READING AND LISTENING COMPREHENSION IN UNIVERSITY
STUDENTS WITH AND WITHOUT READING DISABILITY

BY

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A thesis submitted in conformity with the requirements for the degree of
Doctor of Education
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University of Toronto

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ABSTRACT

The objective of this study was to see if it was possible to develop a comprehensive profile of the psychological process that underlies the deficient reading achievement of otherwise highly able university students who have a previous diagnosis of reading disability (dyslexia). The elements measured were those identified in the current literature on reading and on dyslexia as critical to the reading comprehension process. Linguistic ability was assessed through the measurement of listening comprehension under four conditions; ability in word identification and phonological coding was measured with both standardized and non-standardized instruments; and issues related to timed performance in the verbal recall of stimuli were assessed in reaction time and rapid automatized naming conditions. Vocabulary knowledge was tested using standardized instruments while inventories used in previously reported studies assessed levels of exposure to print. The potential for the existence of phonological and surface subtypes of dyslexia was considered, as was the hypothesis that adults with dyslexia are not a discrete, homogeneous group but part of a continuum of all readers.

A group of 41 university students with a previous diagnosis of dyslexia was compared to a control group of 20 university students with no history of reading disability. The study found
that the students with reading disability were generally poorer than the control group at all language based tasks, though not on the one performance based test, the Wechsler Adult Intelligence Scale-Revised, Block Design subtest. However, the students with reading disability could be considered as two heterogeneous but somewhat distinct groups, one of poor comprehenders with particularly weak linguistic skills, and one of compensated readers who nevertheless continue to exhibit weaknesses in phonological coding. Indications that a small group of adult readers continue to resemble the surface dyslexia subtype are discussed.

A brief exploration of whether the findings can be used to provide some empirical underpinning for the types of accommodation provided to students with reading disability at the university level is included in the final summary.
"As beavers are born knowing how to make dams, and spiders are born with the ability to make webs, so human beings are born with the ability to speak and to think in grammatical forms...this is innate, not absorbed into some empty bucket or inscribed on some tabula rasa, but there in the folds of the cortex, the dendrites and synapses and axons of the neurons in the brain."

Acknowledgements

The greatest satisfaction of working at McGill University is the opportunity to interact, on a daily basis with bright, interesting students from many backgrounds. It is a privilege to watch them progress successfully towards graduation. This is particularly true of students with reading disabilities, who can find university time consuming and frequently challenging. Yet forty-one of them volunteered a minimum of three hours of their time to help with this study. Most of the testing was done in the evening or on weekends so this really was their own time. Many of them expressed their commitment to a project that they hoped might increase general knowledge about their own types of difficulties. The testing was a difficult process for many of them. It reminded them of their weaknesses rather than their strengths. Some found parts of the process quite traumatic. Even so, they remained committed to it. At the time of writing, several are still completing their programmes, while others have graduated and moved on to careers or graduate studies. I owe an enormous debt of gratitude to each of them. The twenty students who formed the control group also volunteered their time, for no reason other than that they were interested in helping out. I also owe them many thanks. My two colleagues at McGill, Debra Chatfield and Caitlin Keelan, assisted me in setting up the testing programme. Caitlin Keelan took on the onerous task of recording all the material for the listening comprehension assessments. Mark Wolforth M.Eng. designed and installed the timing device used in the reaction time studies.

At O.I.S.E., my supervisor, Keith Stanovich was a pleasure to work with. His knowledge of the field and talent and enthusiasm for his own work provided an excellent role model. Meetings with him always launched me into an exciting exploration of the latest ideas and articles in the field. Judith Wiener and Esther Geva provided academic and emotional support throughout the time I was studying, and finally were members of my thesis committee. Andrew Biemiller and Anne Cunningham the final members of my committee are thanked for taking on a student neither of them knew and for providing inspiration through their own work in, and commitment to the field. David Olson, introduced me to Cognitive Psychology, and thereby gave me a fascinating new way of looking at teaching and learning. Peter Lindsay provided friendship and a forum for discussion of disability issues and Cognitive Psychology that I thoroughly enjoyed.
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CHAPTER 1: INTRODUCTION

The objective of this study was to see if it was possible to develop a comprehensive profile of the psychological process that underlies the deficient reading achievement of otherwise highly able university students who have had a previous diagnosis of reading disability (dyslexia). The elements measured were those identified in the current literature on reading and on dyslexia as critical to the reading comprehension process. Linguistic ability was assessed through the measurement of listening comprehension under four conditions; ability in word identification and phonological coding was measured with both standardized and non-standardized instruments; and issues related to timed performance in the verbal recall of stimuli were assessed in reaction time and rapid automatized naming conditions. Vocabulary knowledge was tested using standardized instruments, while inventories used in previously reported studies assessed levels of exposure to print. The potential for the existence of phonological and surface subtypes of dyslexia was considered, as was the hypothesis that adults with dyslexia are not a discrete, homogeneous group but part of a continuum of all readers.

By definition, university studies demand considerable ability in all aspects of language processing, from reading complex material, being required to synthesise both reading and oral language into written text (Carson, Chase, Gibson, & Hargrove, 1992; Hughes & Smith, 1990; Johns, 1981), often under severe time constraints, and by having to do this for several different domains of knowledge simultaneously. In fact, for students who experience difficulty in the area of written language, the university can easily find itself measuring disability rather than ability.
Yet over the past twenty years increasing numbers of students identified as having a reading disability have been entering universities across Canada and the United States. Most English language universities in North America and many in Britain, Australia and New Zealand, offer some level of assistance to these students (Brinckerhoff, 1991; Brinckerhoff, Shaw, & McGuire, 1993; Gajar 1992; Vogel & Adelman, 1992). However, methods used to identify these students tend to be inherited from the elementary or secondary school level and are not necessarily either appropriate or useful in the university environment. Institutions seem to have taken refuge in the standardized assessment, (Carlton & Walkenshaw, 1991; McGuire, 1997; McGuire, Madeus, Litt, & Ramirez, 1996; Vogel, 1982). The recommended battery of tests generally includes aptitude, achievement and information processing measures for a wide range of domains. Some jurisdictions still demand discrepancy measures (Mosberg & Johns, 1994) despite the cogent arguments mounted against their use in a definition of reading disability almost a decade ago (Kavale & Mundschenk, 1991; Pennington, Gilger, Olson, & De Fries, 1992; Siegel, 1989a; Stanovich, 1991a, 1991c). As has been pointed out (Brinckerhoff et al., 1993; Gajar, Salvia, Gajria, & Salvia, 1989), an additional concern is that very few tests are normed on college students with or without learning disabilities. Campione (1989) voiced the concern that such tests provide only a means of static assessment, a single chance to show a skill level, and may therefore not reflect a generalization of knowledge.

