or to the same item on its first presentation.

Similar parallels between the analyses of the test phase and the Rep-3 condition were observed in the skilled readers' performance. Naming latencies on the second trial were not significantly faster than on the first trial (difference = 66.72, critical difference (8,144) = 86.02; $p > .05$); a finding which replicates the nonsignificant difference observed in the test phase between items which had previously been presented once and New items. Faster latencies on trial 3 and the test trial resulted in significant differences over trial 1 performance (differences > critical

Table 11: Latencies for Correct Pronunciations of Pseudowords Presented Four Times in Experiment 2 (msec)

	TRIAL			
	1	2	3	Test
Less-skilled (N=25)	862 (264)	732 (153)	699 (119)	685 (109)
Skilled (N=25)	709 (168)	643 (130)	622 (116)	615 (129)

difference $(8,144) = 86.02$, $p < .05$), replicating the significant facilitation effect observed after three prior presentations.

The results from this experiment, then, indicate that both skilled and less-skilled readers benefit from repeated experience with pseudowords. In absolute terms, the benefit derived by the less-skilled readers was greater than that derived by their more skilled peers. While the improvement in naming speed was statistically significant after only one prior exposure for the less-skilled readers, the skilled reader group required at least two previous repetitions before an improvement of the same magnitude was observed.

The greater improvement in naming speed demonstrated by the less-skilled readers may, however, have been a consequence of their slower performance initially. As a result, this group had a wider range within which improved performance could have been demonstrated. In contrast, the skilled readers' opportunity to improve their performance was constrained by naming times which were initially closer to optimal performance levels. These differences in initial naming times may have contributed to, or been responsible for, the differences between the reader groups in the absolute benefit derived from repeated experience. While these differences in initial levels of performance make the inference that less-skilled readers derive greater benefit from repetition a tenuous one, there is no indication that the less-skilled readers derived less benefit than did the skilled readers: relative to their initial levels of performance, the less-skilled readers derived at least as much, if not more, benefit over three repetitions (20%) as did the skilled readers (14%). Because of the differences in the scale of measurement between the groups, the more conservative interpretation -- that the less-skilled readers benefit to at least the same extent as the skilled readers -- is most appropriate.

The finding that the less-skilled readers do demonstrate such a benefit, however, is surprising. The pseudoword items employed in this experiment were chosen because of the difficulty they pose for less-skilled readers in adult, and other younger populations. Because the items are unfamiliar, they are assumed to require the use of phonological analysis in order to identify or name them. In younger less-skilled readers, these analytic skills are acquired more slowly and are hypothesized to continue to pose a source of difficulty in reading single words into adulthood. If the less-skilled readers in this experiment were slower and less accurate in pseudoword naming because of these poorer analysis skills, it was expected that they would benefit less than the skilled readers. Instead, the results from this study suggest that the less-skilled readers in this population are at least as able to benefit from prior experience as their more skilled peers.

In the present experiment, there was no effect of changing from upper-case in the first phase to lower-case presentation during the test phase. While changes in case, or other superficial visual characteristics of the stimulus materials, may attenuate the benefits of repeated experience (e.g., Jacoby & Witherspoon, 1983; Kolers et al, 1980; Levy, 1983), the effects may be small, and are not consistently observed across all performance measures (e.g., Brown et al, 1984). The results from the present experiment indicate that changes in case over repeated trials in the naming paradigm have no effect on the extent of transfer observed in the performance of either the skilled or less-skilled readers.

Recent research with children has suggested that the gains demonstrated by less-skilled readers are specific to the material which they have been exposed to (e.g., Lesgold, Resnick & Hammond, 1985; Lovett et al., in press), and suggest that a difficulty in generalizing to novel material may be characteristic of the less-skilled reader (Lovett et al., in press). The extent to which less-skilled readers are able to generalize across different materials and across changes in the same material, compared to skilled readers, remain subjects for further investigation.

The case manipulation was incorporated into the present experiment in order to evaluate whether changes in superficial visual characteristics influenced the less-skilled readers' performance. In that changes in visual characteristics appear to attenuate transfer over repeated trials when subjects have little experience with the items (Jacoby & Brooks, 1984), it might have been expected that the less-skilled readers would have shown less facilitation when the case was changed than when the same case was maintained across all trials in the experiment. The results of the experiment suggested that, like the skilled readers, the less-skilled readers were not dependent upon these superficial visual characteristics when processing novel items.

This failure to find a difference across changes in case in the performance of either the less-skilled or skilled readers may be due to the use of the naming paradigm: it may be that this paradigm is not sufficiently sensitive to reflect subtle changes in processing.

Alternatively, such changes may be irrelevant to the naming performance of either group of readers in this population. Despite the speculation that the reader groups may be differentiated by their amount of exposure to print, their educational status suggests that in absolute terms, both groups have had extensive experience with print. It may be that it is this experience with print in various forms, rather than the novelty of the pseudowords as unique items, which makes changes in visual characteristics irrelevant to their performance. If it is this varied experience more generally which is critical, it may be that younger, or early, readers would be more dependent upon specific characteristics of items during processing.

Despite the similarities in the benefit observed after repeated experience in the two reader groups, the naming latencies demonstrated by the less-skilled readers remained substantially slower than those of the skilled readers. This effect is similar to that observed with younger populations after repeated trials (Ehri & Wilce, 1983; Hogaboam & Perfetti, 1978). The basis of this generally slower performance in processing lexical items, however, remains to be clarified in future research. Whether the slower performance of the less-skilled readers in this population, as well as that of younger readers, reflects slower name retrieval (e.g., Jackson, 1980) or more generally slower processing cannot be ascertained. In that no measures of speed of processing that were independent of the pseudoword task were administered in the present experiment, this hypothesis cannot be addressed directly.

The poorer processing of pseudowords by the less-skilled reading group, despite their improvement with repeated exposure, is consistent with bottom-up processing models of reading and with bottom-up processing accounts of individual differences in reading skill. By these accounts, the major source of individual differences is proposed to be in processing at the word or subword level. These word-level processes are further hypothesized to limit subsequent higher-order processing when words are placed in meaningful context. The present experiment demonstrated that the performance of less-skilled readers could improve over successive presentations at the word level to the same extent as that of the skilled readers. The following experiment addressed whether such facilitation could also be observed within meaningful text.

CHAPTER 6

Experiment 4: Repetition of Single Words and Words in Text

A. Word Identification for Single Words and Words in Text

The previous studies were focused on group differences in reading single word and pseudoword items, and demonstrated that despite slower and less accurate initial performance, the less-skilled readers were as able to benefit from repeated experience as were their more skilled peers. While differences at the word level have been proposed to be a major source of individual differences in reading, models of proficient reading differ as to whether processing of single words is hypothesized to be different from processing words in meaningful text.

Central to top-down processing models of reading is the proposal that reading text is different from reading single words: rather than identifying each word in a text display, the reader is hypothesized to sample individual items in order to construct the meaning of the text. The extent to which this sampling occurs is dependent upon the linguistic skill of the reader. With good language skills, the reader samples relatively little of the text itself; as a consequence, individual words receive minimal attention. Less skilled readers, on the other hand, because of their hypothesized poorer general language skills, are characterized as reading in a "word-by-word" fashion. By top-down accounts, then, skill differences are apparent in the relative attention given to individual words in the text. Less-skilled readers are hypothesized to give more attention to individual words in order to construct meaning, while the more skilled reader merely identifies as many words as necessary to allow meaning to be generated.

A major assertion in bottom-up processing models is that the same data-driven processes underlie word identification in reading words presented singly and in text. Because of the serial nature of the processes in reading, conceptually-driven processes (based on either prior knowledge or on the meaning derived from text) cannot act to influence earlier stages of processing. As a consequence, meaning is derived only after processing of the word has been completed. Prior to the extraction of meaning, word identification is achieved by mechanisms which are independent of whether the word is presented alone or in a meaningful context. By this formulation, individual differences in reading may result from poor or less efficient data-driven processes. As a result, these inefficient data-driven processes influence all later stages of processing; in text processing this ultimately results in poorer comprehension.

While top-down and bottom-up processing models propose different accounts of reading, predictions from both models propose that, for the less-skilled reader, processing of single words is similar to processing words in text. By top-down accounts, the less-skilled reader actually performs greater analysis of individual words than the better reader. In contrast, bottom-up processing models propose that less-skilled readers allocate greater attention to these data-driven processes because they are less accurate, slower, and/or non-automatic. Rather than performing more analysis (as proposed in top-down processing models), however, the analysis that occurs is hypothesized to be slower and less efficient.

In contrast to the individual difference predictions made for single word identification, the two types of models make different predictions for the processing of words in meaningful contexts. In bottom-up processing models, no mechanism is proposed whereby conceptually-driven processes can influence ongoing word identification. Consequently, no difference between processing of single words and words in meaningful contexts is hypothesized for either skilled or less-skilled readers. In top-down processing models, however, word identification in text is proposed to result primarily from processing meaning. For skilled readers, words presented within a text are expected to be identified more easily, although less often, than when presented in isolation. Less skilled readers are hypothesized to be less able to rely on higher-order processing when attempting to identify words. As a consequence, it would be expected that words in text would be read similarly to words presented in isolation.

Different predictions are derived from interactive processing models. In that multiple processing levels are hypothesized to be activated simultaneously, segments of text may be processed at the same time and relatively more independently of word-level processing. In the presence of poorer data-driven processes at the word level, the less-skilled reader is hypothesized to rely more on conceptually-driven processes in order to identify words in text (Stanovich, 1980). In contrast, the skilled reader is proposed to have better single word identification skills, and consequently to be less dependent on higher-order processing when reading words. Because processing at the word level operates rapidly, there is less time available for the execution of higher-order processes. Relative to the skilled reader, the less-skilled reader may be hypothesized to demonstrate a greater benefit from reading words in context compared to isolated words; in the skilled reader this benefit would be expected to be attenuated.

In summary, very different predictions concerning individual differences in the identification of words presented singly compared to words presented in text can be derived from models of proficient reading. According to bottom-up processing accounts, no difference between identifying words in the two conditions would be expected for either skilled or less-skilled readers. Top-down processing models explicitly predict that the skilled readers take more advantage of meaning when processing words in text, whereas the less-skilled readers do not. The opposite prediction is derived from interactive models: it is expected that it is the less-skilled readers who benefit more from the context provided in meaningful text than do their more skilled peers.

B. Repetition and Word Identification in Text

The preceding discussion indicates that, on the basis of predictions derived from top-down and interactive processing models, the processing of words in text may differ from that of isolated words. In addition, the way in which readers process individual words when reading text may have implications for their comprehension of the meaning inherent in the text. These implications differ depending upon the model of skilled reading from which predictions are derived. Experiment 3 was designed to compare processing of both isolated words and words in meaningful text, to investigate the role of repetition at the word and text levels, and to evaluate whether readers at different skill levels differ in the relative benefit derived from repetition at these levels.

While top-down and interactive processing models do not make explicit predictions as to whether, and if so how, repetition would be expected to influence reading skill, bottom-up processing models have been used to derive a remedial technique based on repeated trials. In the educational literature, Samuels (1979) has advocated employing repeated reading of text as an instructional technique; this technique consists of reading a passage over a series of trials until a criterion of speed and accuracy has been met. This technique has been employed with diverse populations, including the mentally retarded (Samuels, Dahl & Archwamety, 1974), poor readers (Samuels, 1979), acquired dyslexics and proficient readers presented with difficult material (Moyer, 1982).

The effectiveness of this technique is hypothesized by Samuels

(1979) to be due to its facilitation of accurate, automatized data-driven processing. Morenver, with repeated reading, comprehension improves because "the decoding barrier to comprehension is gradually overcome" (page 405) and more attention is available for higher-level processing of meaning. Once automatic data-driven processing and effective comprehension have been achieved, the benefit of repeated reading is purported to transfer to new material.

Despite the advocacy of this technique, there have been few rigorous investigations of its effectiveness. Recently, however, Rashotte & Torgeson (1985) found that poor readers demonstrated significantly greater gains in reading speed over repeated trials of the same text than over repeated trials of different text. There was also suggestive evidence that when new sessions consisted of text material which contained a large number of words common to passages in previous sessions of repeated reading, the gains in overall reading speed were maximal. There was, however, no evidence to indicate a generalized gain in comprehension. These data suggest that repetition of text material can result in improvements in reading speed; what is not clear from investigations of this method is whether these improvements are a result of facilitation at the word level or of facilitation at other, or all, processing levels (Moyer, 1982; Piggins & Barron, 1982).

An important component of bottom-up-processing models is that it is the development of accurate and speeded data-driven processes which characterize the skilled reader. Slow, inefficient word-level processing results in a "bottleneck" (Perfetti & Lesgold, 1977); with repeated trials at the word level, speed and accuracy should increase, with a corresponding increment in comprehension once the words are placed in a meaningful context. Fleischer, Jenkins & Pany (1979) tested the bottleneck hypothesis by training less-skilled readers on single word reading to the level of speed and accuracy attained by untrained good readers. Despite word naming times which were equivalent to the skilled readers, the less-skilled readers demonstrated poorer comprehension when these words were later presented in text form. In fact, the less-skilled readers' comprehension was not different from a similar group of poor readers who had not received the training on single words.

Despite evidence that training had improved naming speed for single words, these naming speed gains did not consistently transfer to reading text in the two experiments reported by Fleisher et al. (1979). Similar findings have been reported by Piggins & Barron (1982). Moreover, Piggins & Barron included an additional control condition to evaluate the extent to which a decrease in articulation time contributed to the improvement in word naming speed observed after training. In this control condition, children were required to delay naming the word until they were cued one second after its presentation. Comparisons of naming times after training in the delayed (control) and immediate naming conditions indicated that the effect of training could be attributed to a decrease in articulation time, rather than to a decrease in the time to process the individual words. These results suggest that naming speed may be an inappropriate index of whether benefits in speeded processing occur over repeated trials.

Taken together, the results from these experiments indicate that although word naming times may decrease with repeated trials, the effect of this decline on comprehension of text which includes these words is unclear. If the decline in naming times is due to a decline in articulation, rather than a benefit in reprocessing the words, no improvement in comprehension would be expected (Piggins & Barron, 1982). However, if repeated experience at the word level facilitates word-level reprocessing on subsequent trials, according to the bottleneck hypothesis, this should result in better comprehension.

Although previous research has examined the benefit of repetition of both single words and words in text in less-skilled readers, there has been no direct comparison of the relative benefits of repetition at the word and the text levels. This comparison is an important one because groups differing in reading have been proposed to differ in their reliance on higher-order processing when identifying words in text. However, in that the top-down and interactive processing models were developed to account for a single reading episode, no direct predictions concerning the effects of repeated experience can be derived. Bottom-up processing models (LaBerge & Samuels, 1974; Perfetti & Lesgold, 1977; Samuels, 1979), however, hypothesize that the benefits of repeated experience with text are a result of facilitation of word-level processing. This hypothesis was tested in Experiment 3 by comparing the effects of repeated experience with single words with that of words in meaningful text.

The results of Experiment 2 indicated that less-skilled readers demonstrated benefits of repeated experience with pseudowords which were at least as great as those demonstrated for the skilled readers. It was expected that this effect would generalize to repeated experience with words in Experiment 3. Moreover, if the benefit of repeated experience at the word level generalizes to words in meaningful text, then more fluent processing of text, as well as better comprehension, was expected when text was read after previous repetition of single words. In addition, the extent to which the two groups of readers differed in the relative benefit from repetition at text and word levels allowed evaluation of the contribution of higher-order processing over repeated trials.

In order to compare the effect of repetition of single words with that of words in text, the paradigm employed was changed from word naming to proofreading (Levy, 1983; Levy & Begin, 1984). In this paradigm, subjects are asked to proofread passages containing words with spelling errors. The passages are either unfamiliar or familiar to the subjects; familiarization is accomplished in an earlier phase by asking the subjects to read an error-free version of the passage over repeated trials. Two measures provide an indication of the effects of repeated experience. The accurate detection of spelling errors during proofreading provides a measure of the extent of processing at the word or subword level, in that an analysis of each word is required in order to detect these errors. This word-level measure provides an advantage over the naming latency measure employed in Experiments 1 and 2 because it is not confounded with a decline in articulation times over repeated trials (Piggins & Barron, 1982). In addition to the accuracy measure, the time taken to proofread the passage provides a measure of subjects' reading fluency. Rereading times when proofreading familiar material provide a measure of the effect of previous experience on reading fluency: increases in reading fluency are attributed to faster, more efficient reprocessing of the material at all levels of processing available to the subject.

In previous work, Levy (1983; Levy & Begin, 1984) has found that prior familiarization resulted in better accuracy in detecting spelling errors. Moreover, concurrent improvement in proofreading speed was dependent upon the type of material which was read by the subjects during the familiarization and proofreading phases. In the Levy & Begin (1984) study, subjects first read either a meaningful passage (normal) or a passage which consisted of randomly arranged words (scrambled). The scrambled passages were constructed so that they contained the same words as the corresponding normal passage but due to the rearrangement of word order, the passages were neither meaningful nor contained normal syntactic constraints. After familiarization with either a normal or a scrambled passage, subjects then proofread a normal or a scrambled passage. The results indicated that the maximal benefit in proofreading speed occurred when subjects proofread text of the same structure with which they had been familiarized. When proofreading normal text, subjects demonstrated greater improvements, over unfamiliar text, after having been familiarized with the normal text than with the scrambled text. Similarly, maximal gains in proofreading scrambled text were observed after familiarization with the scrambled, rather than the normal, text structure. These results indicate that improvement in word-level processing (proofreading accuracy) is observed over repeated experience with text. Moreover, improvement in reading fluency appears to be dependent on the similarity in text structure between the familiarization and proofreading phases.

Experiment 3 was designed to evaluate whether there were individual differences in the benefit derived from repeated trials of words, compared to words in meaningful text. Of particular interest was a comparison of the extent of transfer across text of different structure (single words versus meaningful text), as well as improvement in comprehension of normal text, between the skilled and less-skilled readers. Following Levy & Begin (1984; Experiment 2), two types of text material were employed in order to compare processing of single words with words in meaningful text. On a single trial, subjects proofread either normal, meaningful text, or text consisting of a set of randomly ordered words. On some trials, subjects were familiarized with the text prior to proofreading. The familiarization and proofreading phases were conducted with either the same or different text format (scrambled or normal), so that the transfer of processing at word and text levels could be evaluated.