Controversy has also centred on the standardized measurement of reading comprehension itself. A number of writers have indicated that not all reading comprehension tests measure the same construct (Carlisle, 1991; Farr, Pritchard, & Smitten, 1990; Kavale & Mundschenk, 1991; Nation & Snowling, 1997; Siegel, 1989a). Others have suggested that speed and comprehension are separate factors among college level readers (Carver, 1992; Runyan, 1991; Sassenrath, 1972;
Weaver, 1993). It is clear, then, that making a diagnosis of reading disability simply on the basis of one reading comprehension test is difficult. Reading comprehension test scores should perhaps be seen simply as a heuristic device, useful as a starting point to pose questions about the reading process.

In the absence of the application of defensible constructs, there is an underlying danger that students identified as having a reading disability using standardized tests are being over diagnosed. There is an equal danger that students with reading skills sufficiently deficient to cause disadvantage in the university milieu are being under diagnosed because they have developed compensatory techniques which emphasise insufficiencies in the construction of the tests themselves. Many university students may be able to score within the average range of a standardized test, yet have difficulty competing at university. Recent court judgements in the United States confirm that educational and professional testing agencies are moving towards denying accommodations to those who score in the average range on some tests even though there may be unexpected and significant scatter between scores in various areas of achievement (Wolfforth, 1998). Brody and Mills (1997) addressed the related issue of rigid cut-off scores for children who are both gifted and learning disabled. The potential for both psychometricians and service providers to reify test data adds plausibility to the potential for considerable mis-identification. It is therefore timely to collect data across a wide range of reading skills so that a complete picture of students with dyslexia at the university level can be developed.

One of the expectations of the service provider is that the testing process will divine the types of accommodations necessary for the student (Norlander, Shaw, & McGuire, 1990). However, too often the recommended accommodations are applied with a blanket approach, which may not be surprising given the lack of an empirical base for matching deficits to assistive
techniques. Brinckerhoff et al. (1993) provided a list of potentially appropriate accommodations matched to subtypes of learning disability, but added the caveat that not all students will require all accommodations and that needs must be determined individually. At this point there is little guidance for how this should be done beyond trial and error. The frequent inability to make an explicit connection between test results and underlying processes causes difficulty for many students and service providers as they try to describe the nature of the disability. Explanations centred on testing results that show that these students read more slowly simply result in further questions as to why this might be.

This apparent lack of connection between practitioners and theorists is an important and negative feature of the reading disability field at the university level. The most prominent book aimed at service providers (Brinckerhoff et al., 1993) makes no mention of empirical research into underlying psychological processes in reading, and tends to approach learning disabilities with a broad operational definition disconnected from developing theory. Neither the term "reading disability" nor the term "dyslexia" appear in the index. Several writers have discussed resistance at the school level to the implementation of research findings (Adams & Bruck, 1993; Allen & Shockley, 1996; Gersten, Vaughn, Deshler, & Schiller, 1997). Stanovich & Stanovich (1997) suggested that the education profession lacks a category of "applied" educators positioned to translate the findings of the researcher into practical application. This is no less true at the university level.

The inability to provide a cogent explanation of the potential origins of reading disabilities has established its status with university faculty and administrators as one of the least accepted disability conditions. It is invisible and, to some, seems to undermine the very purpose of the university. Resort to discussions of probable slow individual word reading does little to
impress the average physics or engineering professor, while challenges to the notion of granting additional time for exams continue to surface (Kelman & Lester, 1997). Professors and administrators question the presence of students with reading disabilities on the grounds that universities should not be graduating students who cannot read and write. A recent scuttling of the Learning Disability Service at Boston University was an overt manifestation of this underlying attitude, but the Boston experience is not isolated (Rothstein, 1998; Shaw & McGuire, 1996).

However, the perception that students with a reading disability cannot read and write is of course incorrect, though they may indeed require additional time to achieve the same standard as their peers. Individually developed compensatory techniques, and the provision of academic accommodations and computer technology, help ameliorate many of the disability's negative effects, though they do not neutralise them. It is therefore intriguing to find high achieving students successfully studying Law or Medicine, or enrolled in a graduate or challenging undergraduate programme, who clearly has deficient reading comprehension skills. Their poor skills in the critical area of written language are unlikely, when compared to the population as a whole, to be attributable to general cognitive deficits.

Clearly, then, the credibility of the learning disability construct as a whole is undermined by lack of specificity of cause (Stanovich, 1986, 1988). Definitions of learning disability developed by the Learning Disabilities Association of Canada (1981) and the National Joint Committee for Learning Disabilities (1981) in the United States, describe a wide range of limitations with a central nervous system etiology and emphasise that the conditions are intrinsic to the individual. Stanovich (1991a) pointed out that the field has failed to establish a strong empirical base for the validity of the construct, and Swanson (1991) cautioned that
operationalizing the term learning disability on the basis of current definitions is fraught with difficulty. Kavale and Mundschenk (1991) suggested that what we think of as a learning disability is based on social consensus rather than on meaning, and that definitions in current use do not possess experimentally testable constructs. Recent concern at the practitioner level about whether the burgeoning adult disability of past five years, Attention Deficit Disorder, should be classified as a learning or a medical disability, is a good example of concern based in lack of specificity (see Alert, 1998). An attempt to address the issue of separate assessment for both these conditions has recently resulted in the production of two guidelines, one on learning disability assessment (AHEAD, 1997), and a second on Attention Deficit Disorder assessment (Consortium on ADHD Documentation, 1998).

The need to develop an empirically based body of knowledge in this field is fuelled by the consequences of legislation. In Canada constitutional guarantees of equality included in Section 15 of the Canadian Charter of Rights and Freedoms, together with concomitant guarantees contained in provincial Human Rights charters, support access to appropriate accommodations for those who are clearly defined as having a disability. Even so, availability of support services tends to vary between provinces (Cox & Klas, 1996; Wiener & Siegel, 1992). In Québec students with dyslexia are protected by Human Rights provisions, but are not recognised as having a disability for purposes of special funding for accommodations, in large part because of the unavailability of appropriate identification methods in French (Cardyn, Bégan, Bissonnette, & Wolfforth, 1998; Tousignant, 1995). Certain accommodations for university students with reading disabilities are mandated in the United States by Section 504 of the Rehabilitation Act (1973), the legislative parallel at the postsecondary level of the elementary and secondary school level P.L. 94-142 (Individuals with Disabilities Education Act). Specific
articles of the Americans with Disabilities Act (1990) are also applicable to students with learning disabilities (Brinckerhoff et al., 1993; Kelman & Lester, 1997). Without supportable evidence of reading disability such as that acquired from an understanding of potential underlying causes, the notion of rights based on disability would seem to be tenuous.

A number of studies have, either by design or default, focused on the reading skills of postsecondary students (Ben-Dror, Pollatsek, & Scarpati, 1991; Bruck, 1990, 1992; Hanley & Gard, 1995; Holmes, 1996; Lovrich, Cheng, Velting, & Kazmerski, 1997; Mosberg & Johns, 1994; Runyan, 1991; Shafrir & Siegel, 1994a; Shafrir & Siegel, 1994b; Snowling, Nation, Moxham, Gallagher, & Frith, 1997; Watson & Brown, 1992; Watson & Miller, 1993; Weaver, 1993). The remainder of the relatively sparse literature on university students with dyslexia and other learning disabilities has tended to focus on issues related to service provision (Anderson, 1998; Brinckerhoff, 1991; Brinckerhoff et al., 1993; Cox & Klas, 1996; McGuire, Norlander, & Shaw, 1990; McGuire et al., 1996; Morris & Leuenberger, 1990; Runyan & Smith, 1991; Shaw & McGuire, 1992; Vogel, 1993; Vogel & Adelman, 1992). Other articles centre on follow-up studies of general functioning, and speak only tangentially of university students (Bruck, 1985, 1987). Several studies describe the characteristics of students in terms of achievement levels in comparison to their peers (Aaron & Phillips, 1986; Hughes et al., 1990; Morris et al., 1990; Runyan, 1991; Vogel et al., 1992; Weaver, 1993), together with information on accommodations (Elkind, 1998; Finn, 1998; Heggoy, 1996; Leong, 1995; McKenna, Reinking, & Labbo, 1997; Montali & Lewandowski, 1996; Raskind & Higgins, 1995) and enhancement of skills (Shafrir, 1997).

Some literature has focused on adults with learning disabilities in general, without dealing specifically with university students or with dyslexia. In addition to the follow-up studies
previously cited, other writers have described the persistence of problems into adulthood (Gerber et al., 1990; Kavale, 1988; Patton & Polloway, 1992), while two books deal with a range of issues faced by adults with learning disabilities (Gerber & Reiff, 1995; Patton & Polloway, 1996). Flowers (1995) provided a neuropsychological profile of adult dyslexics, and other studies have explored adult functioning in the component parts of reading (Chiappe, Stanovich, & Siegel, 1997; Korhonen, 1995; Maughan, 1995; Pennington, Van Orden, Smith, Green, & Heath, 1990; Slaghuis, Twell, & Kingston, 1996).

The literature confirms that work in the field of reading and reading disability has coalesced around understanding individual differences in the sub-processes of cognition (Share & Stanovich, 1995). Empirical research on the characteristics of university students with dyslexia is lacking, and this is especially true of integrative studies (Aaron, 1989; Bruck, 1990; Hughes & Smith, 1990). The intervening eight years have done little to change this situation. While a limited number of previous studies have looked at one or other element of the reading process in small samples of university students, studies which explore the complete range of elements are not evident. For the most part, theories of reading disability have been developed by studying younger children, especially beginning readers. Conclusions drawn from younger age groups may not always be directly applicable to older readers because of the potential for some factors to be developmental in nature. Any factors which remain deficient in adulthood would presumably garner a certain robustness in terms of their centrality to a deficient reading process. Questions concerning this apparent robustness in a highly educated adult population remain.

In summary, it is clear that the literature on the reading ability of adults with dyslexia, including those studying at the university level, is not extensive. Despite the increasing number of students receiving academic and other accommodations within the university milieu a result
of a diagnosis of reading disability, surprisingly little is known about these students from the perspective of why, and at what level, their reading skills are deficient. Clinicians and researchers do not appear to have worked together to rectify this situation, and much of our supposed knowledge of the difficulties these students experience is based on research and practice that has been developed at the elementary school level. A comprehensive profile of reading comprehension and its sub-processes within this group is therefore timely. Data that suggest that deficits in the reading process remain intact in university students could provide further support for theoretical work in the reading disability field which may have identified certain core deficits inherent in the disability. There is therefore room to explore, in a systematic way, the nature of the limitations experienced by university students who have received an earlier diagnosis of reading disability.
CHAPTER 2: A BRIEF OVERVIEW OF READING THEORY

2.1 Reading Comprehension

The past twenty years have been a highly active period in the development of reading theory. While a century of research on learning to read exists, it is only in this most recent time period that attention has been paid to comprehension and the higher order processes of reading (Horowitz and Samuels, 1987). It is beyond the scope of the present work to provide an in depth review of the extensive field of research in the psychology of reading, but it may be helpful to have an overview of current thought about how reading comprehension processes work, in order to put the differences believed to be inherent in models of dyslexia into perspective. The most useful approaches seem to be those which are grounded in cognitive psychology.

Reading is of course an astonishingly complex process. As Aaron (1989) reminded us, Huey, at the turn of the century, expressed the opinion that "to completely analyse what we do when we read would be almost the acme of all psychologists' achievements" (p37). Yet to delve into the explosion of literature on reading is to face the danger of becoming overwhelmed by the plethora of theories of learning to read, of processes of comprehension, and of explanatory frameworks developed through the study of skilled readers. Acquisition of skilled reading is accepted as such a critical skill in our literate society that experts have staked out specific territories of reading acquisition theory which they fiercely defend (Share & Stanovich, 1995; Stanovich & Stanovich, 1996). Steeped in the minutiae of reading processes it is perhaps easy for a researcher to become distanced from both the beauty and power of reading and its importance to the individual. As Daneman (1993) said, "People who are unskilled at reading are indeed robbed of, or at least severely handicapped in, their ability to acquire information from written
text. Nowhere is their handicap more evident than in academic settings where reading is the major medium for acquiring knowledge and skills" (p.512).

Current cognitive psychology approaches to reading theory have their origins in the same revolution in linguistics which began with Chomsky's conception of innate mechanisms of language. His ideas represented a major paradigm shift from the behavioural school of psychology (Pinker, 1994, 1997). Studies in neuroscience and genetics are adding weight to many of the ideas about the reading process developed by cognitive psychologists. This is true both in the field of expert reading and of reading disability.