Method

Materials. The passages used in the experiment were the same as those employed by Levy & Begin (1984; see Appendix C). These passages were descriptive narratives taken from the Intermediate level of the Science Research Associates reading series. Each passage was 350 words in length. There were both normal and scrambled versions of each passage. The scrambled versions were created by randomly rearranging the order of the individual words so that normal meaningful and syntactic relationships were no longer present.

The words containing spelling errors in the proofreading versions were in approximately the same place for both normal and scrambled text. These errors were distributed approximately equally throughout the passage. Each passage contained twenty-four errors: these errors occurred equally often in function, verb, adjective and noun word classes. The errors were constructed by changing a single letter in a word according to the following criteria: (1) words were always changed into pseudowords, (2) the original shape of the word was maintained, and (3) the resultant error was never acoustically similar in pronunciation to the original word.

Six comprehension questions were constructed for each passage. These questions were in the form of true/false statements, which were based on information in the passage. For the true versions, two of these statements were of the exact form as sentences in the text (literal), two were paraphrases of a single sentence (paraphrase), and two statements made explicit a relationship which was implied across two sentences in the original text (inferential). The false versions of these statements consisted of a single word change, which resulted in an alteration of the truth or falsity of the sentence. Two forms of the comprehension questions were constructed: each form contained one true and one false version of the literal, paraphrase, and inferential statements. The forms contained different true and false versions of each statement so that any individual statement did not contribute differentially to any of the effects of interest.

Procedure. A total of 8 passages were proofread by each subject: 4 were normal versions and 4 were scrambled. Subjects were instructed to proofread each passage, crossing out words containing spelling errors, as quickly but as accurately as possible. On each trial, the passage was presented on a single page, and the time to proofread it was recorded with a stopwatch by the experimenter. The time taken to proofread each passage, as well as the number of spelling errors correctly detected, were the dependent measures of interest in the proofreading phase.

In order to evaluate the effects of repeated experience on proofreading, subjects were familiarized with half of the normal and scrambled passages prior to proofreading them. This familiarization consisted of reading aloud an error-free version of the passage on three consecutive trials. The time to read the passage aloud on each trial was recorded by the experimenter for later analysis of repetition effects during the familiarization phase.

For each passage, subjects were familiarized with either the scrambled version or with the normal version of the text; this manipulation allowed comparison of repeated experience of single words with words in text on subsequent proofreading. For a given trial, the familiarization and proofreading conditions consisted of either the same versions of the text in both phases (Familiarize Normal - Proofread Normal; Familiarize Scrambled - Proofread Scrambled) or different versions (Familiarize Normal - Proofread Scrambled; Familiarize Scrambled - Proofread Normal). Proofreading after familiarization was compared with proofreading of unfamiliar text.

After proofreading each passage, subjects answered the comprehension questions. For each passage, the same comprehension questions were used for the normal and scrambled versions. In that no meaningful content was presented in the scrambled version of the passages, subjects were encouraged to guess in order to answer the questions. Rather than reflecting "comprehension", responding in the scrambled condition provided a baseline measure of item difficulty.

The passages were always presented in the same order, but each passage served in all Familiarization-Proofreading conditions across subjects. These conditions were counterbalanced within each reader group, so that eight different presentation orders were administered. For each of these presentation orders, the two forms of the comprehension questions for each passage were administered equally often within each reader group.

Results and Discussion

Oral Reading Times. The results of Experiment 2 indicated that the decline in naming times over repeated trials was greater for the less-skilled readers. The oral reading times for the three trials of the Familiarization phase were examined in order to evaluate whether this group effect was also observed in the present experiment and whether improvement differed for the two types of text (see Table 12). The data were analyzed using a 2 (Group) X 2 (Text Format) X 3 (Trials) analysis of variance, with Group as the between-subjects effect. The results of the analysis of

Table 12: Mean Oral Reading Times During the Familiarization Phase of Experiment 3 (sec)

(a) LESS-SKILLED READERS (N=32)

Trial	1	2	3
Read Normal	130.91 (20.4)	118.08 (14.7)	114.64 (13.3)
Read Scrambled	184.41 (36.6)	169.05 (30.7)	163.41 (29.5)

(b) SKILLED READERS (N=32)

Trial	1	2	3
Read Normal	113.73 (13.1)	107.56 (11.8)	105.75 (11.2)
Read Scrambled	159.33 (27.2)	146.80 (22.8)	142.91 (22.5)

variance indicated that significant effects of Text, $F(1,62) = 388.06$, $MSe = 520.51$, $p < .001$, and Trials, $F(2,124) = 180.27$, $MSe = 46.01$, $p < .001$, were qualified by their significant interaction, $F(2,124) = 13.29$, $MSe = 27.19$, $p < .001$. Across trials, the Normal text was read faster than the Scrambled text. ~~The~~ significant trials effect indicated that reading times on the second trial were faster than on the first trial (difference = 10.72, critical difference (3,124) = 5.04, $p < .01$), while there was no difference between trials 2 and 3 (difference = 3.60, $p > .05$). The significant interaction indicated that the increment in reading speed differed somewhat for the two types of text. For Scrambled versions, the text was read significantly faster on each successive trial (difference between trials 1 and 2 = 11.94, critical difference (6.124) = 3.17, $p < .01$; difference between trials 2 and 3 = 6.77, $p < .01$) while for the Normal text, the improvement on trial 3 just failed to reach significance (difference between trials 1 and 2 = 9.5, $p < .01$; difference between trials 2 and 3 = 2.62, critical difference (6,124) = 2.67, $p > .05$).

Of major interest in this analysis was whether the skilled and less-skilled readers were different in their reading times for normal and scrambled text over repeated trials. Over all conditions, the less-skilled readers were slower in reading than the skilled readers, $F(1,62) = 12.04$, $MSe = 2414.04$, $p < .002$. Moreover, reader group interacted with both the text format, $F(1,62) = 5.00$, $MSe = 520.51$, $p < .03$, and with the trials effect, $F(2,124) = 7.73$, $MSe = 46.01$, $p < .002$. Comparisons of the groups for each type of text indicated that the less-skilled readers were substantially slower in reading the scrambled text, $F(1,62) = 16.72$, $MSe = 1467.28$, $p < .001$, although group differences were also apparent in the time taken to read the normal text, $F(1,62) = 4.86$, $MSe = 1467.28$, $p < .05$.

In view of the second order interactions with reader group, as well as the *a priori* interest in the third order interaction of these effects, further inspection was made of the Group X Text X Trials interaction, $F(2,124) = 1.39$, $MSe = 27.19$, $p > .05$. Examination of the skilled readers' performance indicated that for normal text, there was a significant improvement in reading speed from trial 1 to 2 (difference = 6.17, critical difference (12,124) = 5.00, $p < .01$), but not from trial 2 to 3 (difference = 1.81, critical difference = 4.00, $p > .05$). This same pattern was observed for the less-skilled readers in their performance on normal text: the increment between trials 1 and 2 was significant (difference = 12.83; $p < .01$) but a further increment from trial 2 to 3 was not demonstrated (difference = 3.44; $p > .05$). When reading normal text in the present experiment, then, the pattern of facilitation observed across repeated trials with normal text was similar for the two reader groups, despite the fact that overall reading times remained slower in the less-skilled group.

In contrast, group differences were observed in the pattern of facilitation to the scrambled text. Increases in the less-skilled readers' speed were apparent across all consecutive trials in reading the Scrambled text (differences > 5.00, $p < .01$), while increases in the skilled readers' rates occurred only on trial 2 (difference = 12.0, $p < .05$; for trial 2 to trial 3: difference = 4.0, $p > .05$). The different patterns of performance across repeated trials for the Scrambled text parallel the results observed in Experiment 2 which employed a different procedure. Although different materials were also used across the two studies, the absolute gains demonstrated by the less-skilled readers for words in scrambled text in the present experiment and isolated pseudowords in Experiment 2 were greater than corresponding gains in the skilled readers' performance.

The results of the oral reading analyses, then, indicate that compared to skilled readers, the less-skilled readers were significantly slower in reading text consisting of randomly ordered words and demonstrated greater gains with repeated experience. In contrast, while their reading rates to normal text were also significantly slower than those of their more skilled peers, the pattern of facilitation over repeated trials was similar. As the oral reading measure includes an articulatory component, which has been demonstrated to contribute to improved performance (Piggins & Barron, 1982), the relative benefit in processing speed cannot be evaluated independently. Subsequent comparisons on proofreading measures were important in evaluating whether a similar pattern of performance is evident when the articulatory requirement is absent.

Proofreading Accuracy. As proofreading accuracy provides a measure of word-level processing, it was expected that the less-skilled readers would be poorer in detecting spelling errors than skilled readers.

Moreover, in view of later comparison of proofreading speed, it was important to establish that any improvements in speed after familiarization were not achieved at the expense of poorer accuracy.

Because the false alarm rate (or the proportion of correctly-spelled words which subjects indicated were wrong) approached zero, these data will not be considered further.[9] The mean values for proofreading accuracy in each condition for both reader groups are presented in Table 13. A 2 (Group) X 2 (Proofreading) X 3 (Familiarity) analysis of variance was conducted, with Group as a between-subject effect, and Familiarity and Proofreading as within-subject effects. There was a significant effect of Group, $\underline{F}$ (1,62) = 15.78, $\underline{MSe}$ = 476.94, $\underline{p}$ < .001, indicating that the less-skilled readers were poorer at detecting spelling errors than were the skilled readers. The poorer accuracy demonstrated by the less-skilled group in proofreading provides further evidence of their poorer processing at the word level, a finding which is consistent with the results of Experiments 1 and 2 using the naming paradigm.

Proofreading accuracy for the scrambled text format was superior to that for the normal format, $\underline{F}$ (1,62) = 5.43, $\underline{MSe}$ = 48.06, $\underline{p}$ < .02. This result differs from that of Levy & Begin (1984), who found no differences between the normal and scrambled text in proofreading accuracy. One explanation for the significant effect demonstrated here is the addition of comprehension testing after the proofreading task. While there is evidence that subjects spontaneously engage in comprehension processing during the proofreading task (Levy & Begin, 1984; Levy, Newell, Snyder &

Table 13: Proofreading Accuracy in Experiment 3
(percent; maximum raw score = 24)

(a) LESS-SKILLED READERS (N = 32)

	Unfamiliar	Familiarize Normal	Familiarize Scrambled
Proofread Normal	77.0 (13.2)	81.5 (11.4)	79.0 (14.8)
Proofread Scrambled	77.0 (13.2)	81.9 (13.1)	81.9 (13.8)

(b) SKILLED READERS (N = 32)

	Unfamiliar	Familiarize Normal	Familiarize Scrambled
Proofread Normal	85.7 (6.0)	90.4 (7.0)	86.3 (8.9)
Proofread Scrambled	88.3 (6.8)	91.5 (6.6)	89.2 (8.6)

Timmins, 1986), the addition of the comprehension questions after proofreading may have encouraged subjects to monitor the meaning of the normal text more closely, which may have reduced word level analysis.

There was also a significant effect of familiarity, $F(2,124) = 13.66$; $MSe = 44.57$, $p < .001$. In order to determine the basis of this effect, proofreading of unfamiliar passages was compared to proofreading after familiarization with both normal and scrambled texts. Tukey comparisons indicated that familiarity with normal text resulted in better accuracy than proofreading unfamiliar text (difference = 4.36; critical difference (3,124) = 2.79, $p < .05$). Although familiarization with scrambled text was not significantly better than proofreading unfamiliar text (difference = 2.15, $p > .05$), this difference was in the expected direction, and did not differ significantly from prior familiarization with normal text (difference = 2.21). Critical to subsequent comparisons of proofreading times is the failure to find evidence of poorer proofreading accuracy after familiarization. Had poorer error detection been observed in conjunction with faster proofreading speed, an explanation due to a trade-off between speed and accuracy could not have been excluded. Because proofreading accuracy after familiarization was either better than, or equivalent to, unfamiliar proofreading, any benefits in proofreading speed with familiarity cannot be attributed to a speed-accuracy trade-off.

While there were significant main effects, there was no interection of Group with proofreading condition, $F(1,62) < 1.0$, $p > .05$, or with familiarity, $F(2,124) = 1.42$, $MSe = 44.57$, $p > .05$. Moreover, familiarity did not interact with proofreading, nor was the third order interaction with group significant, *F*s < 1.0, $p > .05$. The absence of significant interactions, particularly the interaction of familiarization condition with the type of text proofread, then allows comparison of these effects in proofreading times.

<u>Proofreading Speed</u>. Analysis of the accuracy data indicated that although the two reader groups differed in this measure of word-level processing, both groups benefitted from familiarity at the word level. Of interest in examining the speed measure was whether the groups were different in the relative benefit they derived from familiarity at the word and text levels, and whether this benefit interacted with the text format during proofreading. The focus of the speed comparisons, then, was on the interaction of group with the familiarization and proofreading conditions.

The mean proofreading times for all conditions are presented in Table 14. A 2 (Group) X 2 (Proofreading) X 3 (Familiarity) analysis of variance was conducted, with Group as a between-subjects effect. There was a significant interaction of Familiarity X Proofreading, $F\ (2,124) = 20.63$, $MSe = 139.28$, $p < .001$, as well as significant effects of both Familiarity, $F\ (2,124) = 31.47$, $MSe = 123.06$, $p < .001$, and Proofreading, $F\ (1,62) = 88.68$, $MSe = 271.48$, $p < .001$. In order to determine the nature of the interaction, proofreading times for unfamiliar texts were compared with proofreading after familiarization, and evaluated using the Tukey's HSD test. In that six means were being compared, a critical difference of 8.57 was needed to achieve a $p = .05$

Table 14: Proofreading Times for All Conditions in Experiment 3 (sec)

(a) LESS-SKILLED READERS (N = 32)

	Unfamiliar	Familiarize Normal	Familiarize Scrambled
Proofread Normal	127.48 (34.1)	114.22 (32.1)	121.50 (31.6)
Proofread Scrambled	142.17 (40.6)	135.75 (38.5)	122.91 (33.6)

(b) SKILLED READERS (N = 32)

	Unfamiliar	Familiarize Normal	Familiarize Scrambled
Proofread Normal	109.44 (17.0)	97.28 (16.3)	108.78 (21.5)
Proofread Scrambled	130.45 (26.2)	124.03 (28.7)	118.41 (23.2)

level of significance and a difference of 10.18 needed for a $p = .01$ level (critical difference (6,124) = 4.10 at $p = .05$; critical difference (6,124) = 4.87 at $p = .01$).

These comparisons indicated that familiarity resulted in faster proofreading only when familiarization and proofreading were performed with the same text format. That is, when subjects were familiarized with normal text and subsequently proofread normal text, their proofreading was significantly faster than when proofreading unfamiliar normal text (difference = 12.71; $p < .01$) or when proofreading after familiarization with scrambled text (difference = 9.39, $p < .01$). The difference between proofreading after familiarization with scrambled text and proofreading unfamiliar text was not significant (difference = 3.32, $p > .05$). Similar results were observed when subjects proofread scrambled text. After familiarization with scrambled text, proofreading times were faster than for unfamiliar text (difference = 15.65, $p < .01$) or after familiarization with normal text (difference = 9.23, $p < .05$). Familiarization with normal text did not result in faster proofreading when compared to unfamiliar scrambled text (difference = 3.32, $p > .05$). The Familiarity X Proofreading interaction in this experiment indicates that a transfer from prior Familiarization occurs when subjects' prior experience and proofreading are carried with the same text format, and replicates the results reported by Levy & Begin (1984; Experiment 2).

While the interaction of Group X Familiarity X Proofreading was nonsignificant, F (2, 124) < 1.0, $p > .05$, Group interacted with both Familiarity, F (2,124) = 3.14, MSe = 123.06, $p < .05$, and with the type of text proofread, F (1,62) = 3.84, MSe = 271.48, p = .05. The Group effect was observed as a nonsignificant trend, F (1,62) = 3.42, MSe = 4463.53, p = .06.

In order to further explore these group effects, a subsequent analysis examined the difference between familiar and unfamiliar proofreading for each familiarization condition. These difference, or savings scores adjust for differences between the groups in their unfamiliarized proofreading rates. The mean savings scores for each condition are presented in Table 15. A 2 (Group) X 2 (Familiarity) X (Proofreading) analysis of variance revealed the significant Familiarity X Proofreading interaction, F (1,62) = 27.18, MSe = 204.21, p < .001). Moreover, a significant Group X Familiarity interaction was observed, F (1,62) = 3.74, MSe = 140.10, p = .05). A simple main effects analysis was conducted in order to compare the groups' performance in each familiarization condition. This analysis revealed that, while no differences were observed between the groups after familiarization with normal text, F (1,62) < 1.0, p > .05, the less-skilled readers demonstrated significantly greater savings after familiarization with the scrambled text, F (1,62) = 5.49, MSe = 229.07, p < .03.

Comparison of the effects of repeated exposure to words and text in this experiment indicates that both groups of readers derive benefit from such experience. When familiarization occurs with normal meaningful text, the relative benefit of this prior experience on later processing of the same text is equivalent for the skilled and less-skilled readers. In contrast, the less-skilled readers derived significantly greater benefit

Table 15: Savings (Unfamiliar - Familiar) Scores for Proofreading Familiar Text in Experiment 3 (sec)

(a) LESS-SKILLED READERS (N = 32)

	Familiarize Normal	Familiarize Scrambled
Proofread Normal	13.27 (12.9)	5.98 (11.0)
Proofread Scrambled	6.42 (24.3)	19.27 (15.8)

(b) SKILLED READERS (N = 32)

	Familiarize Normal	Familiarize Scrambled
Proofread Normal	12.16 (7.9)	0.66 (14.3)
Proofread Scrambled	6.42 (13.9)	12.05 (13.6)

from familiarization with Scrambled text than did the skilled readers.

In Experiment 2, the less-skilled readers demonstrated a benefit in repeated experience at the word level which, in absolute amount, was greater than that observed in the skilled reader group. Those results were obtained when a pseudoword naming task was employed. The results from Experiment 3 support the general findings of Experiment 2 by demonstrating that repeated experience at the word level facilitates subsequent proofreading speed to a greater extent in the less-skilled, compared to the skilled, reader. This result was indicated by the greater relative benefit derived by the less-skilled readers after familiarization with the scrambled text. Moreover, this result extends the findings of Experiment 2 to word stimuli, and to the proofreading paradigm. The fact that improvements in the speed of proofreading normal text after experience at the word level can be demonstrated suggest that the findings of Experiment 2 are not attributable solely to changes in articulation latency (Piggins & Barron, 1982), but result from faster, more efficient processing of the words over repeated trials.