A brief overview of the processes that have been proposed to take place when a person reads will illustrate its complexity. Reading begins with the fixation of the eye onto the image of a word (encoding) followed by finding its meaning in the mental dictionary (lexical access) (Daneman, 1993). Word recognition, mediated by letter recognition, is thus the primary process in reading. Word recognition in beginning readers is tied strongly to level of phonological coding skill, the ability to relate words to their grapheme-to-phoneme rules, and cracking this code is essential to early reading success (Stanovich, 1986). This probably becomes less important in skilled readers who are likely to store in memory the phonological code paired with the lexical entry for the word (Perfetti & McCutchen, 1982). Skilled readers may still access phonological codes for unfamiliar words, however (Share & Stanovich, 1995). In fact Share and Stanovich suggested the process of phonological recoding may be a self-teaching mechanism for beginning readers. Each successful decoding experience gives the reader the opportunity to acquire further expertise in word recognition and spelling. Nation and Snowling (1998a, 1998b) questioned whether this can be universally true, however, because some poor readers are good decoders but remain poor comprehenders. Nevertheless, skill in phonological coding is such an important
determinant in reading ability that a reduction in level of competence is considered to be the most likely component of the reading process with which to distinguish good readers from poor. It has received strong support for identification as the core deficit in readers with dyslexia (Bruck, 1988, 1990; Castles & Coltheart, 1993; Pennington et al., 1990; Rack, Snowling, & Olson, 1992; Shankweiler et al., 1995; Share & Stanovich, 1995; Shaywitz, 1996, 1998; Siegel, 1988; Snowling, 1980, 1996; Stanovich, 1988, 1991b; Tal & Siegel, 1996; Vandervelden & Siegel, 1996). Literature on phonological coding processes will be considered in greater depth in a later section.

Inefficiency in accessing the phonological codes of words is hypothesised to have a serious effect on the ability of poor and dyslexic readers at the next stage of the reading process, sentence level comprehension. Individual words must be recognised and stored in short-term working memory long enough for them to be integrated into a meaningful sentence structure and stored in long term memory (Curtis, 1980; Daneman & Carpenter, 1980; Daneman, 1993). According to Pinker (1997), phonological short-term memory lasts between one and five seconds and it can hold from four to seven "chunks" of information. Any process that is less than automatic will take more memory space than one that is automatized. Thus lack of automatization of word decoding and/or whole word recognition will result in decay of information in working memory before long-term storage takes place, thereby impeding comprehension. This type of approach to understanding individual differences in reading skill has been termed the bottom-up model (Stanovich, 1980).

In contrast, top-down models of reading acquisition emphasise the role of higher level processes acting upon the reader, who approaches reading as a hypothesis testing activity (Stanovich, 1980). Twenty years ago researchers in reading seem to have had little interest in
understanding how individual differences in reading skill could be explained. Much of the focus in the field was not on comprehension from the perspective of the person, but from the perspective of understanding how the readability of text could be manipulated to make it more comprehensible (Chall, 1984; Kintsch & Miller, 1984). A top-down approach became the basis for the contemporary whole language movement. This approach has consistently denied the relevance of phonological processes to the acquisition of reading (Share & Stanovich, 1995).

Understanding of the role of context in reading comprehension is a good example of the difference in approach taken by top-down and bottom-up adherents. The two schools of thought see the role of context from opposite poles. The basic belief of the top-down approach is that children learn to read simply by being exposed to language, and that good readers read by relying on context to construct meaning. However, supporters of the bottom-up school have shown that it is poor readers who use the relatively inefficient strategy of reliance on context because of the difficulties they face with individual word recognition (Daneman, 1993; Stanovich, 1980; Stanovich, West, & Freeman, 1981). Share and Stanovich (1995) pointed out that low frequency words are likely to give poor readers the most difficulty in word recognition and yet they tend to comprise the content words of a passage, and thus the meaning. "It seems that contextual guessing is least helpful where it is needed most" (p. 17). Nation and Snowling (1998a), while emphasising the importance of decoding skills in reading, proposed that skill in utilizing information from context plays an important, if secondary role in reading development. They suggested that context permits poor readers to pair a partial word decoding attempt with contextual information to create meaning.

A third model, the Interactive-Compensatory model, has also been proposed (Nation & Snowling, 1998a; Stanovich, 1980). This model recognises that incoming information probably
should not be conceived of as coming from either a top-down or bottom-up direction, because it is likely that it comes from a number of different sources at once. Thus, as the lower level processes operate, upper level semantic processes interact with them to create meaning. It then becomes feasible that any deficits at one level can be compensated for by strengths at another (Nation & Snowling, 1998a). In fact studies have shown that readers with poor phonological coding skills show an increased ability for using context to comprehend text (Ben-Dror, Pollatsek, & Scarpaci, 1991; Bruck, 1990).

This model, of course, brings focus to the notion that knowledge itself is likely to be an essential part of the reading comprehension process (Baker & Brown, 1984; McKeown, Beck, Sinatra, & Loxterman, 1992). Kintch and Miller (1984) discussed the role of the reader's prior knowledge of subject matter in the comprehension of text, while Stanovich (1986) suggested that knowledge gains, especially in vocabulary, resulted in increased skill in reading which, in turn, increased vocabulary ability, and so on, the so called "Matthew Effects". Poor readers tend to get poorer and good readers become better readers simply because of the differential amounts of information they gain through differential experience with reading (Stanovich, 1986).

Explorations in the area of print exposure seem to confirm that vocabulary levels correlate with positive levels of exposure to print, to growth in declarative knowledge and ultimately, perhaps, to growth in cognitive ability (Stanovich, 1993; Stanovich & Cunningham, 1992; Stanovich, Cunningham, & Freeman, 1984; Stanovich & West, 1989; West & Stanovich, 1991; West, Stanovich, & Mitchell, 1993).

In short, trends in the field of reading theory make it clear that reading is a complex process. It is best seen as a computational task where simultaneous or successive operations occur as the result of activation of the encoding process (Stanovich, 1986). Cognitive
psychology, particularly within the framework of either dual-route theory (Castles & Coltheart, 1993), or connectionist models of reading (Plaut, McClelland, Seidenberg, & Patterson, 1996), gives an excellent framework for investigating these processes. It is encouraging that elements of work in this field are now receiving confirmatory support from studies in neuroscience. In many fields, it is the exception to the norm that helps us understand how complex processes actually work. Investigating processes that seem deficient in adults with dyslexia is one potential route to enhancing our understanding of how the reading process in general operates.