Comprehension. The previous analyses were directed toward evaluating the effects of repeated experience at the word and text levels by examining improvements in proofreading accuracy and reprocessing fluency after familiarization. In proofreading normal text, these analyses indicated improved performance followed familiarization with normal text. In addition, the less-skilled readers also benefitted from prior experience at the word level (with the scrambled text), although this benefit was less than for normal text. The final analysis examined whether this improved performance was also evident in subjects' comprehension.

While the comprehension measure reflected meaning derived from the normal text, when only scrambled text was presented (in Unfamiliar Scrambled, and in Familiarize Scrambled - Proofread Scrambled conditions), this measure provided an indication of chance responding to the questions themselves. The mean number of correct responses to the true/false statements in each condition are presented in Table 16. The correct responses for each subject were subjected to a 2 (Group) X 2 (Proofreading) X 3 (Familiarity) analysis of variance, with Group as the between-subjects effect. This analysis indicated that the less-skilled readers demonstrated poorer comprehension than the skilled readers, $\underline{F}$ (1,62) = 16.20, $\underline{MSe}$ = 1.15, $\underline{p}$ < .001. This result was expected in that the groups were selected on the basis of their comprehension skill.

In addition to the Group effect, significant effects of Familiarity, $\underline{F}$ (2,124) = 48.34, $\underline{MSe}$ = .90, $\underline{p}$ < .001, and Proofreading, $\underline{F}$ (1,62) = 33.17, $\underline{MSe}$ = 1.05, $\underline{p}$ < .001, were qualified by their significant interaction, $\underline{F}$ (2,124) = 3.21, $\underline{MSe}$ = 1.24, $\underline{p}$ < .04. This interaction indicated that better comprehension scores were achieved after proofreading scrambled text only when subjects had been familiarized with the normal, meaningful text (comparisons with unfamiliar and familiarize - scrambled conditions > critical difference (6,124) = 0.97, $\underline{p}$ < .01). No differences were observed between familiarization conditions for proofreading normal text.

Closer inspection of the data indicated that the skilled readers'

Table 16: Comprehension of Passages after Proofreading in Experiment 3 (maximum = 6)

(a) LESS-SKILLED READERS (N = 32)

	Unfamiliar	Familiarize Normal	Familiarize Scrambled
Proofread Normal	3.78 (0.9)	4.75 (1.0)	3.69 (1.5)
Proofread Scrambled	3.25 (0.8)	4.31 (1.1)	3.13 (1.0)

(b) SKILLED READERS (N = 32)

	Unfamiliar	Familiarize Normal	Familiarize Scrambled
Proofread Normal	4.31 (1.1)	4.91 (0.9)	4.59 (1.3)
Proofread Scrambled	3.58 (0.8)	4.88 (1.1)	3.28 (1.0)

comprehension scores for normal text were high across all familiarization conditions, and suggested that any differences attributable to familiarization may have been obscured by comprehension levels which were close to maximum performance. Separate Tukey comparisons conducted on the skilled readers' scores indicated a pattern similar to that reflected in the overall analysis: comprehension scores were higher for scrambled text only after familiarization with the normal text (differences compared to both unfamiliar scrambled and familiarize - scrambled > critical difference (12,124) = 1.12, $p < .01$). Familiarization did not result in improved comprehension for the normal text (differences < 6.0, $p > .05$).

In contrast, the less-skilled readers' comprehension of both normal and scrambled text was improved after prior familiarization with the normal text (differences > critical difference (12,124) = .96, $p < .05$). There was no evidence to indicate that prior familiarity with words alone facilitated comprehension when proofreading, and no evidence to suggest that prior familiarity with the words alone facilitated comprehension when proofreading normal meaningful text (difference between Familiarize Scrambled - Proofread Normal and Unfamiliarized Normal = -0.09).

The finding that prior experience with normal text facilitates later comprehension in the less-skilled group supports the proposal in the educational literature that the method of repeated reading is an effective remedial technique for facilitating comprehension (Samuels, 1979). However, the results from the present experiment do not support the theoretical basis underlying this technique: there was no evidence to suggest that facilitation of comprehension resulted from repeated experience solely at the word level. The less-skilled readers, despite the fact that there was some transfer from familiarization with Scrambled text to the time taken to proofread Normal text, did not demonstrate improved comprehension under the same conditions. This finding is consistent with the results of research evaluating the effect of training in word naming on later comprehension (e.g., Fleisher et al., 1979; Piggins & Barron, 1982).

Previous failures to facilitate comprehension after repeated experience at the word level have been attributed to a failure in the experimental manipulation in that improvement in naming times may include decreases in articulation latency (Piggins & Barron, 1982) or do not result in consistently fast reading times when words are placed in text (e.g., Fleischer et al., 1979). Rather than indicating that this failure is a methodological weakness, the results of Experiment 3 suggest that this lack of transfer reflects the specificity of the effects of repeated experience to a particular text. Comprehension was facilitated only when subjects were able to engage in processing of the meaning of the material over successive trials. While ceiling effects in measuring the skilled readers' comprehension precluded comparisons of the relative benefit for the skill groups in comprehension, the relative benefit in proofreading speed over repeated trials with the Normal text indicated similar gains for the two groups. Further investigation of skill differences in comprehension was conducted in Experiment 4.

CHAPTER 7

Experiment 4: Individual Differences in Processing Text

The first two experiments in the thesis were concerned with group differences at the word level; Experiment 3 extended between-group comparisons to include an examination of processing of text. The results of the analysis of oral reading times during the familiarization phase of Experiment 3 suggested that the less-skilled readers were more affected by the text manipulation: relative to the skilled readers, their reading times were differentially slower to the scrambled passages, which were both semantically and syntactically anomalous, than to the normal meaningful text. Moreover, they demonstrated a similar degree of facilitation as the skilled readers over repeated trials with the normal text. These findings tentatively suggest that the less-skilled readers are sensitive to higher-order dimensions inherent in the structure of meaningful, semantically regular text. Experiment 4 explored more directly whether less-skilled readers demonstrate sensitivity to higher-order dimensions of text in a way that is different from their more skilled peers, and whether different patterns of performance are observed after experience with text structure.

Recent research within cognitive psychology has indicated that the way in which a text is structured is a powerful determinant of its comprehension (e.g., Bower, 1976; Kintsch & VanDyke, 1975; Rumelhart, 1975; Stein & Glenn, 1979; Thorndyke, 1977). This research has led to the development of grammars which specify the structure of different types of text (e.g., narrative, expository), analogous in general form to representations of sentence structure. Validation for story grammars has been provided by research indicating that subjects' recall parallels the passages' structure: important idea units, or propositions, are generally recalled better than non-essential or detailed propositions.

More importantly, texts with a logically-ordered, cohesive structure are better comprehended than are texts that are poorly organized. The organization of a text may be manipulated by scrambling the order of selected propositions (e.g., Rahman & Bisanz, in press), removing referents to the main theme (e.g., Bower, 1976; Thorndyke, 1977) or removing linguistic markers which denote relationships between individual propositions (e.g., Meyer, Brandt & Bluth, 1980). The benefit in comprehension, typically measured as recall, with well-structured text compared to poorly-structured text indicates that subjects make use of the organization of text in order to process its meaning. Moreover, experience with text that has a well-defined structure appears to transfer to the comprehension of text with a similar structure. Thorndyke (1977; Bower, 1976) has demonstrated that recall for a second passage is better if it has the same structure as the first passage. In contrast, if the passages are similar in content but differ in their structure, recall is poorer than for unrelated passages.

The grammars which model text structure have been developed by cognitive psychologists concerned with how prior knowledge influences the storage of information in memory: A central assumption is that prior knowledge is represented as abstract schemata; these schemata are hypothesized to act in a conceptually-driven fashion to guide encoding, retrieval and interpretation of stories or passages. The proposal that this knowledge is represented in an abstract form falls within the domain of traditional cognitive theorizing which posits invariant abstract processes to account for cognitive phenomena (Jacoby & Brooks, 1984). While such an assumption may not be warranted (Alba & Hasher, 1984), schema theorists have been important in stimulating research on higher-order dimensions of linguistic processing, and in providing a methodology which can be readily applied to the study of text processing.

There have been relatively few investigations of individual differences in processing text structure. Most of these studies have used story grammar categories to evaluate less-skilled readers' pattern of recall of simple, narrative text. For example, studies conducted with young children (Feagans & Short, 1984; Weaver & Dickinson, 1982) and learning-disabled university students (Worden, Malmgren & Labourie, 1982) have indicated that less-skilled readers demonstrate patterns of recall that are similar to those of skilled readers. Despite these similar patterns of recall, the less-skilled readers' overall level of recall has been found to be significantly less than that of skilled readers. These studies have evaluated recall after listening; however, Meyer, Brandt &

Bluth (1980) have reported similar results with reading.

Comparison of the pattern of subjects' recall, however, has been criticized as an inappropriate measure of sensitivity to text structure (Weaver & Dickinson, 1982; Stein, 1982). Rather, comparing differences in recall between well- and poorly-structured text provides a better basis for evaluating the benefit derived from well-constructed text. Using this method, Rahman & Bisanz (in press) have found evidence to indicate that skilled readers are more sensitive to text structure than are less-skilled readers. While there were no group differences in recalling poorly-structured text in that study, skilled readers' recall of the well-structured text was superior to that of the less-skilled readers. Subjects in the Rahman & Bisanz (in press) study were grade 6 students; whether similar patterns of performance characterize skill differences in university students was addressed in Experiment 4.

The finding that less-skilled readers are less sensitive to text structure could be accounted for by their poorer data-driven processing skills: because of greater demands in processing at the word level, subjects would be less able to engage in higher-order processing. However, if subjects listened to the text, it might be expected that they would differentiate between well- and poorly-constructed text because the word-level processing component is not present. In contrast, according to conceptually-driven models, no difference between reading and listening would be expected, as these models propose that the primary difficulty of the less-skilled reader is in higher-order linguistic processing. According to both bottom-up and top-down processing models, less-skilled readers would be expected to be less sensitive to text structure in reading; the two types of models differ, however, in whether similar results are expected for listening. According to interactive models, however, less-skilled readers would be more likely to use higher-order dimensions of text to aid their less efficient lower-level processing. Consequently, it would be expected that the less-skilled readers would be able to differentiate between texts differing in the integrity of their structure. Experiment 4 was designed to evaluate skill differences in sensitivity to text structure by comparing comprehension of well- and poorly-constructed text under reading (both oral and silent) and listening conditions.

In addition to comparing comprehension of well- and poorly-constructed text, the present experiment was also designed to evaluate transfer across the two types of text. The presentation of the two types of text was blocked, so that subjects received three passages of either well- or poorly-constructed text, followed by three passages of the other type of text. Across subjects, the order of presentation of the two types of text was counterbalanced so that an equal number of subjects in each group received each type of text first. The design of the experiment, then, allowed comparison of the effect of repeated experience with text structure by examining the effect of the order in which the well- and poorly-constructed types of text were presented.

Of particular interest in the experiment was whether experience with well-constructed text would facilitate comprehension of poorly-structured text when it was presented second. Stein (1982) has argued that subjects' recall of poorly-constructed text allows inferences to be made about their use of knowledge acquired about text structure. If repeated experience with a set of well-constructed passages of similar structure facilitates comprehension (Bower, 1976; Thorndyke, 1977), then the knowledge acquired from experience with the well-structured text should transfer to the processing of poorly structured text if it is presented later. In contrast, if experience with well-structured text is unimportant in facilitating later recall, the order in which the two types of text are presented should have no effect. Moreover, if less-skilled readers in university are insensitive to structural dimensions of text, the order in which the two types of text are presented should have no effect on their performance.

While story grammars have been developed primarily for narrative passages, the passages selected for the present study were examples of expository text. This type of text was employed in order to provide material sufficiently challenging for a university sample, and because it is typical of the material which students read at this educational level. As is typical in story grammar research, comprehension was measured by asking subjects to recall as much of the passage as possible. In addition, standard questions were answered by the subject after recall of each passage. If the free recall measure of less-skilled readers' comprehension reflects their lesser ability to organize and integrate the material at recall rather than their comprehension during reading, it would be expected that answers to probe questions would result in significantly better performance than free recall in the less-skilled readers relative to their more skilled peers.

Method

Materials. Six passages were presented to each subject. All passages dealt with a problem of current social concern (e.g., radioactive waste disposal, problems of food supply), and were modifications of essays written by Isaac Asimov (Asimov, 1967; 1975a; 1975b; 1978a; 1978b; 1978c). The passages can be considered as a form of expository prose, although they are "problem-based" and contain more evaluative statements than typical expository text. This format was chosen in order to minimize prior knowledge effects, and to provide passages which were similar to material to which students were exposed in an academic environment.

The passages were modified from their original versions so that they were similar to each other in structure and length, although the content differed for each passage. Each text consisted of three paragraphs. In the first paragraph, the problem to be addressed in the passage was stated and elaborated upon. Possible solutions to the problem were presented in the second paragraph, as well as statements evaluating these solutions. In the third paragraph the author's preferred, final solution and its evaluation were presented. In order to ensure that the passages were structurally similar, all texts had the same number of propositions. Following Stein & Glenn (1979), a proposition was defined as a simple sentence of text containing a single unit of meaning. For all passages, the introductory paragraph stating the problem contained three propositions, while the paragraphs containing possible solutions (paragraph 2) and the author's preferred solution (paragraph 3) each contained 7 propositions.

Two versions of each passage were constructed in order to manipulate text structure. High Constraint versions of the passages were constructed in the order described above, and thus constituted well-ordered, logical text. The Low Constraint versions were constructed by reordering 6 of the 17 propositions. While the introductory paragraph was left intact, three propositions from each of paragraphs 2 and 3 were changed: the first proposition in each paragraph was presented later in the same paragraph, while the last 2 propositions in these paragraphs were exchanged. This reordering of propositions (1 to 3; 5 to 8; 4, 16, 17, 12 to 15; 9, 10) was the same for all passages.

Eight questions were constructed for each passage and measured comprehension for the: problem statement (1 question) and its elaboration (1 question), possible solution (1 question) and its elaboration (2 questions), and the preferred best solution (1 question) and its elaboration (2 questions). Probe questions were presented in written form in the order in which the probed information occurred in the passage. Consequently, the order in which the questions were presented differed for High and Low Constraint versions of each text. The text material, and corresponding questions, are presented in Appendix D.

Procedure. Each subject was presented with a passage to be listened to, read silently, or read aloud. Following the presentation of each passage, the subject wrote as much as s/he could remember. Subjects were instructed to record as much of the content as possible, rather than attempting verbatim recall. Recall was written in sentence form. Following recall, each subject answered the probe questions for that passage. In order to familiarize subjects with the procedure, one practice passage, shorter than the test passages but of similar structure, was presented for silent reading followed by oral recall and question answering.

All subjects participated in all six conditions: reading silently (RS), reading orally (RO), and listening (L) to both High and Low Constraint text. High and Low Constraint passages were presented in blocks, so that a subject was presented with three High Constraint passages followed by 3 Low Constraint passages (HL order), or vice versa (LH order). In order to ensure that a particular passage did not contribute differentially to the Modality or Constraint effects, each passage served in each condition across all subjects in each of the reader groups. The order of the 6 passages, 2 Orders (HL, LH) and 3 Modality (RO, RS, L) conditions was counterbalanced, so that any specific order and passage effects were distributed across all modality and text conditions. Consequently, there were 36 different presentation orders for each reader group.

In the Listening conditions, passages were presented by a tape recorder, at an average rate of 150 words per minute. Prior to reading conditions, each subject was instructed to read the passage once at a normal rate without backtracking. While this strategy is probably not compatible with normal reading, these instructions avoided study strategies and ensured some comparison with the listening condition.

Results and Discussion

Performance on the Nelson-Denny Test. In this experiment, there were two between-subject variables: reader group, and the order in which the sets of High and Low text were presented. The skilled and less-skilled reader groups were each composed of subjects who had received one of two orders of text presentation (i.e. either three High followed by three Low Constraint text, or three Low Constraint followed by three High Constraint passages). In order to determine whether the groups of subjects in these orders were different prior to the experiment, preliminary analyses were conducted on measures from the Nelson-Denny test administered at screening. Mean scores for each presentation order on the Nelson-Denny measures are presented in Table 17.

Separate analyses of variance were conducted for each reading measure from the Nelson-Denny test, with skill group and presentation order comprising between-subject effects. In each analysis, there was a main effect of reading skill: this effect was present for the comprehension raw score measure, F (1,68) = 412.12, MSe = 5.86, p < .001, for the correct comprehension score expressed as a percentage of the number of questions attempted, F (1,68) = 49.29, MSe = 103.55, p < .001, as well as for reading rate, F (1,68) = 8.07, MSe = 2613.24, p < .001. Neither the presentation order, nor the interaction of presentation order X

Table 17: Nelson-Denny Scores for Each Presentation Order within Skilled and Less-Skilled Reader Groups

(a) LESS-SKILLED READERS

Order	Comprehension Raw Score (max=36)	Comprehension Raw Score/Attempted (percent)	Rate (wpm)
High - Low (N=18)	18.67 (2.1)	70.88 (10.2)	211.00 (44.7)
Low - High (N=18)	17.94 (3.9)	69.73 (15.2)	201.33 (45.3)

(b) SKILLED READERS

Order	Comprehension Raw Score (max=36)	Comprehension Raw Score/Attempted (percent)	Rate (wpm)
High - Low (N=18)	29.89 (1.4)	86.79 (6.3)	259.50 (52.4)
Low - High (N=18)	29.89 (1.5)	87.51 (6.4)	255.28 (60.5)

reading skill was significant (all $\underline{F}$ (1,68) values < 1.00, $\underline{p}$ > .05) for any of the screening test measures. These data indicate that while the skilled and less- skilled reading groups differed from each other on all of the reading measures, the two groups of subjects who received the two presentation orders <u>within</u> each reading group did not differ. This suggests that any effects involving presentation order are attributable to subjects' experience with different types of text, rather than to differences existing between the groups of subjects prior to the experiment.

<u>Scoring of Recall</u>. In order to evaluate free recall, a scoring system was developed which was based on the propositions contained in each passage. Each subjects' recall was evaluated with reference to the propositional base established for the passage. If the subject recalled the main idea in a proposition, a point was given, so that the maximum score for each passage was 17. All protocols were scored so that the examiner was unaware of the condition in which the passage had been presented and the reading group of the subject.

In order to establish reliability of the scoring criteria, a representative subset of the recall protocols was evaluated by a second scorer who was unaware of the purposes of the experiment. One-third of the protocols (i.e. 144) were evaluated by the second scorer for reliability purposes. These protocols were selected so that one protocol for each subject was included, and across subjects in each group, all of the conditions in the experiment (2 types of text and 3 modality conditions) and the 6 passages were represented equally often.

In general, there was a high degree of correspondence between the two scorers. The mean number of propositions scored as correct was similar (M 1 = 7.25, SD = 2.65; M 2 = 7.24, SD = 2.53). Moreover, the correlation between the two scorers was .90, indicating that the method of scoring the recall protocols was reliable across different examiners. High correlations were also observed when the two types of text were examined separately: the correlation between independent scorers was .91 for High Constraint text and .85 for Low Constraint text.

Free Recall. The number of propositions correctly recalled were subjected to a 2 (Reading Group) X 2 (Presentation Order) X 2 (Structure) X 3 (Modality) analysis of variance, with reader group and presentation order as between-subject effects.

There was a significant effect of the modality in which the text was presented, F (2,136) = 7.51, MSe = 4.73, $p < .002$. Tukey comparisons indicated that, over all conditions, listening (M =7.60) produced better recall than did reading orally (M = 6.64; critical difference (3,136) = .87, $p < .05$). Mean recall after reading silently (M = 6.91) fell between recall after listening and reading aloud, and was not significantly different from either condition. It is noteworthy that the interaction of Modality X Order X Text, F (2,136) = 2.80, MSe = 3.71, p = .06, was observed as a nonsignificant trend. Further examination of this trend, employing Tukey's HSD test, indicated that listening produced greater recall than did reading orally only for High

Constraint text when it was presented first (M difference = 1.72, critical difference (12, 136) = 1.51, $p < .05$). This effect was attenuated when Low Constraint text was presented first (M difference = 1.28), and was not present when either High (M difference = 0.33) or Low (M difference = 0.53) text was presented second. Modality did not interact with any other effects in the experiment. Mean recall for each modality condition, collapsed across reader group is presented in Table 18.

The poorer recall after reading aloud, compared to listening, indicates that the requirement of articulation, as well as processing for meaning, resulted in poorer comprehension. This is substantiated by subjects' ratings of the modality conditions: most subjects reported that reading aloud tended to focus their attention on articulation at the expense of comprehension. In contrast, listening required processing of meaning without the visual processing component inherent in reading, and resulted in higher recall.

These modality effects appeared to be greatest for the first set of passages, particularly for well-structured text. For poorly structured text, or for the second set of either type of text, these modality effects were attenuated. While this interaction was present only as a trend, it suggests that listening was advantageous primarily on initial presentation, and when the text was well integrated. After repeated experience with the recall task, the modality of presentation became less influential, either because of fatigue effects across the course of the experiment or because the knowledge acquired about the texts overcame the initial advantage due to listening.

Table 18: Comparison of Recall of High and Low Constraint Passages as a Function of Modality and Presentation Order (maximum = 17)

	TEXT CONSTRAINT					
	High			Low		
Modality	RO	RS	L	RO	RS	L
Order						
High - Low (N=36)	7.09 (2.90)	7.39 (2.22)	8.81 (2.71)	6.61 (2.25)	6.72 (2.37)	7.14 (2.09)
Low - High (N=36)	7.84 (2.42)	7.83 (2.43)	8.17 (2.37)	5.00 (2.22)	5.70 (2.28)	6.28 (1.99)

While modality influenced subjects' recall, there was no difference between the skilled and less-skilled readers in their average pattern of performance under the different modality conditions. This finding is in contrast to research reported with children: less-skilled readers have been found to demonstrate better comprehension after reading a text aloud (Hinchley & Levy, 1985; Miller & Smith, 1985). This superiority of oral reading for less-skilled readers in childhood has been attributed to its effects in facilitating attention to each word (Miller & Smith, 1985), facilitation of phonological analysis (Juel & Holmes, 1981) and to the maintenance of a verbal code in working memory (Goldman, Hogaboam, Bell & Perfetti, 1980). The failure to find a similar effect in less-skilled adult subjects in the present study may be a function of their higher level of reading proficiency more generally. Alternatively, and in contrast to children, oral reading appears to be a much less practiced skill in this adult population than is silent reading; the differential effects of modality across samples differing in age and educational level may be attributable to such effects. It would appear that at higher levels of reading proficiency, less-skilled readers demonstrate similar modality effects as their more skilled peers.

As expected, there was a main effect of text structure, $\underline{F}$ (1,68) = 48.41, $\underline{MSe}$ = 5.79, $\underline{p}$ < .001, indicating that well-structured passages were recalled better than the Low Constraint passages. However, this effect was dependent upon the order in which the text was presented. Although the main effect of presentation order was nonsignificant, $\underline{F}$ (1,68) = 2.56, $\underline{MSe}$ = 10.15, $\underline{p}$ > .05, presentation order interacted with text structure, $F(1, 68) = 8.52$, $MSe = 5.79$, $p < .006$. Further comparison between the conditions were made using the Tukey HSD test; the relevant means, collapsed across modality and reader group are presented in Table 19. These comparisons indicated that the High Constraint text was recalled significantly better than Low Constraint text when the Low Constraint text was presented first (M difference = 2.28, critical difference (4, 68) = 1.84, $p < .05$). In contrast, there was no difference between the two types of text when the High Constraint passages were presented first (M difference = 0.93).

Whether differences in recall are observed between the High and Low Constraint text, then, depends upon their relative order of presentation. The finding that recall of poorly-constructed text is worse when it precedes the well-constructed text suggests that the two types of text differ in their comprehensibility. In contrast, when High Constraint text is presented first, there appears to be no effect of text structure: High and Low Constraint text are recalled equally well. In this condition, however, experience with the well-structured text appears to be facilitating later recall of the poorly-structured text. Once subjects have been exposed to a set of well-integrated passages of similar structure, they are able to transfer knowledge about the structure to aid their recall of more poorly-structured text.

Of primary interest in the experiment, however, was whether the less-skilled readers differed from their more skilled peers in their sensitivity to text structure. While there was a significant effect of reader group, $F(1,68) = 7.06$, $MSe = 10.15$, $p < .01$, reader group

Table 19: Mean Recall of High and Low Constraint Passages as a Function of Presentation Order (maximum = 17)

	TEXT CONSTRAINT	
Order	High	Low
High - Low (N=36)	7.76 (2.15)	6.82 (1.54)
Low - High (N=36)	7.94 (1.62)	5.66 (1.32)

also interacted with text structure, F (1,68) = 3.68, MSe = 5.79, p = .056. This interaction indicated that the skilled and less-skilled readers demonstrated a different pattern of recall for the High and Low Constraint text. While the skilled readers recalled more of the High than Low Constraint text (M difference = 2.05; critical difference (4, 68) = 1.84, $p < .01$), the less-skilled readers did not differentiate between the two types of text in their recall (M difference = 1.16, $p > .05$).

While the skilled and less-skilled readers demonstrated a different pattern to the High and Low Constraint text, the group differences were not dependent upon the order of presentation. The Group X Order X Text interaction was nonsignificant, F (1, 68) < 1.0, $p > .05$, and there was no evidence to indicate that the groups responded differently to High and Low Constraint text between the two presentation orders (see Table 20).

The results of analyses of the recall data indicate that the less-skilled readers do not discriminate between well- and poorly-structured text to the same extent as the skilled readers. This suggests that, like younger readers (eg. Meyer et al., 1980; Rahman & Bisanz, in press), the less-skilled group is less sensitive to the higher-order dimensions of text structure. However, the less-skilled readers demonstrated a similar pattern of performance as the skilled readers when the order of presentation of the two types of text was considered. Like the group of skilled readers, the less-skilled readers' recall was dependent upon which type of text was presented first. While the overall differences between High and Low Constraint text were nonsignificant, the less-skilled readers demonstrated a similar pattern of

Table 20: Recall of High and Low Constraint Passages as a Function of Presentation Order and Reader Group (maximum = 17)

(a) LESS-SKILLED READERS

Order	TEXT CONSTRAINT High	TEXT CONSTRAINT Low
High - Low (N=18)	6.87 (1.94)	6.59 (1.55)
Low - High (N=18)	7.58 (1.62)	5.52 (1.29)

(b) SKILLED READERS

Order	TEXT CONSTRAINT High	TEXT CONSTRAINT Low
High - Low (N=18)	8.65 (2.01)	7.06 (1.54)
Low - High (N=18)	8.31 (1.59)	5.80 (1.37)

facilitation to Low Constraint text after experience with the High Constraint passages. Similarly, their pattern of performance in the Low - High order was similar to the skilled readers. These results suggest that, while the less-skilled readers appear to be less sensitive to the structural dimensions of text, they are able to use some knowledge of well-constrained text to facilitate their comprehension of poorly constructed passages presented subsequently.

Comparison of Free and Probed Recall. A secondary issue was whether the skilled and less-skilled readers differed in the relative benefit they derived from questions probing specific information, compared with recall. In order to compare answers to the probe questions with the written recall measure, the number of correctly answered questions were compared to recall of the propositions which the questions were designed to test.

A 2 (Reading Group) X 2 (Order) X 2 (Structure) X 3 (Modality) X 2 (Response) analysis of variance was conducted with reading group and order as between-subject factors. There was a significant effect of the type of response measure, $\underline{F}$ (1,68) = 400.17, $\underline{MSe}$ = .80, $\underline{p}$ < .001, indicating that probed recall resulted in better performance than did free recall. This finding indicates that cueing recall of specific information results in superior performance to free recall. In the present experiment, the probe question appeared to act as a cue for specific information which was not remembered by the subject under free recall conditions. This demonstrated superiority of the probe question may also be a function of the more restricted criteria by which a question may be evaluated by the subject. Typically, some portion of the proposition served as the question; the remainder was required as the correct answer. Not only was less information required for a correct response to a probe question, but information was provided which allowed the generation of a response. Free recall, on the other hand, required understanding and remembering the entire proposition, and placing it in the appropriate context so that the original meaning was present.

While the probed measure produced higher comprehension scores, there was no interaction between the type of comprehension measure and reader group, $\underline{F}$ (1,68) < 1.0, $\underline{p}$ > .05. This indicates that the less-skilled readers' recall was not differentially aided by cueing specific information, and suggests that their poorer recall is not due to a relative inability to organize and integrate information at retrieval.

With one exception, the remaining significant effects were similar to the results of the analysis of the free recall data alone. The main effect of Modality, $\underline{F}$ (2, 136) = 6.96, $\underline{MSe}$ = 1.71, $\underline{p}$ < .002, was qualified by a significant interaction of Order X Structure X Modality X Response, $\underline{F}$ (2, 136) = 3.02, $\underline{MSe}$ = 0.10, $\underline{p}$ = .05. This interaction indicated that the modality effects observed for free recall were not apparent when comprehension was tested by the probed recall measure (see Table 21). For free recall, listening resulted in better free recall but only for the first set of passages presented to the subjects. When Low Constraint text presented first, recall after listening was better than after reading aloud (difference = 0.78, critical difference (24, 136) =

Table 21: Comparison of Recall and Answers to Questions in Experiment 4 as a Function of Text Constraint and Presentation Order (maximum = 6)

(a) HIGH - LOW ORDER (N=36)

	TEXT CONSTRAINT					
	High			Low		
Modality	RO	RS	L	RO	RS	L
Free Recall	3.53 (1.59)	3.81 (1.43)	4.56 (1.93)	3.44 (1.27)	3.28 (1.32)	3.39 (1.40)
Probe Question	4.75 (1.48)	4.78 (1.42)	5.19 (1.28)	4.47 (1.46)	4.67 (1.35)	4.69 (1.12)

(b) LOW - HIGH ORDER (N=36)

	TEXT CONSTRAINT					
	High			Low		
Modality	RO	RS	L	RO	RS	L
Free Recall	4.00 (1.55)	4.06 (1.72)	4.19 (1.67)	2.61 (1.38)	2.94 (1.37)	3.39 (1.20)
Probe Question	5.14 (1.15)	5.67 (1.43)	5.47 (1.48)	4.06 (1.29)	4.36 (1.31)	4.36 (1.17)

0.72, $p < .05$). When the High Constraint text was presented first, listening resulted in better recall than did both reading silently (difference = 0.78, $p < .05$) and reading aloud (difference = 1.03, $p < .01$). Modality differences were not observed in free recall for the second set of passages (differences < critical value (24, 136) = 0.72, $p > .05$). In contrast to free recall, the probed recall measure was insensitive to modality effects: differences in performance between the modality for the text types in each order were small and nonsignificant (differences < critical value (24, 136) = 0.72, $p > .05$).

As had been observed in the free recall analysis, the significant effect of Structure, F (1, 68) = 62.05, MSe = 2.17, $p < .001$, was qualified by the interaction of Structure with Order, F (1, 68) = 11.85, MSe = 2.17, $p < .002$ (see Table 19). This interaction indicated that comprehension of High Constraint text (M = 4.78) was superior to that of Low (M = 3.62) in the Low - High order (difference = 1.16, critical difference (4, 68) = 0.90, $p < .05$), but not in the High - Low order (difference = 0.45, $p > .05$).

In addition to a significant difference between the skill groups, F (1,68) = 11.59, MSe = 5.06, $p < .002$, reading skill interacted with text structure, F (1, 68) = 5.44, MSe = 2.17, $p < .03$. As had been observed with the free recall measure alone, the difference between comprehension measures for High and Low Constraint text was significant for the skilled readers (difference = 1.02, critical difference (4, 68) = 0.90, $p < .05$) but not for the less-skilled readers (difference = 0.55, $p > .05$).

Comparison of the results of the probed and free recall indices of comprehension suggest that, in some respects, these measures provide different information. Overall, the probed recall measure resulted in higher performance than did free recall of the same propositions. This finding was interpreted as being a result of both the cueing function that the probe served, as well as to the more restricted criteria which could be used by the subject to retrieve an answer to the probe question.

While the results from probed recall suggest that subjects have access to information which they do not generate in free recall, there is some evidence to indicate that free recall may be a more sensitive index of an individual's understanding of text. The free recall measure, unlike that of probed recall, provided an indication that the modality of presentation was important for subjects' initial experience with the text. By the second set of passages, independent of the type of text presented, the prior experience had attenuated any modality effects. In contrast, probed recall was insensitive to the modality of presentation. This differential effect of modality on the two comprehension measures suggests that it may play an important role in mediating comprehension when generation, organization, and integration are components of the measure. The superiority of listening, on initial presentations, suggests that the absence of the processing required in reading may allow greater integrative processing of the text. When recall of specific information is required, as in probe responses, this higher-order integrative processing confers no advantage. This interpretation is tentative, however, in that the high probed recall levels (particularly in the skilled group) may have been at ceiling, and consequently modality effects may have been obscured.

Despite these differences, both the free and probed recall measures indicate that whether a difference between well- and poorly-constructed text is observed under the conditions of the present experiment depends upon the order in which the types of text are presented. This dependence on order suggests that recall of the two types of text does not measure solely the subjects' sensitivity to the difference between them. Rather there appears to be an asymmetrical transfer which depends on similarities between the two types of text. In the High-Low order, for example, knowledge acquired about the well-constructed text across three consecutive trials appears to transfer to text which is not as well constructed. This transfer from well- to poorly-constructed text, then, obscures any performance-based differences between them. On the other hand, in the Low-High order, subjects are first provided with experience in processing poorly constructed text. This experience does not appear to transfer to processing of the High Constraint text; rather, subjects appear to benefit from the contrast between the two types. This contrast results in high levels of comprehension and large differences between the High- and Low-Constraint text.

Reading Times. In Experiment 3, the use of reading time as a dependent measure was predicated on the assumption that changes in reading and in proofreading times provided indices of changes in the efficiency of processing text. This rationale was also employed in the present experiment in order to examine whether there were changes in reading time with a change in text structure. As noted in the Method section, subjects were asked to read each passage once at their normal reading speed without backtracking. The mean reading times for silent and oral reading conditions are presented in Tables 22 and 23, respectively. For both oral and silent reading, the data were subjected to a 2 (Reading Skill) X 2 (Order) X 2 (Text Structure) analysis of variance.

The results of the analysis of silent reading times indicated that the skilled readers were faster than the less-skilled group, F (1, 68) = 14.74, MSe = 448.92, p < .001. However, there were also significant effects of Order, F (1, 68) = 4.31, MSe = 448.92, p < .04, and Text Structure, F (1, 68) = 4.92, MSe = 97.96, p < .04, which were qualified by their interaction, F (1,68) = 4.65, MSe = 97.96, p < .04. The interaction indicated that subjects in the Low - High order read the two types of text at the same rate (difference = .10; critical difference (4, 68) = 6.17, p > .05), while subjects in the High - Low order read the Low text significant slower than they read the High Constraint text (difference = 7.22, p < .05). This effect was present for both the skilled and less-skilled readers; there was no interaction of group with any of the other effects, Fs < 1.0, p > .05.

These results, like the reading time measures in the previous experiments, provide further evidence that the skilled readers are faster readers than are the less-skilled readers. Despite this difference in reading speed, however, the two groups did not differ in their pattern of performance to the two types of text. The silent reading times for High and Low Constraint text did, however, differ for both groups of readers in

Table 22: Silent Reading Rates for Passages in Experiment 4 (sec)

(a) LESS-SKILLED READERS

Order	TEXT CONSTRAINT High	TEXT CONSTRAINT Low
High - Low (N=18)	75.35 (16.7)	84.66 (15.6)
Low - High (N=18)	70.87 (16.7)	71.36 (16.8)

(b) SKILLED READERS

Order	TEXT CONSTRAINT High	TEXT CONSTRAINT Low
High - Low (N=18)	62.32 (19.9)	67.45 (18.1)
Low - High (N=18)	59.26 (13.1)	58.97 (14.5)

Table 23: Oral Reading Rates for Passages in Experiment 4 (sec)

(a) LESS-SKILLED READERS

	TEXT CONSTRAINT	
	High	Low
Order		
High - Low (N=18)	84.27 (23.4)	85.08 (17.4)
Low - High (N=18)	81.39 (10.6)	79.57 (12.7)

(b) SKILLED READERS

	TEXT CONSTRAINT	
	High	Low
Order		
High - Low (N=18)	71.45 (8.4)	72.10 (8.6)
Low - High (N=18)	71.59 (4.7)	70.48 (5.3)

a way which was dependent upon the order of presentation.