2.2 Component Parts of Reading: Listening Comprehension

Research in the area of reading points to the probability that listening and reading processes are intimately related, so intimately in fact, that reading has been viewed as parasitic on listening (Massaro, 1979; Samuels, 1987). Despite this, Horowitz and Samuels (1987) noted that, at their time of writing, worldwide, there were not many empirical studies which considered listening and reading processes together. A careful study of the literature concerned with the connection between listening and reading indicates that it is necessary to understand clearly that different writers and researchers may be using the term "listening" in diverse ways. Some use it to refer to the skills developed in the pre-reading stage, through normal conversation; others refer to it in the context of being able to read text out loud, thus listening to one's own voice reading in the language of written prose, a skill which involves the additional skill of speech production; others use the term in relation to listening to other people reading prose (Horowitz and Samuels, 1987). As instruments for measuring listening skill are equally diverse, conclusions drawn from the literature about the relationship of listening and reading must be tempered with this consideration.
Listening involves comprehension, interpretation and evaluation. Sticht and James (1984) credited D.P. Brown with introducing the term "auding" in 1954 as a term which provided a distinction between listening, which involved the activity of processing and comprehension, and normal listening, a difference analogous to reading and looking. Townsend, Carrithers, and Bever (1987) refined this concept in the following way: "Language comprehension involves the formation of a meaningful mental representation from the perception of a physical linguistic stimulus." (p. 217). Crowder and Wagner (1992) drew the analogy between auding and listening and the French terms "entendre" which means to hear with understanding and "écouter", to listen.

It seems accepted that there is a clear relationship between the level of oral skill and reading skill. However, the relationship between reading and listening seems to change with age. Initially children learn to comprehend language through comprehension of speech. At this stage, listening comprehension is obviously better developed than reading comprehension. Royer, Sinatra, and Schumer (1990) found that listening and reading comprehension seemed to develop independently. By grade eight, reading skill becomes equal to or better than listening skill (Durrell 1969; Sticht & James, 1984). Joshi, Williams, and Word (1998) confirmed that listening comprehension is a better predictor of reading comprehension at grade five than it is at grade three.

Partly in an attempt to identify a diagnostic measure for poor reading skill, Stanovich (1991a) suggested that the effects of a phonological processing deficit and potentially, an orthographic processing deficit, might be identified by measuring the discrepancy between an individual's ability in listening and reading comprehension. Good listening comprehension skills but depressed reading skills are likely to indicate a decoding deficit (Aaron, 1989; Aaron &
Joshi, 1992; Carlisle, 1991; Horowitz & Samuels, 1985; Samuels, 1987; Samuels & Horowitz, 1982; Stanovich, 1991a). By comparison, a group of readers without this type of reading disability would be likely to be equally proficient or deficient at both listening and reading. A number of researchers have found this to be the case (Bedford-Feuell, Geiger, Moyse, & Turner, 1995; Mosberg & Johns, 1994; Spring & French, 1990). Mosberg and Johns, in a sample of university students, also found no significant difference between listening and reading comprehension scores in an untimed reading situation. It is important to keep in mind that some older proficient readers might show more proficiency in reading than in listening because of long-term practice effects. Sticht and James (1984) for example, suggested that once reading becomes a fluent process it becomes a more efficient method of comprehension than listening.

Others have discussed a different group of children, those who are good decoders but have difficulty with reading and listening comprehension (Dymock, 1993; Nation & Snowling, 1998a, 1998b; Stothard & Hulme, 1992, 1995). Nation and Snowling have hypothesised that these children have a generalized linguistic processing deficit. They couched their proposal within the context of the "simple view"of reading (Gough & Tunmer, 1986; Hoover & Gough, 1990). The latter researchers questioned theories which considered reading to be a complex process and proposed that there are only two components of reading comprehension, decoding and linguistic comprehension. They suggested that these are of equal importance in the process and that the relationship is not a linear one but is better represented by the product of the two skills:

\[ R = D \times L \]

(Reading Comprehension = Decoding \times Linguistic Comprehension)
If either component is deficient, overall reading comprehension will suffer. Linguistic comprehension is described as "the ability to take lexical information (i.e. semantic information at the word level) and derive sentence and discourse interpretations. Reading comprehension involves the same ability, but one that relies on graphic-based information arriving through the eye" (Hoover & Gough, 1990, p.131). Gough (1996) argued that reading comprehension depends on the same "natural" forces that govern acquisition of spoken language. Decoding alone does not constitute reading and must be explicitly taught. According to the "simple view" of reading, it should be possible to predict reading comprehension ability by measuring both decoding and listening comprehension ability. A problem with skill in either component will effect the outcome in reading. Hence, any deficit in reading comprehension in the presence of unimpaired listening comprehension would be attributable to a decoding problem and vice versa. In the case of students with dyslexia, an inability to decode words is thought to be the core deficit of the condition. Therefore, according to the theory, listening comprehension ability should be comparable to students without dyslexia, and any variation in reading comprehension should be explainable in terms of a single word decoding deficit. Nation and Snowling (1998a, 1998b) argued that the same should be true for the second component. It should be possible to find poor readers who are proficient decoders but poor at linguistic processing, as measured by listening comprehension ability, because of inefficiencies in the semantic pathway.

Other writers have posited the idea that listening and reading share a single, unitary, comprehension process (Aaron, 1989, Daneman, 1993; Gernsbacher & Faust, 1991; Jackson & McClelland, 1979; Sticht & James, 1984; Townsend et al., 1987). However, Palmer, McCleod, Hunt, and Davidson (1985) found that, among university undergraduates, reading comprehension was indistinguishable from listening comprehension (r = .82), but reading speed correlated only
moderately with listening comprehension ($r = .56$). Emphasising that they were measuring not the language of speech, but the ability to comprehend written English with the visual component removed, they concluded that reading speed and reading comprehension depend on somewhat distinct abilities. Speed varies with visual word processing and reading comprehension with listening. Danks (1980) and Horowitz and Samuels (1987) raised the issue of whether all types of listening are the same and use the same process. Is listening to a conversation the same as listening to a university lecture? Is listening to a movie, with added visual clues, a third different process? Does listening to a lecture have more in common with reading an appropriate text than it does with having a conversation? Danks concluded by wondering if a unitary process would ever be proven given the variety of conditions which must be considered.

Comprehending speech and reading do seem to require many of the same basic skills. The speaker and listener must both have comparable vocabularies. The listener must also be proficient enough at language to be able to segment the speech stream into meaningful units, hold them in working memory, recall appropriate mental representations and thereby construct meaning to be stored in long-term memory. It is particularly important to be skilled at segmenting complex sentences into basic syntactic units (Samuels, 1987). Danks and End (1987) described upper elementary skilled readers who were tested in a condition of simultaneous reading and listening to text. Both their memory and comprehension scores increased because they were able to use cognitive resources more efficiently. However, they found a group of younger readers who suffered losses in comprehension and memory when they had to read out-loud. Sinatra (1990), in a study of university students, suggested that words accessed through either listening or reading share the same lexicon. Crain-Thoreson (1996) concluded from her
experiments with young readers that phonemic information is activated in similar ways in both silent reading and listening modalities.

Vocabulary knowledge is a key component of comprehension in both reading and listening (Aaron, 1989, Stanovich, 1986). A substantial pre-reading spoken vocabulary gives the opportunity to learn how to read a greater number of words more quickly, but it also aids in constructing meaning from context. In fact, in many cases, listening comprehension might be more complex than reading in this regard. Many English words have similar sounds but different spellings and are thus easier to distinguish in print (e.g. patients/patience: the doctor has patients/patience; tea/tee: let's go to the tea/tee). Samuels (1987) asserted that many children also do not know the multiple meanings of words that are spelled with only one form; they may only know the most common meaning (e.g. money bank but not river bank; the talk bored the audience/ the drill bored a hole). Only context gives clues as to which form is correct. Listening comprehension measures based solely on measuring vocabulary knowledge may therefore be over-estimating knowledge of appropriate word usage in context.

Reading and listening rate has also been considered in the discussion of the unitary relationship of listening and reading. If reading and listening comprehension use a common process, the rate for auding and reading should have comparable upper limits (Stitch & James, 1984). Jester and Travers (1966) found that, in college students, listening skills were superior at lower rates of presentation (200 words per minute) but reading skills were superior at faster rates (300 words per minute). Carver (1973), and Sticht and James (1984) both found that in terms of receptive skills, college level students could both read and aud optimally at around 300 words per minute. They suggested this was proof that, in terms of comprehension and rate of presentation, a relationship between listening and reading existed. Speakers usually present
material at between 100 and 150 words per minute (Carver, 1973; Sticht, 1968), a speed which presumably is related to how quickly mental representations can be formed and produced as speech. Danks (1980), in his consideration of methods with which to measure reading and listening skills, pointed out that this difference of processing time between reading and speaking skills gives the readers time to read and re-read the written material if both tasks are assigned the same quantity of time for completion.

Given the amount of research in the area of using listening and reading comprehension differences as a diagnostic tool, it is surprising that a survey of reading disability diagnosticians found few used listening comprehension assessment in the testing process. They concentrated, instead, on reading and decoding skills (German, Johnson, & Schneider, 1985). However, the issue of finding a comparable way of measuring reading and listening processes is a real one (Carlisle, 1990, 1991; Durrell, 1969; Neville & Pugh, 1976). Dependable comparisons between listening and reading skills demand that measures used in testing parallel each other. A number of researchers have adapted standardized tests or devised their own materials to investigate listening and reading comprehension with younger age groups (Aaron, 1989; Carlisle, 1989, 1990, 1991; Curtis, 1980; Royer, Greene, & Sinatra, 1987; Royer, Hastings, & Hook, 1979; Royer, Sinatra, & Schumer, 1990). Nation and Snowling (1997) found that tests of reading comprehension consisting of sentence completion exercises measured word recognition, but tests consisting of longer text passages could be related to listening comprehension skills. Few standardized test batteries normed on college students contain measures to compare listening and reading skills.

There remains, therefore, room to investigate whether university students who have a reading disability do, in fact, exhibit depressed phonological coding skills but have listening
skills equivalent to their peers, or whether they show evidence of the reverse implication of the "simple view" and have good decoding skills but poor linguistic comprehension. An investigation into whether comprehension skill differs under differential conditions of presentation could help in the identification of underlying processes. In a university population, the most useful aspect of such an investigation field would seem to be the possibility of harnessing the framework proposed by the concept of the "simple view" of reading to distinguish deficit processes in readers with a disability from their peers.

2.3 Component Parts of Reading: Word Recognition

It is clear from the previous sections on reading and listening comprehension that reaching the point of understanding the meaning of the words of the speaker or the writer depends on the initial stage of that process, accurate input of the smallest units, phonemes. To give a somewhat simplistic analogy, pressing the wrong command key on a computer will result in the wrong input, and of course, the wrong output. Study of how knowledge of phonemes are combined into meaningful spoken or read words has been a focus for many researchers in psycholinguistics, cognitive psychology and the neurosciences. This work is increasingly coalescing into a picture of the neurological base for this skill, and consequently an understanding of how deficiencies in the process can manifest themselves.

Reading is essentially the subservient aspect of language, something that must be learned, rather than a natural skill. Many of the world's languages do not, of course, have a written form, and others, such as Inuktitut, have only recently developed a written code. Reading has been described as an example of opportunistic processing, a relatively recent invention for which the
brain did not initially evolve (Kosslyn & Koenig, 1995; Seidenberg, 1993). Thus sub-systems of the brain designed for more general functions, such as object identification, may have been co-opted into the reading process.

The initial visual encoding process of word recognition consists of complex eye movements which involve at least four parts of the visual areas of the brain (Breitmeyer, 1984). Rayner and Bertera (1979) found that readers do not skim text but fixate on the detail of each word. In fact, removing one letter from the foveal range reduces reading speed by fifty percent. Skilled readers can encode short words with one fixation, with time increasing for each additional letter (Kosslyn & Koenig, 1995). Rayner and Pollatsek (1989) found that information processed on the periphery of the foveal range, within the parafoveal area seems to assist in the processing of connected text. Willows (1991) defined six separate visual operations as necessary for the reading process. The visual system itself utilises more than thirty different brain regions, each one apparently specialising in a particular task (Pinker, 1997). Learning to read, which involves associating spoken words with the appropriate visual code, the grapheme-phoneme transfer, is considerably more complex than theories which describe reading as simply mapping visual codes onto spoken codes would imply. Much work in cognitive psychology has centred on how this transfer occurs in beginning readers (Ehri, 1997; Rack et al., 1992; Torgesen, Wagner, & Rashotte, 1997). Other work has concentrated on models related to the word access of older readers, and still further work has looked at how the processes seem to differ in less skilled readers.

However, the bulk of studies have centred on the mechanism used by beginning readers to crack the grapheme-phoneme code. Phonological awareness now seems to have been defined as the primary indicator of later reading ability (Goswami, 1993; McBride-Chang, 1995a;
McDougall, Hulme, Ellis, & Monk, 1994; Stanovich, 1986; Wagner, Torgesen, & Rashotte, 1994), though controversy remains about which part of the reading process is indicative of the first step. Goswami (1993) has promoted the idea that a pre-phoneme-grapheme stage, at the onset-rime level, should be considered the initial stage of reading in English. In contrast, Seymour and Evans (1994) found that segmentation ability progressed from phonemes to initial consonants to onset-rime, the opposite of usual hierarchical models. Shankweiler and Crain (1986) reported that weakness in phonemic segmentation ability was characteristic of poor readers, while later studies have confirmed that despite weaknesses in phonemic skill, syntactic skill seems to remain intact (Shankweiler et al., 1995).