An examination of silent reading times provides a different pattern of results than the recall data, and suggests that whether subjects demonstrate sensitivity to text structure depends both on their experience throughout the testing session and on specific measures of reading. The silent reading times were significantly different under specific conditions: reading rate was slower for Low Constraint text when it was presented after the High Constraint passages. The finding that subjects in this condition read the texts at different rates suggests that both groups of subjects were sensitive to the structural dimensions of the text in this condition. That is, once subjects had experience with well-constrained text over a series of trials, subsequent variations of that structure were responded to, and were reflected in slower reading times. This difference between the types of text in the High - Low order is in contrast to the similar levels of free recall demonstrated by both the less-skilled and skilled reader groups. It appears that after repeated experience with High Constraint text, the transfer which is evident in free recall is preceded by an increase in reading rate when confronted with the poorly constructed text.

The opposite pattern of results is observed in the Low - High condition. While the silent reading times between the Low- and High-Constraint text do not differ, recall for High Constraint passages is substantially greater than for the Low Constraint text. The pattern of results in this condition indicate that after experience with poorly constructed text, subjects were able to recall more propositions of well-constructed text without a corresponding increment in their silent reading rate.

The silent reading times, then, appear to be sensitive to text structure effects in a way which is opposite to those differences demonstrated in free recall. The pattern of results, when taken in conjunction with the free recall data, indicate that both groups of readers are sensitive to text structure, but that subjects' experience with specific types of text may mediate their performance on subsequent trials. Despite the fact that the less-skilled readers demonstrated sensitivity to text structure in their reading times, they did not discriminate between High and Low Constraint text in their overall levels of recall.

In contrast to the silent reading times, the results of the analysis of oral reading rate indicated that both well- and poorly-constructed text were read at the same rate. The results of the analysis of oral reading indicated that there was a significant effect of skill group, $\underline{F}(1, 68) = 14.60$, $\underline{MSe} = 307.72$, $\underline{p} < .001$; the skilled readers were faster at reading aloud than were the less-skilled readers. No other effects resulted in significant differences in oral reading times (all $\underline{F}$'s $(1,68) < 2.0$, $\underline{p} > .05$). It was argued earlier that reading the passages aloud consisted of two tasks for the subjects in this experiment, and included a "reading" component as well as an articulatory component. The contrast between the results of analyses of silent and oral reading times suggests that the articulatory demands in reading aloud overrode any differences in sensitivity in the High - Low condition.

The major purpose of Experiment 4 was to determine whether less-skilled readers are as sensitive to higher-order dimensions of text structure as the skilled readers. The results of this study indicate that, like younger groups of readers (eg. Rahman & Bisanz, in press), less-skilled readers in a university sample do not discriminate between well- and poorly-constructed text in their average level of recall. While the skilled readers recalled the High Constraint text better than the Low Constraint text across all conditions in the experiment, the less-skilled readers' recall did not differ between the two types of text structure. This difference in recall between the two reader groups cannot be attributed to differences in the availability of text content at recall alone, because both groups were aided to the same degree by questions probing selected material from the text. Rather, the group differences appear to reflect the lesser ability of the less-skilled readers to organize, integrate and recall information contained in well-structured text.

The difference between the skilled and less-skilled readers' recall of the two text structures does not indicate that the less-skilled readers were completely insensitive to the structural dimensions of the passages. The less-skilled readers demonstrated the same pattern of performance under different conditions of presentation order as did the skilled readers. In both groups, recall of the Low Constraint text was equivalent to High Constraint text when the latter was presented first. In contrast, when the Low Constraint text was presented first, both groups demonstrated better recall of the High Constraint text. The fact that <u>both</u> groups of readers responded similarly to their experience with the two types of text structure suggests that the less-skilled readers are sensitive to the structural dimensions of text under specific conditions. Additional support for this conclusion was provided by analysis of the silent reading times. During silent reading, both groups of readers adjusted their rate to Low Constraint text when it followed the well-structured text, suggesting that both skilled and less-skilled readers were sensitive to differences in structure. However, the relatively more self-paced nature of the silent reading conditions alone cannot be responsible for the equivalent recall between High and Low Constraint text in the HL order, as similar patterns of recall between the two text structures were observed after reading orally and listening.

The different pattern of performance observed between the two presentation orders suggests that both groups of readers derive benefit from repeated experience with well-structured text. It thus appears that facilitation of comprehension for both skilled and less-skilled readers can result from repeated experience with well-integrated text of a specific structure. In contrast to the results of Experiment 3, as well as those studies examining the method of repeated reading (Samuels, 1979), the results of Experiment 4 suggest that such facilitation may be observed across variations in lexical items and in meaning. Whether the extent of transfer across similarly-structured, well-integrated text is similar for skilled and less-skilled readers remains a subject for future research.

The results of Experiment 4, then, indicate that the less-skilled readers in university do not discriminate between well- and poorly-structured text as well as their more skilled peers. In addition, their reading rates (both silent and oral) are markedly slower. However, their pattern of performance across different modality conditions was not different from the skilled readers. This lack of a modality effect between groups suggests that the less-skilled readers' poorer comprehension is not purely a function of their poorer word-level processing, as would be predicted from bottom-up processing models. Rather, the results indicate that in addition to the poorer word-level processing demonstrated in the first three experiments, the less-skilled readers also demonstrate poorer conceptually-driven processing than their more skilled peers.

CHAPTER 8

General Discussion

Summary of the Thesis Research

The experiments in the thesis were concerned with individual differences in processing at the word and text levels, and in examining whether different patterns of performance were observed between reader groups across repeated trials. The population of interest was the adult reader in university; two groups differing in reading skill were selected on the basis of their performance on a standardized measure of reading comprehension.

The results of Experiment 1 indicated that less-skilled readers in the university sample demonstrated slower naming times to words and pseudowords than their more skilled peers. This result is surprising in that students in this sample have developed relatively proficient levels of reading comprehension skill. Given this level of proficient reading comprehension, it might have been expected that optimal performance in lower-level processing would have been achieved by both groups of readers. Moreover, the less-skilled readers were differentially slower in naming pseudowords, a finding which replicated previous research across a range of age and skill levels (e.g., Backman et al., 1984; Mason, 1978; Perfetti & Hogaboam, 1975). This finding suggests that less-skilled readers have particular difficulty in identifying unfamiliar lexical items, and is consistent with the hypothesis that phonological processing skill is a source of individual differences at the word level (see Chapter 2).

Despite their generally poorer performance, the less-skilled readers were similar to the skilled readers in their pattern of responding to the regular and exception items: there was no evidence to indicate that irregular and inconsistent orthographic patterns posed particular difficulty for them. This is in contrast to the findings with younger populations (e.g., Backman et al., 1984; Lovett, in press; Waters et al, 1984). This contrast suggests that with continued experience, irregular spelling patterns may not present difficulty for the less-skilled reader.

The second experiment investigated whether the less-skilled readers were less able to benefit from repeated experience with unfamiliar pseudowords, which are hypothesized to require more reliance on phonological analysis. In absolute terms, the less-skilled readers demonstrated a greater improvement in naming speed than the skilled readers. Although this greater gain may be due to differences in the scale of measurement (i.e., the less-skilled readers' slower naming times provided a wider range for improvement), there was no evidence to suggest that the less-skilled readers were less able to benefit from repetition at the word level.

Similarly, in Experiment 3 the less-skilled readers demonstrated greater gains in both oral reading and proofreading speed for words in scrambled text (Familiarize Scrambled - Proofread Scrambled condition) than did the skilled readers. This finding is important because it indicates that the improvement over repeated trials is not merely a consequence of improved articulation speed in the naming task (Piggins & Barron, 1982). Moreover, the results from this condition in Experiment 3 indicate that the same pattern of facilitation over repeated trials is observed with words and pseudowords.

Taken together, the results from the first two experiments and from the scrambled conditions in Experiment 3 indicate that, across a variety of measures, the less-skilled readers are poorer at word-level processing: they are slower in naming individual words and pseudowords, and are slower and less accurate in detecting proofreading errors than are more skilled readers. These results are consistent with predictions derived from bottom-up processing models, which posit that the major source of individual differences is in processing at the word or subword level. Moreover, these experiments indicate that the less-skilled readers are at least as able to benefit from repeated experience at the word level.

According to bottom-up processing models, facilitation of word-level processing should result in better comprehension (Perfetti & Lesgold, 1977, 1978; Samuels, 1979). This hypothesis was tested in Experiment 3. The results of the study indicated that after familiarization with the words in scrambled text, the less-skilled readers' proofreading of normal text was faster and more accurate than their proofreading of unfamiliar normal text. This facilitation was not observed in the skilled readers' performance. This suggests that the less-skilled readers' improved word-level processing does transfer to reading text, although the gains were small. However, there was no evidence to indicate that the less-skilled readers' comprehension improved as a result of experience at the word level.

Facilitation of processing of meaningful text was observed primarily after repeated experience with the text. This was apparent at all levels of reading examined: proofreading accuracy, proofreading speed and comprehension. Moreover, the absolute benefit in reading fluency was similar for the two groups of readers.

The results from comparing repeated experience with words versus text indicate that facilitation is observed primarily when the materials are the same across trials. This specificity indicates that improved processing occurs only at those levels of reading which are engaged across repeated trials. While the less-skilled readers did transfer word-level experience to reading text, there was no evidence to support the prediction from bottom-up processing models that improved comprehension would result.

The facilitation of text processing observed in Experiment 3 suggested that the less-skilled readers were sensitive to higher-order dimensions of text. Experiment 4 examined whether less-skilled readers were sensitive to text structure, and whether their comprehension reflected experience with different text of similar structure. The results indicated that the less-skilled readers, in contrast to their skilled peers, did not differentiate between well- and poorly-constructed text in their levels of recall. This result was consistent with recent research with children, which has been interpreted as indicating that less-skilled readers are insensitive to text structure (e.g.,, Meyer et al, 1980; Rahman & Bisanz, in press).

Two additional findings from Experiment 4, however, provided evidence that the less-skilled readers were sensitive to the way in which the text was structured. Comparison of the relative order in which the two types of text were presented indicated that the pattern of performance was similar for the two groups: significant differences in the recall of well- and poorly constructed text were observed for both groups when the poorly-constructed text was presented first. Such differences in recall between the two types of text were not observed when the well-constructed passages were presented first for either skilled or less-skilled readers. Subsequent analyses of silent reading times indicated that the less-skilled readers, like the skilled readers, read the poorly-constructed text more slowly when it followed experience with the well-constructed text. These findings indicate that despite equivalent levels of recall in the High - Low presentation order, both groups of readers demonstrated sensitivity to text structure in their silent reading speed. The results from Experiment 4, then, indicate that the less-skilled readers on average, do not recall well-structured text better than poorly structured text. However, comparison of their recall across different presentation orders and of their silent reading rates indicated that the less-skilled readers, like their skilled peers, were sensitive to the structural differences between the passages. The results from the experiment suggest that whether group differences are observed depends upon the conditions under which passages are presented, and illustrate the importance of examining multiple measures of reading in order to evaluate differences in processing under different conditions.

Implications for Models of Reading

The results of the experiments reported in the thesis have implications for models of proficient reading which have been applied to the study of individual differences in reading skill. As noted earlier, the slower and less accurate word-level skills demonstrated by the less-skilled readers are consistent with the hypothesis derived from bottom-up processing models, that processes at the word or subword level are a major source of individual differences.

According to both bottom-up and top-down processing models, less-skilled readers should process words presented in meaningful text in a way which is more similar to their processing of isolated words than should the less-skilled readers. Comparisons of both oral reading and proofreading of normal and scrambled text in Experiment 3, however, indicated that the pattern of performance to the two types of text was similar for the skilled and less-skilled readers. While the less-skilled readers were more generally slower, both groups processed the normal text faster than the scrambled text. These findings suggest that the less-skilled readers, like the skilled readers, are using semantic and syntactic information to their advantage in reading normal text. This finding is not consistent with either the hypothesis that the less-skilled readers' poor word-level processing constrains subsequent higher-order processing of syntax and meaning, or with the hypothesis that the less-skilled readers' relative inability to process higher-order dimensions of text forces them to read at the word level.

The investigation of individual differences in processing higher-order dimensions of text was conducted in Experiment 4 in order to further evaluate differences in top-down processing. Comparisons of comprehension after either reading or listening to a passage indicated that there was no evidence to suggest that the less-skilled readers' comprehension difficulties were specific to print. While their overall comprehension was significantly lower, their pattern of performance under reading and listening conditions was similar to that of the skilled readers. Rather, these data indicate that poorer language comprehension skills are characteristic of the less-skilled reader, which corroborates research conducted across a wide range of skill levels observed in both childhood (e.g., Curtis, 1980) and in university students (Palmer et al., 1985).

While the less-skilled readers' lower comprehension levels after listening supports the prediction of poorer linguistic knowledge derived from top-down processing models, the less-skilled readers did demonstrate sensitivity to the higher-order dimension of text structure in a way which was similar to the skilled readers. This sensitivity was demonstrated under conditions of different order of repeated experience with well- and poorly-structured text. In recall, the results suggested that less-skilled readers were able to take advantage of previous experience with well-constructed text in aiding their recall of the more poorly constructed text which followed.

The results of the experiments reported in the thesis indicate that differences between skill groups are apparent along multiple dimensions of reading. On initial trials, between-group differences were evident at the word level, as demonstrated by the less-skilled readers' slower naming (Experiments 1 and 2) and slower and less accurate proofreading (Experiment 3). Moreover, the less-skilled readers were slower on all measures of reading rate, including the standardized measure obtained at initial screening, oral reading (Experiments 3 and 4) and silent reading (Experiment 4). Their poorer comprehension, which was the basis on which individuals in the group were selected, was further validated by various measures of comprehension (Experiments 3 and 4).

The effects of repetition, which were investigated in the last three experiments, indicated that like the skilled readers, the less-skilled readers were able to benefit from repeated experience at all processing levels available to them on a given task. They were at least as able to benefit from repeated experience at the word level (Experiments 2 and 3), as well as from repeated experience with the same meaningful text (Experiment 3), and texts of similar structure (Experiment 4). These data suggest that the less-skilled readers are using multiple sources of knowledge during reading, and that they are able to benefit when either the same material (words or text) or similarly structured material was presented over a series of trials. These results are consistent with interactive models of reading (Rumelhart, 1977; Stanovich, 1980), which postulate that multiple independent processes and sources of knowledge operate simultaneously during reading.

What interactive models have not yet accounted for, however, is the effects which would be expected over repeated trials. The results of Experiment 3 indicate that there is a high degree of specificity in the effects observed across material differing in the arrangement of the same words. Whether reprocessing benefits are observed across variations in the structure or synonymous words derived from a single text remains to be determined, and cannot be predicted -- for either skilled or less-skilled readers -- by current interactive models. The results of Experiment 4 indicated that the benefit of repeated experience could be observed across texts varying in structure. Whether the less-skilled readers would be expected to demonstrate as great a benefit as skilled readers across repeated trials of different text with similar structure cannot be addressed by the current interactive account.

A major limitation of the models which have been developed to account for proficient reading skill is the failure to address the more dynamic aspects of reading and how changes in processing might be expected to occur across repeated trials of the same, or similar, material. This limitation is particularly constraining when the models are applied to the investigation of children who are in the process of acquiring proficient reading skills and to the study of individuals who appear less able than their peers to acquire these skills at a normal rate.

Individual Differences and Adults: Implications for Future Research

The population selected for the set of studies examining individual differences in reading was the adult reader, specifically students in a university population. The groups of skilled and less-skilled readers were defined on the basis of their comprehension scores relative to those observed in similar university samples. Due to the nature of selection factors in the university population more generally, the skills demonstrated by these groups cannot be considered to be representative of the range of skills found in young adults of similar age, and the groups selected for the thesis research are probably more homogeneous than other samples selected at younger ages. Because of the nature of the sample, the less-skilled readers cannot be considered to be "disabled" in that they were engaged in academic pursuits requiring well-developed levels of reading proficiency. It is noteworthy, however, that a small proportion of the less-skilled readers spontaneously reported a history of reading difficulty in childhood, accompanied by a history of remedial intervention.

As is characteristic of other individual difference research, the performance of the less-skilled group was considerably more variable than that observed in the skilled readers. In word and pseudoword naming (Experiments 1 and 2), for example, the naming times of the less-skilled readers ranged from times equivalent to those demonstrated by the most skilled readers to substantially longer times. Inspection of the errors made to these items suggested that the general pattern of errors was similar for the two groups, although the skilled readers made fewer errors overall. In the word and pseudoword naming task of Experiment 1, for example, typical errors consisted of mispronunciations of both vowel and consonant sounds (e.g., "built" for pilt; "wet" for weat; "pain" for plain). These typically resulted in the pronunciation of an incorrect word, although occasionally pseudoword pronunciations were given ("prode" for pode). A few of the less-skilled readers, however, made occasional pronunciation errors to pseudowords which were less graphically constrained (e.g., "boned" for domb; "loyal" for lole), suggesting that their knowledge of sound-symbol correspondences was less developed.

Similar variation was observed across other experiments in the thesis. Such variability is also apparent when the performance of subjects participating in more than one experiment is considered. Seventy of 72 subjects participated in both Experiments 1 and 4. Although it is speculative to compare subjects across different conditions in these experiments, there was considerable variability in subjects' relative performance on the two tasks. There was no strong evidence to indicate that markedly slow or less accurate word identification was accompanied by markedly deficient comprehension or slow reading rates, or (in the High - Low order condition of Experiment 4) less transfer of knowledge of well-integrated text to the Low Constraint text presented subsequently.

Despite the fact that students in university have achieved more proficient levels of reading than younger children, and have had more extensive experience with print throughout their educational history, there were a number of similarities in the performance of the two university-level reading groups to those observed with younger children.

As noted earlier, the failure of the less-skilled readers to differentiate between well- and poorly-constructed text in their recall parallels similar findings with children in grades 6 (Rahman & Bisanz, in press) and 9 (Meyer, Brandt & Bluth, 1980). However, unlike younger readers (Hinchley & Levy, 1985; Miller & Smith, 1985), the less-skilled readers' recall was not aided when the passages were read aloud. It is likely that at higher levels of proficiency, reading silently is the preferred, and best developed, mode for reading, and that the attentional (Miller & Smith, 1985) or mnemonic (Goldman et al., 1980) function of reading aloud confers no additional advantage. Rather, most subjects (in both reader groups) reported that reading aloud interfered with comprehension by focusing their attention on articulation; these reports were corroborated by the low comprehension scores observed in the oral reading condition. It is noteworthy that some individuals in the less-skilled reader group reported that reading aloud was an effectively used strategy to aid their comprehension when studying. Despite these reports, there was no evidence to indicate that under the conditions of Experiment 4, their comprehension was better than after reading silently or listening. However, it may be that under conditions where comprehension is low, such as for difficult and unfamiliar material, reading aloud provides important attentional and mnemonic aid.

The poorer performance of the less-skilled readers in word and pseudoword naming also parallels similar results demonstrated by younger children (see Chapter 2). This research, including research with university-level adults (Mason, 1978), has consistently demonstrated that less-skilled readers are particularly slow in pronouncing pseudowords. Because pseudowords are unfamiliar and must involve at least some phonological analysis and synthesis, these results have been interpreted as reflecting the less proficient phonological skills of the young child. In contrast to research conducted with young children, there was no evidence to indicate that irregular orthographic patterns posed particular difficulty for the less-skilled readers. Despite the similar patterns of performance demonstrated by the two reader groups, substantial between-group differences were observed in overall naming times.

Moreover, the finding that the less-skilled readers demonstrated at least as great a benefit with repetition of pseudowords parallels similar individual difference research with children (Ehri & Wilce, 1983; Hogaboam & Perfetti, 1978). However, the interpretations from that research have been focused on the less-skilled readers' level of performance after repeated trials: they did not reach naming speed equivalent to those of skilled readers (Hogaboam & Perfetti, 1978), nor did they reach levels hypothesized to represent automatized performance (Ehri & Wilce, 1983). What is striking from the data, however, was that there was no evidence to indicate that the less-skilled readers benefit <u>less</u> from repeated experience with particular material. If less-skilled readers as a group are slower to acquire reading skills, or are deficient in specific processes (such as phonological awareness) which are hypothesized to be critical to proficient reading, it would have been expected that they would benefit less from repeated experience with pseudowords. Similarly, if less-skilled readers are insensitive to higher-order dimensions of text structure (Meyer et al., 1980; Rahman & Bisanz, in press), they should be less able to transfer from High to Low Constraint text. Instead, the results of the experiments conducted in the thesis research demonstrated that the less-skilled readers were as able as skilled readers to benefit from repetition of both words and text.

These results raise the question of the role of experience in the development of proficient reading skill, and how experience might contribute to the individual differences observed in adulthood. While there was no evidence in the experiments of the thesis to indicate that the less-skilled readers were less able to take advantage of repeated experience, this pattern of results may be specific to the population of young adults in university. While the results of Hogaboam & Perfetti (1978) and Ehri & Wilce (1983) suggest that younger less-skilled readers, like the adults in Experiment 2, benefit from repeated experience, it may be the case that slower acquisition rates are characteristic of a subset of younger less-skilled readers, particularly of the more disabled, or dyslexic, reader.

A second possibility is that, despite similar acquisition rates, less-skilled readers may be less able to transfer knowledge already learned to similar new material. This hypothesis has been proposed by Lovett, Ransby, Hardwick & Johns (in press; see also Lesgold, Resnick & Hammond, 1985), based on the results of an intervention study with dyslexic children. In this study, disabled readers demonstrated gains on tests measuring content which had been directly taught to them, although similar gains were not observed on uninstructed content.

The hypothesis that less-skilled readers are less able to transfer to novel material appears to be a fruitful area for future investigation, particularly in examining reading in the young child. At the word level, if less-skilled readers have less well-developed phonological skills, it would be expected that they would be less able to transfer experience with recently acquired words to similar new words. Recently, Stanovich (1986) has proposed that phonological skills are critical in word learning during early reading; slow learning in the initial stages is then proposed to constrain the acquisition of a wide range of words, and consequently to result in impoverished word-level processing in later stages of development. While the role of phonology is well-documented, the contribution of analogy (Glushko, 1979) as a potential basis for generalization to new similar words in children's learning (Goswami, 1985), particularly in discriminating between skill groups remains to be investigated.

Moreover, whether accurate and automatic learning of individual words then transfers to reading words in meaningful text remains to be further explored with children, particularly in the less-skilled reader. While the results of Experiment 3 indicated that small gains were apparent, these effects were observed in time measures in a relatively proficient adult population. Whether transfer can be ~~readily~~ observed in reading accuracy, as well as latency measures, could have implications for remedial instruction. The results of Experiment 3 also indicated that there is specificity in the conditions under which transfer is observed. The benefit of repeated experience was primarily observed when proofreading and familiarization were to the same text format. This finding is consistent with a growing body of research indicating that the similarity of learning and test conditions is a critical feature in optimal performance. Whether transfer is observed across variations in wording, syntax, semantics, and structure of text material remain subjects for future research.

If the younger less-skilled reader is less able to learn from repeated experience, or to transfer new learning, such demonstrations would draw attention to the conditions under which learning takes place. If disabled readers are less able to benefit from repeated experience, it would suggest that the conditions under which learning occurred, including the type of material, the amount of repeated experience, the spacing of repeated trials, and the introduction of new material, would be fruitful directions for further empirical exploration. Moreover, investigation of such parameters involved in learning could have important implications for remedial intervention. It may be, for example, that the less-skilled reader is more dependent upon the educational environment to facilitate learning than is the skilled reader. Investigation of materials, particularly those which facilitate transfer, and to instructional content would then be important in explicating variables which for the skilled reader may be less relevant.

The demonstration that less-skilled readers in university were able to benefit from repeated experience suggests that these individuals are able to take advantage of that experience in order to improve their performance. In this context, the consistent main effect of reader group observed throughout the experiments, however, is puzzling. The hypotheses which have been advanced to account for individual differences by cognitive psychologists have ranged from slower visual processing to inadequate comprehension (see Chapter 2). Notably, as a general class, these hypotheses focus on factors which are intrinsic to a group of individuals, and which differentiate them from their more highly-achieving peers. As was observed with current models of reading, relatively little emphasis has been placed on more dynamic aspects of acquisition, and the role that experience might play in contributing to individual differences.

It would not be unreasonable to anticipate that experience with print more generally is a potent variable in contributing to the development of proficient reading. In the present set of experiments, several subjects in the less-skilled reader group reported that they rarely read more than demanded by their academic requirements. In contrast, the skilled readers were likely to report that they read often for pleasure, as well as for their coursework. In fact, differences in exposure to print, correlating with reading ability, have been noted in the early school years (Allington, 1984; Biemiller, 1977-1978). While these differences may be attributable to the ease of reading, continued exposure to print may facilitate further development of reading skills, as well as linguistic and general knowledge (e.g., Bruck, 1985).

Recently, Stanovich (1986) has argued that some of the differences observed between individuals in adulthood may be a function of their reading histories. In particular, Stanovich (1986) focuses on the importance of good phonological skills in the early school years, which have been demonstrated to be a powerful predictor of later reading skill.

According to Stanovich (1986), those individuals who easily acquire reading in the initial stages are more likely to engage in subsequent reading experiences. These experiences are then hypothesized to facilitate fast and accurate word-level processing, as well as further development of vocabulary, syntax, meaning and general world knowledge. In contrast, for children who have initial difficulty in reading, the lack of exposure is hypothesized to delay automatic word-level processing. Moreover, the children then become exposed to material which is beyond their reading level, which further compounds unrewarding early experiences and delays development along multiple dimensions of reading. Individual differences observed in adulthood, then, are hypothesized to reflect not only individual differences in initial acquisition, but the consequences of differential exposure to print throughout several years of development.

This conceptualization of individual differences focuses attention on the skills which the beginning reader brings to the complex task of learning to read. While the importance of phonology in the initial stages is well-documented, the importance of other factors in learning to read remains to be explored in future research. For example, preschool children differ in their knowledge of story structures (Young, 1983; 1987); this knowledge, as well as experiences which orient children to print as a communicative medium, would be expected to influence early reading experiences.

The results of the experiments reported in the thesis indicated that individual differences in adulthood were apparent on all dimensions of reading which were examined. The extent to which these differences reflect differences in stable cognitive characteristics which are intrinsic to a particular group of individuals, or reflect their experience with print are difficult to disentangle in an adult population. It has been argued here that an examination of the role that experience with print plays in the development of proficient reading skill and in contributing to the differences observed in adulthood may lead to a better understanding of how these differences develop. While such an examination may have direct implications for remedial intervention, this research strategy would also permit the direct evaluation of learning in those children currently identified as "learning disabled".

FOOTNOTES

1

The World Federation of Neurology defines developmental dyslexia as a "disorder manifested by difficulty in learning to read, despite conventional instruction, adequate intelligence, and socio-cultural opportunity" (Critchley, 1970).

2

While the reading criteria used to select dyslexic and poor-reader samples is frequently similar, there is considerable variability in the way in which groups may be defined. In some cases, attention is given to factors other than reading. In research investigating developmental dyslexia, attempts are made to screen children for any factors which might contribute to reading failure, most notably those exclusionary criteria specified in the definition of dyslexia proposed by the World Federation of Neurology. These selection criteria are not typically employed in research conducted within an educational setting. Moreover, while the reading criterion for defining dyslexia is frequently similar to other individual difference research, this is not necessarily the case. In some research where subjects are drawn from a single classroom or set of classrooms, the less-skilled and skilled readers may be differentiated by less stringent reading criteria: as an extreme example, in some studies individuals scoring above a classroom median reading measure have been compared with those scoring below it.

Despite such variability in the criteria employed to select subjects, there has been a remarkable degree of consistency in the results of experiments conducted with different samples (Perfetti, 1985; Stanovich, 1982a; 1985). In order to avoid cumbersome descriptions of the subject samples in the studies which will be reviewed, attention will be drawn to particular samples only when the results of the research are relevant to a particular age group or level of reading skill, or when differences in the criteria employed to select groups of readers might account for conflicting results between studies.

3

This pilot study was conducted with 470 Introductory Psychology students. One purpose of this study was to validate the norms provided in the test with the sample from which subjects for the thesis research would be drawn. In contrast to the American norming sample, students who formed the subject pool had completed an additional year of secondary school (i.e. grade 13). Consequently, this sample was evaluated against grade 14 university norms, rather than the grade 13 norms which consisted of first year students in the norming sample.

In order to evaluate whether the reported test norms were an appropriate comparison for this population, the distribution of scores from the norming sample were compared to those Introductory students who received Form F of the test (N=255), using the Kolmogorov-Smirnov test (Siegel, 1956). These results indicated that for both comprehension (D = .07; D crit = .10; $p > .05$) and reading rate (D = .09; D crit = .10; $p > .05$), the norming sample did not differ from the sample of Introductory psychology students who formed the pool from which subjects in the thesis research were drawn.

4

The selection of median, rather than mean, latencies was made in Experiments 1 and 2 in order to minimize the effect of outliers in each individual's latency data. In each experiment, subsequent analysis of data based on mean correct latencies, however, revealed the same pattern of significant effects and interactions as those reported for the analyses based on median latencies.

5

The results reported for the latency data in Experiments 1 and 2 were obtained from an analysis of variance model with items treated as a fixed effect. While Clark (1973; 1976) has advocated that linguistic items be treated as random effects, the fixed effect assumption was made in view of criticisms of this procedure. These criticisms are based on statistical concerns which have been raised (Wike and Church, 1976; Cohen, 1976), as well as the fact that the method of item selection in the study precluded an assumption of random sampling (Cohen, 1976; Keppel, 1976; Smith, 1976). It is noteworthy, however, that the same pattern of significant main effects and interactions was observed for analyses based on both subject and item means.

6

According to Kucera & Francis (1967) norms, the mean frequency values for items employed in the experiment were 79.13 for regular words and 474.44 for exception words. Median frequency values were 20 and 52 for regular and exception words respectively.

7

The results are based on a separate 2 (Group) X 2 (Order) analysis of variance. Neither the Group effect, $F(1, 68) = 3.01$, $p > .08$, nor the Group X Order interaction, $F < 1.0$, $p > .05$, were statistically significant.

8

The results of this 2 (Group) X 2 (Order) analysis of variance indicated that while the effects of Order, F (1, 68) < 1.0, $p > .05$, and Order X Group, F (1, 68) = 1.41, $p > .05$, were nonsignificant, there was a difference between the two reader groups, F (1, 68) = 5.91, MSe = 4.34, $p < .03$. This group effect is discussed subsequently.

9

The false alarm rate, as a proportion of the opportunities available, was .0011 for the less-skilled reader group and .0009 for the skilled readers.

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LIST OF APPENDICES

APPENDIX A

Items Presented in Experiment 1
(from Glushko, 1979; Experiment 1)

WORDS		PSEUDOWORDS	
REGULAR	EXCEPTION	REGULAR	EXCEPTION
bath	both	cath	coth
beef	been	heef	heen
bleed	blood	dreed	drood
breed	bread	sheed	shead
buff	bull	wuff	wull
bust	bush	nust	nush
cold	comb	pold	pomb
code	come	gode	gome
deal	dead	feal	fead
dean	deaf	hean	heaf
dream	dread	bleam	blead
dune	done	mune	mone
feet	foot	peet	poot
goad	good	soad	sood
greet	great	steet	steat
haze	have	taze	tave
heat	head	weat	wead
heed	hood	beed	bood
hoop	hoof	moop	moof
lobe	lose	cobe	cose
lode	love	hode	hove
meld	mild	beld	bild
mode	move	pode	pove
must	most	sust	sost
note	none	wote	wone
pink	pint	bink	bint
plain	plaid	prain	praid
port	post	bort	bost
posh	push	wosh	wush
probe	prove	brobe	brove
puff	pull	suff	sull
shore	shove	plore	plove
soil	said	hoil	haid
sole	some	lole	lome
soon	soot	doon	doot
spool	spook	grool	grook
steal	steak	sweal	sweak
sweet	sweat	speet	speat
told	tomb	dold	domb
wail	wool	lail	lool
weak	wear	meak	mear
wilt	wild	pilt	pild
wore	were	dore	dere

APPENDIX B

Items Presented in Experiment 2

twaik	trast	terth	trald	trune
cleep	clabe	clune	crine	crogs
gence	grick	gocks	grube	glunt
plute	potch	poad	pleke	pote
spum	snule	stipe	speet	sture
road	raste	wreem	reegs	rhoke
frume	firk	felch	floam	frisp
daip	drabe	dinch	drute	drime
chipe	chud	choat	chist	chulp
hile	hudge	haint	heesp	hanch
blaig	blid	balt	blesh	bilm
nink	nube	neest	narce	neld
mesk	meech	mufe	morb	moke
thale	thapt	thisk	thrib	thote
prode	prock	prite	prash	preve

APPENDIX C

Materials Used in Experiment 3
(from Levy & Begin, 1984; Experiment 2)

What Makes Autumn Colours

At the foot of the pastuce stands the graceful long oval of a sugar maple in clear leaf-green. Yet early in October this dependable green will vanish, to be replaced by flaming orange and yellow. Why this swift change, which happens soundlessly, smoothfy, and right on schedale?

The key to this mirache is a tiny band of cells at the base of the stem of each leaf, where that sten is attached to the twig. As summer draws to a close, these special cells beyin to loosen and dry out. Eventually they become so brittle that the leaf bneaks off and falls to the ground. Before that happens, the tree preparos to heal the scar where this break will occur by converting other cells just belou these brittle cells into tough, corky tissue. The tougbening of these cells interfeves with the plumbing system in the leaf stem by stopping up the pipelines that bring the sap into the leaf. The result is to shut off the free flow of sap a couple of weeks bafore the leaf is ready to fall. These are the two weeks of the fall foliage. This is when the pipelines in the leaf stems are plugged up by cork. The procession of colour begins wifh the little things lihe the strawberries and blaokberries and vsrious herbs. Little plants have autumm colours like the big ones. Then in the vanguard of the trees come the reb maples, and after them the sugar maples, elms, ashes, and last of all, the hickories and birches.

As soon as a leaf has its suqply of fresh sap cut off by this plugging of its pipelines, photosynthesis stops. Photosynthesis is the process by which plart cells make sugar from carbon dioxide gas and water, in the presence of chlorophyll and light. Chlorophyll is en unstabfe chemical that must be constantly renewed to exist. Therefore, the chlorophyll, isolatad in the leaf by the cutting off of sap, is destroyed by the sun's rays and disappears. In this way green colour, which is the dominant pigment un-the leaf, is removed.

What Makes Autumn Colors

Chemistry of a vivid becomes pastuce left rays is what removed way leaf the in disappears dominant the is. Green is which October this in is pigment and, demonstration sun's the by destroyed sap colour of. Off cutting by the, leaf the in, smoothfy the chlorophyll exist schedale?

To constantly must be mirache is chemical is and of the in chlorophyll light the presence the and sugar and, cells from sten gas make which carbon therefore. Process by the is stops photosynthesis, of pipelines photosynthesis beyin plugging fresh cut its before. Leaf this of sap soon off by has bneaks as its birches renewed of a. Hickories as the, and last preparos elms all ashes of after maples maples and sugar the them dioxide come the belou trees the vanguard of big, then in. Ones toughbening colours the like interfeves plants little have by and strawberries things the and colour little the begins of cork procession the are pipelines up. Herbs stems in this plugged the fall the when of is the two foliage are bafore the these weeks leaf to is. Fall leaf the couple sap of shut result free. Weeks into bring these flow of to a leaf the off is sap the. Pipelines into the up that wifh stopping system the lihe plumbing the with blaokberries by vsrious the. Ready cells of autumm these tissue the corky into. Tough these break just other cells brittle by reb converting, occur in happens where will this, tree, heal, scar the to the, that ground falls chlorophyll.

The to water leaf off and the suqply that so they dry brittle change out and graceful to cells, special close. Become a to draws as attached plart summer replaced twig to is where that leaf of, each the of stem that the base. At soundlessly en unstabfe cells and band a tiny this leaf to. Right, the on, isolatad swift happens which this yellow eventually why by the, flaming be to vanish will orange green this. Dependable green yet early sugar, in clear maple oval long un a loosen, foot in the.

Autumn Colours

1. Fall foliage occurs when the transport system is blocked.

True False

2. Cells in the twig start the process of autumn colours.

True False

3. The toughening of cells interferes with the plumbing system in the leaf stem.

True False

4. After the leaf falls, the tree manufactures scar tissue.

True False

5. Usually, chlorophyll is continually being replenished.

True False

6. Chlorophyll, isolated in the leaf, is destroyed by the plant.

True False

Autumn Colours

1. Fall foliage occurs when the transport system is freed.

True False

2. Cells in the leaf start the process of autumn colours.

True False

3. The toughening of cell's facilitates the plumbing system in the leaf stem.

True False

4. Before the leaf falls, the tree manufactures scar tissue.

True False

5. Usually, chlorophyll is not continually being replenished.

True False

6. Chlorophyll, isolated in the leaf, is destroyed by the sun.

True False

The Mystery of the Eels

Female eels live in fnesh water rivers or lakes for the first seven or eight years of life. Then they put on an extra layer of fat and stop eatirg. Their yellowish-brown skin turns silvery, their snouts become sharpar, and their eyes become large and bvlging. Presently they starf their journey to the sea. Near the moutk of the rivers they are joined by the much smaller males, who have aiso become silver-coloured. The eels start their long swim to the spawning ground. Wben they reach the Sargasso Sea, the females lay millions of eggs -- in the damkness 3,000 feet belou the surface. These eggs are fertilized by the males. Then the grown eels die.