The causal relationship between phonological awareness and the development of reading appears to be well accepted (Share & Stanovich, 1995; Olson, Wise, Johnson, & Ring, 1997). A widely held view posits that the relationship is bi-directional and/or reciprocal (Perfetti & McCutchen, 1987; Stanovich, 1986; Wagner, 1988; Wagner, Torgesen et al., 1994). Neurological studies would seem to support the reciprocal nature of the process (Shaywitz et al., 1998).

Stanovich (1986) argued that two elements, phonological sensitivity, the rudimentary recognition of the phonology of spoken language contained in such structures as rhyme and alliteration, and phonological awareness, a more complete awareness of individual phonemes, were both essential to beginning reading. In addition, so was the act of reading itself, since this augments phonemic and word knowledge. Biemiller (1977-8) documented this growth in first grade readers. The gains made by good readers put them well ahead of their peers.

Reading experience clearly improves word recognition in a reciprocal manner in the same way that a reciprocal relationship functions between vocabulary and reading, the so called
"Matthew Effects" (Stanovich, 1986). McBride-Chang, Manis, and Wagner (1996) found that young children identified as gifted had superior phonological awareness skills as measured by assessment of speech perception, short-term verbal memory, and cognitive ability. They suggested this might be reflective of a connection between cognitive ability and precocious reading ability.

In a further investigation of this potential reciprocal relationship, Wagner, Torgesen, et al., (1994) defined and tested five abilities which they believed constituted phonological processing in beginning readers; phonological analysis (phoneme segmentation), phonological synthesis (phoneme blending), phonological coding in working memory, isolated naming and serial naming (retrieval of phonological codes from long-term memory). The results of their longitudinal study seemed to show that, not only do the five abilities exist and are stable over time (kindergarten to grade two), they are also related causally to the development of word decoding ability. In a later study Wagner et al. (1997) reported that individual differences in early phonological awareness significantly influenced subsequent development of word recognition skills. This effect remained through the fourth grade, indicating that some children might continue to benefit from explicit code instruction beyond the primary years. Phonological awareness ability would seem to be related to general cognitive ability (in order to comprehend the task), short-term memory, and accurate speech perception (McBride-Chang, 1995a, 1995b; Shankweiler & Crain 1986; Watson & Miller, 1993).

Word recognition involves the ability to decode a word into its component parts with sufficient efficiency that it can be found in the mental lexicon and its semantic information can be bought into use (Stanovich, 1982). Stanovich (1991b) detailed a number of studies that appeared to show that word decoding automatically leads to semantic activation. Word
recognition speed and accuracy have consistently proved to be correlated with later reading skill (Biemiller, 1977-8; Curtis, 1980). Stanovich (1991b) asserted that average word recognition skills can accompany poor comprehension, but seldom the reverse. Recently this notion has, to some extent, been challenged (Nation and Snowling, 1998a, 1998b).

Even in adults, a significant proportion of the variance in reading comprehension ability appears to be accounted for by word recognition. Cunningham, Stanovich, and Wilson (1990) found this remains true even in university students. In adults, word recognition, or lexicalization, must involve more than a store of whole word mental representations, because a more discriminating process, probably also involving resort to phonemic codes, is required to distinguish words which resemble many others (Forster & Taft, 1994; Share & Stanovich, 1995).

The importance of automaticity in decoding ability, and the consequences if it is lacking, have also been the subject of study. Lack of this skill has been linked to poor comprehension ability, caused by a bottleneck at the working memory level (Perfetti & Hogaboam, 1975; Shankweiler & Crain, 1986). Automaticity is important because it reduces demands on working memory. According to Stanovich (1991b), even adults who read fluently utilize some attentional capacity. Lexical access, the process of accessing the orthographic mental representation of the word (which includes both the meaning of the word and its phonological pattern), is activated by word recognition. If this process does not happen quickly enough to keep the word in working memory, nothing is available to construct comprehension. Thus, word recognition must be the central process in reading (Stanovich, 1991b), though it undoubtedly is a considerably more complex process than would be indicated by simplistic views often applied to descriptions of beginning readers (Share & Stanovich, 1995).
Use of context in the construction of meaning, as discussed in the previous section on reading, has not been found to be an efficient method of word recognition (Schatz & Baldwin, 1986). "Studies employing a wide variety of paradigms have failed to find that good readers rely more on context for word recognition than poor readers." (Stanovich, 1991b, p. 431). After the first grade, children gradually move from dependence on context to using phonemic codes, to a process which co-ordinates both (Biemiller, 1970). Newer models of reading based on the concept of modularity, which posit that processes are not hierarchically arranged, but act as independent modules (Foder, 1983), support this finding (Perfetti & McCutchen, 1987; Stanovich, 1994a). "To use more contemporary terminology, word recognition becomes increasingly encapsulated with skill development" (Stanovich, 1991b, p. 443). Use of encapsulated orthographic skill would seem to be of primary importance when reading connected text. In fact words appear to be read more rapidly in text than they are in isolation (Barker, Torgesen, & Wagner, 1992; Biemiller, 1970, 1977, 1979). Other than the physiological evidence for visual field processing presented earlier, this may be because words in isolation rely more on phonological processes than orthographic ones. Nation and Snowling (1998a) have proposed that use of context can enhance reduced decoding skills, making it a key process in reading comprehension for dyslexic readers. They concluded that individual differences in both phonological coding and general linguistic ability should be considered in discussions of factors that influence reading comprehension.

The role of speech perception may well be a critical element in the development of reading skill. While it has been proposed that differential ability in understanding spoken and written sentences is a defining feature of reading disability, some poor readers appear to have difficulty understanding both written and spoken forms (Shankweiler & Crain, 1986). McBride-
Chang (1995a, 1995b) investigated the interaction of the proposed elements of phonological awareness in third and fourth grade children, and showed that a large part of the variance in phonological awareness is simple speech perception. However, Shankweiler and Crain (1986) suggested that spoken sentence comprehension problems occur only on complex tasks which tax working memory.