Within a few days glass-like baby eels about a quarter of an inch long hatch from the eggs. They float to the upper levels of the sea where they feed on tiny plonts and animals. As they grow they move slowly towards land. Those that come to North America reach the coastal waters in about a year. By this time the glass-like baby eels are ahout three inches long. They begin to change. Their wide, flat bodies narrow, become round, acd turn pink. The babies have turned ivto elvers or eels. They are ready now to begin their inland life.

Adult Europeen eels, like those of North America, smim to the spawning grounds of the Sargasso Sea. But they must travel thnee times as far to get there. When the babies are hatched they also move slowly towards land -- in their case, the coast of Europe. Since the young European eels require three times ac long as the North American eels to reach their coastal waters, they remain in the form of glass-libe baby eels for this longer period. How they can do this is a mysterg scienticts haven't yet explainad.

Another mystery of eel migratior is the ability of the eels to naviyate the trackless ocean. How can baby eels, lately hatched from eggs, find their way to homes in Europe or America with no adults to guide them?

/

The Mystery of the Eels

For put their become fnesh and smaller the eels they eggs these eels die a float tiny slowly. Reach the they become turned their life America but when towards eatirg. The they the this a yet, of baby homes sharpar, them homing lakes they stop snouts bvlging. Large sea starf much the ground of surface. Grown about moutk they on move America time long narrow have begin inland North, Sea there slowly since as waters. For is haven't ability can to guide mysterious or then. When and their become the coloured, the spawning the millions the eels -- eggs feed damkness they North belou this inches. Bodies babies to of Sargasso get move. Europe long coastal eels this.

The how way to some instinct rivers life fat silvery eyes to by silver the hafch lay feet then. Baby the they grow to by three flat the now those the to also plonts of times. Their baby do is ocean their adults with. Water of turns of their journey joined become to females 3,000 males like. From they where come year about wide pink ready like ahout of far they. Coast three reach of. Can eel, trackless find no, born in acd years layer. Skin and their are ivto also swim the. The glass the long sea as that a are.

Their Europeen turn, are eels grounds as hatched, smim the require to form they of the eggs. With are live eight thnee extra born they have they long. Sea in by days inch the animals those in eels change -- round they adult, spawning times are case. Eels the eels how mystery to from America ac they eels or an yellowish presently rivers who their Sargasso fertilized, few an of and land waters glass-libe baby to eels the travel babies. Their European American in period or eels mysterg scienticts hatched another explainad.

Perhaps female seven on migratior the males start the are a of naviyate levels towards coastal. Like begin or to, must the in young, North remain longer the lately Europe first of reach eggs within quarter upper the glass?

The Mystery of the Eels

1. The bodies of female eels change shape after they migrate to spawn.

True False

2. Males and females make the spawning journey along the rivers together.

True False

3. Females put on an extra layer of fat and start eating.

True False

4. Scientists haven't explained how European baby eels find their way to land.

True False

5. European baby eels look baby-like for a much longer period than do North American eels.

True False

6. Baby eels float to the upper levels of the sea where they feed on tiny eggs.

True False

The Mystery of the Eels

1. The bodies of female eels change shape before they migrate to spawn.

True False

2. Males and females make the spawning journey along the rivers separately.

True False

3. Females put on an extra layer of fat and stop eating.

True False

4. Scientists have explained how European baby eels find their way to land.

True False

5. European baby eels look baby-like for a much shorter period than do North American eels.

True False

6. Baby eels float to the upper levels of the sea where they feed on tiny plants.

True False

Giant Waves

What causes the giart waves? Though they are often called tidal waves, tsunami, meaning large waves in harbours, is a more correct one; the rise of the water has nothing to do with the tide. Almost all tsunamis follow undersea earthquahes (seaquakes) or voleanic eruptions that cause seaquakes. Besause these disturbances occur repeatedly in certain areas of the Pacific Ocean, the islands of the Pacific are the most frequently affected.

The most destructive waves have been relatad to volcanic activity. In 1883, when the volcanic island of Krakatoa eruqted, the resulting waves were reported to be over a hundred feet high. They rolled in en the nearhy islands of Java and Sumatra, drowning tens of thousands of their people.

Studies have shown that tsunamis move at an enormovs speed in the open ocean, averaging 450 miles an hour. The tsunami tkat struck Hawaii in 1946 was caused by an earthquake in the Aleutian Islands area. It took the waves four hours to reach the Hawaiian shore.

Most ef the people who were losf during the 1946 tsunami could have saved their lives by runniny to higher ground when the waves first began. But most people ran to see the strange sight of the reefs being laid bare, or went out on the rcefs to pick up the stranded fish -- a natural reaction of people whose livetihood comes from the sea.

Thouph the giant waves cannot be controllod, they can be predicted. With the aid of instruments called seismograpbs, both time and place of every major earthquake and seaquake are recorded. Scientists can then calculate approximately where and wken tsunamis will strike, and warn the islanders.

The warning system can be effectuve. In 1957 warnings were given of a tsunami approaching Hawaii. The people moved to the higher areas and were soved, though a gneat deal of prcperty was destroyed. In 1960 the warnings were ignored, and the waves from an earthquake in Chile took sixty-one lives at Hilo. When the next tsunami strikes, a werning will be given. Whether people escape or not will depend on themselves.

Giant Waves

Themselves depend on giart will? People not or escape given be whether, will a strikes, tsunami next Hilo the when, at sixty-one earthquake took Chile; in lives an 1960 ignored the and were warnings the from waves. In destroyed was nothing a earthquahes (deal) of voleanic though were and areas. Besause higher the to moved a people approaching the given of Hawaii, were warnings 1957 be can system approximately the in islanders.

And strike will tsunamis and warning relatad where calculate when. Can recorded, warn scientists are major and earthquake eruqted, every seaquake of place both called time and instruments aid of the. Cannot be the en can nearhy they with be waves the, sea the giant comes whose stranded from.

People of reaction fish a natural the up enormovs pick the on out bare, or laid to went being. See the tkat sight the to ran reefs strange first people most waves the but when began. Ground tsunami higher to earthquake their 1946 saved have by could.

The ef during were who undersea losf most the Hawaiian the to reach waves the four it runniny took islands the in Aleutian lives hours an. By area struck an 1946 miles in was the Hawaii hour tsunami an 450 ocean, the in speed the at rcefs averaging move open tsunamis that shown -- and people thousands studies have that livetihood Sumatra of drowning feet.

Thouph their rolled Java of islands controllod, predicted tens high in. They over be hundred to caused seismograpbs, eruptions were Krakatoa the of island a 1883 volcanic waves in when. Activity been frequently in to have Pacific wken destructive most the, volcanic the affected waves.

Waves of most islands the effectuve. Ocean the of these in occur Pacific tsunami certain repeatedly. Distrubances area seaquakes undersea with all almost tide the soved, follow do gneat to tsunamis prcperty has water. Of the correct one the rise, more a harbours in large is meaning are waves the called word have. Tidal though they tsunami often, waves werning the causes what. Of reported resulting are the Pacific seaquakes cause water.

Giant Waves

1. Many tsunamis occur in the Pacific islands because of the number of tides there.

True False

2. When travelling through the vast ocean, tidal waves move at fast speeds.

True False

3. The most destructive waves have been related to earthquake activity.

True False

4. A tsunami warning system can be effective in saving lives

True False

5. Most people in the 1946 Hawiian tidal wave ran away from the sea.

True False

6. Giant waves cannot be controlled but they can be predicted.

True False

Giant Waves

1. Many tsunamis occur in the Pacific islands because of the number of earthquakes there.

   True False

2. When travelling through the vast ocean, tidal waves move at slow speeds.

   True False

3. The most destructive waves have been related to volcanic activity.

   True False

4. A tsunami warning system can be effective in saving property.

   True False

5. Most people in the 1946 Hawiian tidal wave ran towards the sea.

   True False

6. Giant waves can be controlled and they can be predicted.

   True False

People of the Desert

No one knows how long the Bedouins have been rosming the deserts of Arabia -- certainly sence before the dawn of recorded history. The Bedouin is a nomed, a wanderer by necessity, for he lives ~~by~~ his herds of camels, his horses, and his sheep. And for those he must have pasture. There are no lush, green fields in Arabia such as we know in temperafe lands. The pastures are small aod thin and parched and quickly grazed, so that the Bedouin must soon move on to other feeding gnounds where winter rains have caused grass to grow. And he can use only those pastures where water is to be found.

It is difficult fer us to apprecuate the hardship of the Bedouin existence. These people have no sektled homes, no land, and few possessions other than the animals under their care. They must be constantlg on the move. Hunger and thirst are the daily companions of thase nomads of the deserts. If a Bedouin's entire food and drink between dawn and sunset consist of a handful of dates and a gourd of brarkish water, he thinks himself both fortunate and satisfied. Generatiovs of hardship have mude the Bedouin tough; he not only survives all this, he thrives on it.

The land of the Bedouin is a vost land and a hard and cruel one, a land of incredible contrasts. To the north, east, and south there lie great, limitless stretches of desert. The wasteland of Rub al Khali to the south is ahout the sixe of Texas, and its deserts of sand and gravel and rock burn all day under a pitiless white sun. The lone travellor, without camel or water, lost in the baking oven of heat of those barren wastes, will have little enough time to bewail his fate bafore death overtabes him. He will surely die from exhaustion and thirst and madness.

It reqvires a very special type of man to survive thase conditions of blizzard, drouqht, desert, and blazing heat. And the Bedouin, the wanderiny Arab of the desert, is just that: a special man indeed.

People of the Desert

Been before a of he in pastures so feeding rosming grow be found hardship -- no sence the on of food handful thinks. Of only it hard nomed, the limitless to of, pitiless water wastes fate exhaustion madness to and, of man, indeed of certainly. A herds those fields the grazed other. To is the have than be companions entire a he satisfied not on temperafe a. To great Khali deserts aod a or barren his from and, survive desert Arab of Bedouins Arabia is his green for lands gnounds quickly to grass water to people other must. Daily Bedouin's of water and thrives contrasts'he and lie at its under.

Camel those bewail fer die thrist apprecuate man blizzard the type the of. Bedouins by and lush sektled in, and on, caused where us these possessions they the a consist of. Fortunate tough he constantlg land incredible there. Rub and day without of to surely and thase of Bedouin of special. Long deserts the lives sheep no know parched move have pastures difficult care existence few are if sunset gourd both Bedouin brarkish a, of south of Texas lone all heat. Generatiovs time will type mude conditions the very; how history the he his are, we and soon rains.

Those is Bedouin and their thirst deserts vost and a himself the all is land, and wasteland of burn the. Of enough he, special, and a knows recorded for, and there as thin. Must winter only it the land under and the dawn ahout and sixe have survives, Bedouin a east the the rock sun oven little him very heat that one of necessity horses. Pasture such travellor, small Bedouin where use, of no animals hunger of between dates hardship the one north, desert is and white baking a have death blazing bafore just overtabes no. Dawn by his have Arabia are the can homes move.

Nomads reqvires drink cruel of south the of gravel the thase will it is, drouqht, the, wanderer camels must. That he the, and wanderiny land and stretches the, and in desert: and the this sand.

People of the Desert

1. The Bedouin must wander to find new pasture for their animals.

   True False

2. Only a unique person can survive Bedouin conditions.

   True False

3. There are many lush, green fields in Arabia.

   True False

4. The Bedouin bewails his life of hunger and thirst.

   True False

5. The Bedouin is not satisified with a small amount of food and water.

   True False

6. The lone traveller will have little time before death overtakes him.

   True False

People of the Desert

1. The Bedouin must wander to find new gourds for their animals.

   True False

2. Only a lonely person can survive Bedouin conditions.

   True False

3. There are no lush, green fields in Arabia.

   True False

4. The Bedouin thrives on his life of hunger and thirst.

   True False

5. The Bedouin is satisified with a small amount of food and water.

   True False

6. The lone traveller will have much time before death overtakes him.

   True False

The Frozen Continent

Antarctica has been called the world's lcst unezplored continent. The Antarctic continent has about nine times as much snow and ice as all the rest of the world put together. The great ice-cap of Antarctica coverx six million spuare miles. But its ice is not frozen water, hard and glassy. Antarctic ice is furmed from snowflakes, which are themselves formed from very fine crystals of ice. Powerfal winds and the warmth of the sun make changes in the fluffy snowflakes. In time, powdered snow forms in layers, which are pnessed down by layers above. Under their heavy weight, snow finally turns icto glacier ice.

With the pile-up of glacier ice and snow, century after certury, one might think that the ice-cap would by now be toweriny up into the sky. And this would have happencd except for the nature of glacier ice. It is not a solid, like rock, nor a liquid, like water; it is something between the two. Glacier ice flows steadily, though very slowly. The great Antarctic ice-cap moves ovtwards to the ocean. There huge icebergs bneak off and float away.

A downward-flowing glacier meets obstacles in its path. A mound of rock unber the ice might check the flow of a glacier. When the glacier forces its way ouer the mound and flows down the other side, the ice cracks fo make large and small crevasses. Rocky rihges in the path to the ocean also hinder the movement of a glacier. The mass of ice is forced to move to one side or the other. This change of direckion causes a tremendaus pressure. Again, a multitode of crevasses will appear.

Crevasses are very often a hidden danger for travellers. As the ice mass moves, crevasses are carried long dictances from the place where they were formed. Crevasses that are open at the top can easily be seen, but most are hidden by snow bridges. The bridge-buildor is the wind, which packs in snow across the top of the crevasse. Then driftinp snow completely covers the bridge and hides the crevasse.

The Frozen Continent

World's about the Antarctica not is lcst unezplored very. Of time by finally ice century by have is steadily is moves off away its the way cracks the glacier the. A appear for are were converx easily the spuare across. Completely sight the has of is of, ice from warmth. In down snow furmed glacier snow, would it would it flows ice-cap icebergs float in check. Powerfal its ice in a or causes will danger crevasses they can bridges snow. Snow from, called continent rest ice-cap ice, Antarctic formed pnessed the a are weight. To ice formed be, snowflakes as the icto path of.

Turns and ice-cap this ice water ice Antarctic, huge and certury, obstacles might forces the rocky of side of crevasses hidden toweriny moves place top snow. In then the been happencd Antarctic the great its glassy themselves and. Fluffy a heavy ice the, and glacier, like glacier great, there meets; ice glacier side crevasses movement one. Change mass a of, the times not. Mass nine the a after though ovtwards the by packs. Crevasse the has bneak crevasse all the miles.

And are winds the layers their glacier that sky. Of liquid two the unber ocean glacier the other the small the to this. A often ice from at hidden ouer which the hides Antarctica continent as to million, hard which ice fo in under in of think. The rihges nature which the slowly the flowing rock when the and hinder move other. Again very the long open are wind of and ice put six water snowflakes. Of changes forms direckion above pile-up tremendaus ~~might.~~ Into, the multitode nor between very together.

Downward of glacier down large also to pressure are. As carried a most the, top bridge and world dictances frozen from crystals where make snow layers. The one up for rock something a mound a flows make, ocean forced crevasses travellers that ~~but~~ is. The bridge-buildor the snow fine, sun powdered with after be except like a of and. The driftinp is crevasses seen covers much the now solid path.

The Frozen Continent

1. Glacier ice doesn't continue to pile higher because it moves very slowly.

True False

2. Warm sunlight and heavy winds hinder ice formation.

True False

3. Antarctic ice is formed from snowflakes.

True False

4. The crevasse's danger is usually exposed because of drifting snow.

True False

5. Some crevasses are begun near rock formations.

True False

6. The great Antarctic ice-cap moves inwards from the ocean.

True False

The Frozen Continent

1. Glacier ice continues to pile higher because it moves very slowly.

   True False

2. Warm sunlight and heavy winds help ice formation.

   True False

3. Antarctic ice is formed from frozen water.

   True False

4. The crevasse's danger is usually hidden because of drifting snow.

   True False

5. Some snow bridges are begun near rock formations.

   True False

6. The great Antarctic ice-cap moves outwards to the ocean.

   True False

The First Meteorologists

Civilized people fivst began learning ahout the atmosphere in the lands that lie between the Indian Ocean and the Mediterranean Sea. There the weather changed often, and out of necessity people observod the sky and winds. To some, the weatker was a matter of life or death. The farmer had to know the best time of year to plart his crops. The fisherman and the sailor had to learn all they could about winds and storms.

Ancient people rarelg asked questions about rain, winds, storms, and the air around them. The control of the weather was in the hands of God, ar of the gohs. To complain about the weather was disrespectful, and to study it was a sin. Yet a few thinkers did try to find out wbat made the atmosphore act the way it did.

In time the common people became amateor "meteorologists". The Jews learned that when clouds darkered the west, showers would follow. Greek furmers listened carefully when a crane gave a shrill cry overhead, for this was a "sure" sign of rain. Greek city-dwellers nofed the weather during the first few days of the new year. They believed that the weather en the first day forecast the weather for the first month, that the weather on the second day predicted the weather for the sesond month, and so on.

From century to centurg, people round the world made thousands qf "meteorological" rules in the form of sayings and rbymes. Some of these rules were the result of kaen observation. "When the sun or moon is in its house, it will rain" is an example of sound weather forecasting: the "house", or halo, is simply a thin veil of high clouds that precehes a storm.

Man has turned to just about anything ir his attempt to understand the atmosphere, and some of his favourife sayings sound rather silly. Some people swear that when their joints ache, it is a sure sign of rain. Others say that if the bubbles in a cup of coffee cotlect in the centre of tha cup, the sun will shine.

The First Meteorologists

Bubbles ~~shine~~ fivst will the ahout cup of centre the in others that if coffee cup the in say a rain. The of sign people is, it a joints of when observod sure that their some. Swear rather, and weatker his sound sayings ache of some atmosphere. And the understand just turned to about his to attempt silly plart to man. Has clouds that thin a storm house the high halo moon about of or sound.

A veil rarelg of forecasting the sun, example, weather, of an is rain will. Its house it in is observation were simply or the when, ar people the gohs. Of some result century and sayings form, is the in rules round thousands made. A forecast thinkers were to on a the to wbat so weather atmosphore and month on the predicted.

And the for second the day amateor "month". The weather the world the that darkered the for, weather believed day. The furmers the weather that first they weather year the Greek days, of the sure during "first" the new weather. The rain nofed city-dwellers of overhead sign few a shrill was this for cry. Gave carefully crane a when en listened Greek follow would west from the clouds when common, showers that learned Jews the meteorologists time the in did became it sesond act, people way made.

The out the centurg, try disrespectful anything did find the meteorological "sin" few a weather yet was it study rbymes. To rules and was of weather these the kaen about. "Complain to the God the of first in hands, was the around" of control the them air the winds: and "storms", about ancient, and rain asked people storms and they winds questions precehes all sailor.

Could learn to had the that fisherman ir the crops his year to best, farmer the time know favorife of to begin death. The some of or winds matter a was, the people and life to sky of. Out often lands changed necessity of Mediterranean Sea there the between cotlect civilized learning atmosphere in tha lie, had Indian Ocean.

The First Meteorologists

1. Most ancient people thought it was important to investigate the weather.

True False

2. People living in Greece's cities believed the first days of a year could predict the weather.

True False

3. Out of curiosity people observed the sky and winds.

True False

4. Weather rules based on observing the sky can be quite accurate.

True False

5. One rule is that rainy weather occurs if bubbles are in the middle of a coffee mug.

True False

6. The Jews learned that when clouds darkened the west, showers would follow.

True False

The First Meteorologists

1. Most ancient people thought it was wrong to investigate the weather.

True False

2. People living in Greece's cities believed the first months of a year could predict the weather.

True False

3. Out of necessity people observed the sky and winds.

True False

4. Weather rules based on observing the sky can be quite silly.

True False

5. One rule is that sunny weather occurs if bubbles are in the middle of a coffee mug.

True False

6. The Jews learned that when clouds darkened the west, sunshine would follow.

True False

The Strange Way of Spiders

Spiders inhabif every part of the world except the Arctic regions and the peaks of the highest mountains. Of the 40,000 species of spiders, some are no bigger than the head of a pin, wkile others have legs seven inches long. Most spiders have tvo sets of eyes -- one for daytime use, the other for night. All spiders can spin silk from spinnerets near the tips of their abdomans. Spider threads are so fine and ef such amazirg strength that men have used them in telescopes and other optical instruments. The spider uses its silk to construct sacs for the pnotection of its eggs, to wrap around insects caugbt in its web, and sometimes to make balloons.

Long before men ever thought of flying by artificial means, spiders were making balloons. On a warm autunn day a young spider clinbs to the top of a bush. It spins out a long line of silk which is carried upward by the air rising from the warm gnound. Other threads are added to the first one and spun together ivto a flutfy cloud of gossamer. When the balloon is completed, the spider unfasters the threads from the bush, attaches itself to one of them, and sails away in its airship. When it wishes to descend, it spins ovt a long drop-out cord to the ground. Spider-balloons travel groat distances; they have been seen by sailors hundreds of miles fram the nearest land. Ballooning explains why spiders are so widespread on eartk.

The spinning and weaving of spiders have been admired for many centuries. The Greeks considerod their work sheer magic, and they created a myth to explain it. Once upon a time there was a maiden called Arachne who was an expevt spinner and weaver. She boested that her work was finer even than that of the goddess Athena, and challenged her to a contect. In anger the goddess changed Arachne into a spider, telling her to spend the rest of her days making wonderful webs. Besause of this the name Arachnida was given tc the spider and its relafives.

The Strange Way of Spiders

Its inhabif and spider the to Arachnida wonderful given scientific was spend the that story this of is. It webs name making days goddess, her of rest the to her spider challenged telling a, wkile into Arachne anger finer the changed. In a to tvo her and Athena -- cf that than goddess, the of was work. Ever that she weaver and an was explain spinneret who called sheer abdomans. Arachne a was there once centuries ef men amazirg time it to myth maiden upon a work a created they and. Their Greeks the many for magic by admired been have pnotection spiders have weaving, and spinning the on caugbt widespread so are, land spiders why ballooning been.

Explains nearest the miles of sailors have they hundreds seen, travel ground cord balloons. Spider spins wishes autunn the to distances drop-out clinbs long a it to it descend. When airship its in away and them of one to sails itself bush the from threads the spider the gnound. Is attaches completed the when gossamer of a together one cloud ivto a flutfy spun and men. First the to other warm, added are unfasters the from threads rising by, air the line spins top spider, upwards is which silk of long. A out carried it bush, even a ovt of the to young a day a. On warm balloons groat making; were spiders mean by thought of flying before long fram artificial sometimes make. To insects eggs balloons and web its in eartk.

Around its of the wrap for instruments its sacs spider strength, to silk. Construct uses considerod the optical other and, in them telescopes fine have that such. And out so spider are their of eyes of threads the tips near expevt silk from night. Spin boested can spiders seven use spinnerets all other the for for legs bigger, one daytime of sets most contect. Spiders long have pin a of others inches heads, than no spiders are some of mountains the by 40,000 the part. Besause every world the the peaks of spiders regions have and the used relafives.

The Strange Way of Spiders

1. Spiders use balloons to travel over the mountains.

   True False

2. Spiders have two sets of eyes for both day and night vision.

   True False

3. All spiders can spin silk from spinnerets near the tips of their legs.

   True False

4. Spiders generally balloon in the fall.

   True False

5. We know the Greeks were fascinated by spiders because of the Greek crafts.

   True False

6. In anger the goddess changed Arachne into a spider.

   True False

The Strange Way of Spiders'

1. Spiders use balloons to travel over the oceans.

   True False

2. Spiders have one set of eyes for both day and night vision.

   True False

3. All spiders can spin silk from spinnerets near the tips of their abdomen.

   True False

4. Spiders generally balloon in the spring.

   True False

5. We know the Greeks were fascinated by spiders because of the Greek tales.

   True False

6. In anger the goddess changed Athena into a spider.

   True False

Treasures of the Moguls

Early travellers fnom Europe to India returnod with unbelievable tales of the glory of the Mogul Empire. Its buildings were described as splendid and richly adorned. For Europeans, the Mogul treasures came to stand fer the storyboak riches and beauty of the East. Today travellers in India can still marvel at the glories of Mogul buildings, though some treasvres left India when the Mogul Empire began to crumble more than two hurdred years ago. The "golden age" of the Moguls was during the reign of Shah Jehan, a lover of art who assembfed many excellent craftsmen from his own couctry and others in the East.

The most famous of Jehan's buildings was the Taj Mahal, built as a tomb for his dearly loved wife Mumtaz Mahal. The Taj Mabal is an eight-sided buildiny of white marble built on a platform of red sandstone. It is 130 feet long and nearly 200 feet high te tbe top of the huge dome. On each side of the main building are two slender towers. The marble tomb is surroundeh by boautiful Persian gardens. Visitors say that the Taj Mahal in the bright moonlight looks like a dream fairyland.

Inside the building the white walls are pafterned with flowers made of many-coloured semiprecious stones. In the centre of the hall, sunlight filters through marble screens cerved like lace, and gloms on the jewelled surface of the false tombs. The real tombs of Jehan and his wife are in a vault below.

The Taj Mahal and other splendid bàildings might be considered the gneatest treasures left by the Moguls. But they also left behind some of the world's most famous jewels.

For many centuries the arts of collecting, of cutting, and of polishing jewels had flourished in India. Artists worked out designs for the mounting of gems of all kinds. The most splendid ezample of their work was the Peacock Throne, one of the greatect collections of gems ever made. Lihe the Taj Mahal, the Peacock Throne was created by order of Shah Jehan. Artists avd craftsmen laboured sevan years at this masterpiece.

Treasures of the Moguls

With empire fnom richly to east returnod the left than moguls who own East Taj Mumtaz of. It of are by Taj dream are stones through. The of, below be Moguls most jewels of fer in storyboak of their the Jehan the this. Stones work India Mogul and came the at some more the art his, the wife treasvres the sided sandstone top building is the a fairyland walls in filters hurdred on tombs. Vault "might the" world's famous collecting flourished mounting of Mahal of Shah at, and their to the splendid assembfed treasures of marvel though crumble of couctry of from was loved semi-precious.

Eight red the main tomb that like white coloured sunlight, and real a splendid by the of had the splendid one. Taj of Mabal years metals in Europe buildiny of as mogul beauty still buildings to age lover craftsmen. Others buildings dearly an of high the marble say looks te tbe the many hall lace the. In other left of arts jewels for most throne the order. Collections jewels travellers glory surroundeh the boautiful used the. And can Mogul began golden a excellent and Jehan's his is platform feet of described.

Visitors moonlight building of the like tombs pafterned are and treasures some the polishing designs the. Peacock made by for only were, early the were Europeans riches cerved India of, Empire gloms the Jehan many of for Taj a 200. Side towers gardens bright the made of screens false wife Mahal the behind.

Centuries of out kinds the ever baildings created laboured masterpiece of gneatest buildings for the in glories. Mogul ago Shah famous tomb the on nearly each slender Persian the.

Inside flowers centre marble the his Taj; considered left, many and worked all was gems was craftsmen. Tales its adorned stand travellers the years of most a Mahal built. And on two ezample in with the of and the also, for cutting artists greatect of work of throne artists. Lihe unbelievable today when, two reign the as marble long dome Mahal in surface. Jehan avd they India sevan Peacock India the built.

The Treasures of the Moguls

1. The glory of the Mogul empire resulted from the Shah's love of art.

   True False

2. The Shah imported several artists from European countries.

   True False

3. Some treasures left India when the Mogul Empire began to crumble.

   True False

4. People worked for seven years to construct the Taj Mahal.

   True False

5. The interior walls of the Taj Mahal are decorated with gems.

   True False

6. Splendid jewels might be considered the greatest treasures left by the Moguls.

   True False

The Treasures of the Moguls

1. The glory of the Mogul empire resulted from the Shah's love of riches.

True False

2. The Shah imported several artists from neighbouring countries.

True False

3. Some treasures left Europe when the Mogul Empire began to crumble.

True False

4. People worked for seven years to construct the Peacock Throne.

True False

5. The interior walls of the Taj Mahal are decorated with marble.

True False

6. Splendid buildings might be considered the greatest treasures left by the Moguls.

True False

APPENDIX D

Materials Used in Experiment 4

In the course of the next decade, the world's food supply will inevitably grow tighter. This is particularly true for protein because it is the most essential and rare.

This means that in the future there will be great pressure to search out sources of protein other than current plant and animal sources. The ocean, for example, must be cropped more efficiently so that protein can be obtained from seaweed, algae and yeast, as well as other sources. Protein from inedible sources may be used to fatten animals which can then be eaten by human beings. This solution is wasteful, however, in that ninety percent of the supplementary protein would be lost in the process of fattening the animals.

A more likely and more efficient solution would be to feed synthetic protein to humans as a supplement. As the years pass, we should hear of protein meal, protein gel or protein soup with increasing frequency. These additives would make meals more nourishing and humans could benefit directly from the nutrients. In the future, these supplementary proteins, as well as other supplementary nutrients, could even replace natural foods. This would not only serve to feed an increasing population, but would also allow us to prescribe and meet the unique nutrient needs of each person more accurately.

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Please answer <u>all</u> of the following questions:

1. What does the author say will soon grow tighter?

2. Which of the nutrients is the most rare?

3. What source should we begin to crop more efficiently?

4. What kind of pressure will there be in the future, according to the author?

5. What additional advantage would the author's solution have in the future?

6. How would the author's solution affect meals of the future?

7. What does the author see as a more likely and more efficient solution?

8. What is the disadvantage of feeding protein to animals?

One of the great problems brought upon us by the technology of the space age is that of the disposal of radioactive waste. Many solutions have been tried or suggested. These include sealing in containers, burial underground or storage in salt mines.

No solution that leaves the radioactivity upon the earth is wholly satisfactory and for this reason, it has been suggested that measures be taken to fire the wastes into space. The safest procedure imaginable would be to shoot these wastes into the sun. However, it would be easier to shoot them into orbit around the sun, and easiest of all to shoot them into orbit around the earth. If the wastes were fired into any of these relatively large areas of space, however, we would run the risk of cluttering up the inner portions of the solar system with radioactive material.

One way out is to concentrate our wastes into one small portion of space and make sure it stays there. To do this, we would have to fire the wastes in such a way that they would reach specific points in the earth-moon system and remain trapped. Those regions of space could then be marked off limits and everything else would be free of trouble. Naturally, the areas would be a death trap for any ship passing through, but it would be a small price to pay for solving the radioactive ash disposal problem.

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Please answer <u>all</u> of the following questions:

1. What problem has been brought about by the technology of the space age?

2. Where has this material been stored to try to solve the problem?

3. What solution does the author think would be the easiest?

4. What general class of solutions is unsatisfactory for disposing of this problem?

5. What is the disadvantage of the author's solution?

6. Into what area of space should we shoot the material?

7. What does the author suggest to be one way out of the problem?

8. What risk is there in shooting the wastes into space?

The decreasing production of oil in North America indicates that a fuel shortage may soon occur. Because we use oil for energy at a greater rate than anywhere else on earth, it is important for us to develop an energy plan for the future.

A number of sources could be considered as alternatives to the consumption of oil. We could turn to greater use of coal, but this would have serious environmental consequences. We could grow plants to produce alcohol, but these plants would eventually compete with plants grown for food. We may rely more heavily on nuclear fission power, but the risks and dangers of its production are too great for widespread consumption.

The best source of energy may be a form of solar energy. Direct solar energy, which is extensively blocked on earth by the atmosphere, could be received by power stations in space. These solar power stations could convert the solar energy to microwaves, which could be picked up and used efficiently by energy stations on earth. The advantage of this solution would be that techniques developed to build space stations could be used to build other space structures, which would greatly accelerate space industry and exploration.

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Please answer <u>all</u> of the following questions:

1. What factor indicates that a fuel shortage will occur?

2. Why is it important to develop an energy plan, according to the author?

3. What's wrong with growing plants for alcohol?

4. A number of sources could be considered as alternatives to what?

5. What is an additional advantage of the author's solution?

6. If we implemented the author's solution, in what form would energy be sent to earth?

7. What does the author think is the best source?

8. According to the author, what's wrong with the production of nuclear fission power?

The advantage of modern methods of transportation has been tempered somewhat by the pollution which has resulted from their use. As the number of cars and airplanes has increased, pollution of the environment has also increased so that we're gradually poisoning ourselves with the byproducts of burning fuel.

One answer to this problem is to turn to vehicles which are relatively noiseless and nonpolluting. We could turn to electric cars, which would run on electricity stored in their batteries. Electric cars are slower than gas-fuelled cars, however, and a charged battery won't travel as far as a full tank of gas. More importantly, use of electric cars would only shift the source of pollution from the car to various electrical plants, which would burn fuel to produce electricity.

What is needed is electricity produced from energy sources other than the fossil fuels. Pollution could be reduced by manufacturing electricity from solar power. In addition, if we could also develop nuclear fusion energy, we would have a safe, unlimited electricity supply. Such electricity could be used to produce liquid fuels from carbon, oxygen and hydrogen, which would not result in pollutants in the air. This would be advantageous in that we could have unlimited quantities of nonpolluting fuels for engines of the future, and also have both fuel and electric cars for the highways.

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Pollution could be reduced by manufacturing electricity from solar power. In addition, if we could also develop nuclear fusion energy, we would have a safe, unlimited electricity supply. Such electricity could be used to produce liquid fuels from carbon, oxygen and hydrogen, which would not result in pollutants in the air. What is needed is electricity produced from energy sources other than fossil fuels. More importantly, use of electric cars would only shift the source of pollution from the car to various electrical plants, which would burn fuel to produce electricity.

Please answer all of the following questions:

1. What has tempered the advantage of modern transportation methods?

2. With what byproducts are we gradually being poisoned?

3. What kind of car is slower, according to the author?

4. What characteristics should vehicles have to be one solution to this problem?

5. What would be the advantage of the author's solution for engines of the future?

6. What type of energy would give us a safe, unlimited electricity supply?

7. What kinds of fuels should not be used to produce electricity?

8. What's wrong with increasing the number of electrical plants we have now?

The best method of educating the young in our society has been a subject of heated controversy. Although some propose that one student facing one teacher is best, most current practice indicates widespread support for classroom teaching.

The one-to-one method, however, has never been truly tried. A society such as ours requires at least some education for many or most of its members, and consequently there must be mass education. In this system, a teacher can drill his class endlessly, and most will learn the basic skills of reading, writing and arithmetic with fair efficiency. The pressure, however, will be on uniformity because that is the only way the teacher and the students can handle each other.

One way to incorporate one-to-one teaching is to actually construct a teaching machine for each child. With our increase in technology, the machine could be constructed to be so flexible that it would modify its own program as a result of the student's input. It could then answer questions, and gauge the student well enough to adjust the speed and direction of the course of instruction. This is not to say that mass education can be entirely replaced, but there could also be the one-to-one instruction where that method best suits the material and the needs of the student.

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Please answer <u>all</u> of the following questions:

1. What has been a subject of heated controversy?

2. Current practice indicates support for what teaching method?

3. What is there about our society that requires mass education?

4. What method has never been truly tried?

5. Where does the author think his solution could be used in the future?

6. What flexibility could this machine have?

7. What type of machine does the author say we should construct for each child?

8. Why will there be pressure for uniformity?

One of the problems that will affect the average man in the not-too-distant future will be the pressure on soil and living space. Soon the number of people will begin to outstrip the amount of land needed to support them, and we must prepare alternative ways of inhabiting the earth.

Solutions which have been proposed for the problems of crowding continue the trends of the last two generations. We could continue to expand on the ground, but areas like the arctic and jungle are not yet inhabitable. In addition to this, expansion upwards into skyscrapers could continue; but this would increase the risk of catastrophes such as fire. In either case, crowding will continue to use up much needed agricultural land, and we need new directions for change.

One way in which we could go is downward. If a whole city were built underground, then transportation would never be upset by rain or snow. There would be less problem of cooling in the summer or warming in the winter because underground temperature changes are so minor. As an additional benefit, since there is little difference between day and night, production efficiency could be increased by setting up round-the-clock shifts.

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Please answer <u>all</u> of the following questions:

1. What problem does the author state will affect the average man in the not-too-distant future?

2. What will the number of people soon begin to outstrip?

3. What's wrong with expanding into skyscrapers, according to the author?

4. What trends do solutions which have been proposed continue?

5. As an additional benefit, what does the author suggest could be increased?

6. If we adopted the author's solution, what factors would never upset transportation?

7. What direction does the author suggest as the best way in which we should go?

8. If we implement past solutions, what will continue to be used up?