A research issue which has received considerable attention is the classification of words used in experimental designs, and whether, in terms of spelling pattern and pronunciation, they can be classified as regular or irregular (Berndt, D'Autrechy, & Reggia, 1994). This is important to establish if research findings are to retain meaning, because the characteristics of the word can affect the time taken to pronounce it. Word naming latency has been shown to be influenced, in particular, by the use of low frequency irregular words (Seidenberg, Waters, Barnes, & Tannenhaus, 1984), while even regular words which have irregular neighbours tend to take longer to pronounce (Brown & Watson, 1994; Stanovich, 1991b). The most frequent grapheme-phoneme correspondences in English permit 80-95% of words to be read (Coltheart & Leahy, 1992). The remainder, with irregular grapheme-phoneme correspondences, are termed "exception" words. Not all words are read by segmentation into phonemes. Some are segmented into onset and rime. Treiman, Mullennix, Bijeljac-Babic, and Richmond-Welty, (1995) found that the relationship between spelling and sound is more predictable when the level of onset and rime is taken into consideration.

Nonwords can be fraught with similar problems. Not all nonwords are equivalent. Treiman, Goswami and Bruck (1990) found that both adults and children performed better on nonwords which shared more common vowel-consonant units. Coltheart and Leahy, (1992) pointed out that adult readers normally apply grapheme-phoneme correspondences when reading...
nonwords that contain rimes which occur as irregular pronunciations in real words. Occasionally they may apply rimes found in exception words. Laxon and Smith (1995) found that, for children, correct responses on nonwords were more likely if they sounded like a real word and if they had a large number of orthographic neighbours. In an attempt to control for experimental design errors in studies demanding the recognition and pronunciation of words, Berndt et al. (1994) produced an extensive list of English words segmented into phoneme-grapheme units.

Views of how processing takes place within the word recognition module have mainly taken two forms, the dual-route model, and the connectionist model. The dual route model of lexical and sub-lexical access in reading aloud suggests that access takes place by two separate routes, the first orthographic, and the second phonologic (Castles & Coltheart, 1993; Coltheart, 1978). The direct lexical route has been described as the route used to read aloud familiar and irregularly spelled words through searching for the phonological pattern appropriate to the already learned orthographic form in the mental lexicon. The indirect sub-lexical, grapheme-phoneme rule governed route is seen as the pathway used to read unfamiliar words, including nonwords. Castles, Holmes and Wong (1997) believed that individual differences in normally developing readers can be accounted for by the speed with which they master the two processes. Different children will be reliant on one or other of the routes at the early stages of reading. Treiman (1984) and Castles et al. (1997) both found that the type of errors in the spelling of early readers supports the hypothesis that both routes are used.

Connectionist theories are based on the idea that the reading aloud process can be conceived of as using a single route, parallel distributed, neural network. McClelland and Rumelhart (1981) designed such a network to simulate the reading process through stages of pattern recognition, letter recognition and finally word recognition. The processes act
simultaneously, with no one process acting in a specific set order (Seidenberg, 1993; Seidenberg & McClelland, 1989). Thus, if one part of the encoded information is missing (e.g. one letter of a word), another part of the system can compensate (Kosslyn & Koenig, 1995). The connectionist model does not contain whole word orthographic representations, nor does it have a rule based sub-lexical conversion system. All words are seen to be read using the common process.

However, the developers showed that after training with over 3000 words, the model did develop regularity as most common pronunciations became encoded. Recent advances in the model address initial criticisms since it is now able to recognise exception words and nonwords (Plaut et al., 1996). As the connectionist model has gained favour, the dual-route model has been much criticized. In fact, Van Orden, Pennington and Stone (1990) declared its demise. However it is clear from subsequent literature that many recent studies in the area of word recognition interpret results within the framework of one or both models, or simply point to the ambiguities in both.

On a tangential note, it is interesting that, recently, researchers have indicated that their results, both in terms of the length of time phonological processes remain in use (Wagner et al., 1997), and the strategies used in spelling (Castles et al., 1997), may be somewhat reflective of teaching styles rather than systems of processing. Whole language teaching with its de-emphasis of explicit phonological training may result in some children favouring the orthographic route.

It seems clear that word recognition is such an important part, probably the most central part, of the reading process, that it will continue to attract ongoing multidisciplinary research. Because of its centrality in the reading process, it is the obvious place to look for deficiencies in readers who have dyslexia.
Preceding sections have illustrated how complicated the process of reading is for normal readers, and how much controversy has been generated by issues related to the acquisition and improvement of reading skills, and the processes that underlie its development. Much of the literature refers, at least tangentially, to less skilled readers, poor readers, disabled readers and readers with dyslexia. However, somewhat paralleling the controversy surrounding the term learning disability, there seems to be a concerted movement among researchers not to use the term dyslexia because it has been used so frequently without specificity. For example, it has been used without discrimination in terms of cause, to describe poor reading skills in adults and children and also to describe a measured discrepancy between presumed aptitude and reading achievement (Crowder & Wagner, 1992; Stanovich, 1994b). Seymour (1986) argued in favour of using the term to refer to all poor readers, while ten years later Shaywitz (1996, 1998) and Snowling (1996) could assert from both sides of the Atlantic that dyslexia can be defined as reduced ability in phonological coding, the initial process in learning to read. While this view, which now seems to be receiving support from brain imaging and genetic evidence, is widely accepted, it does not mean that investigations into dyslexia have ceased. The possibility for the existence of subtypes of dyslexia, perhaps related to more than one defective process or core deficit continues to engage researchers.

There are both children and adults who exhibit poor or non-existent reading skills. The magnitude of studies related to poor school readers and the widespread development of adult literacy programmes attests to the problem. A debate in the field has centred on whether dyslexia should be seen as a separate syndrome, the target of specific interventions, or as part of a continuum of reading ability, the so called dwarfism versus obesity debate (Crowder & Wagner, 1992).
Ellis (1985), in a cogent criticism of the trend to classify syndromes of dyslexia, envisaged a dimensional model where dyslexia exists not as a separate pathological entity, or sub-set of entities, but as part of a continuum of the total population of readers, with little in the way of subtypes distinguishable by homogeneity. Other writers have supported this view of a continuum (Spear-Swerling & Sternberg, 1994; Stanovich, 1988, 1991a, 1994b; Stanovich & Siegel, 1994; Tal & Siegel, 1996).

For many years dyslexia was considered to be a problem of children, a condition of delay or developmental lag. Presumably this is why it became known as developmental dyslexia, to distinguish it from acquired dyslexia (acquired as the result of neurological damage after learning to read). It is only in the last ten years that substantial evidence has been produced to show that dyslexia continues into adulthood (Bruck, 1990, 1992). Bruck pointed out that, despite evidence of word recognition skills that are not age appropriate, dyslexic adults use processes that are the same as all readers. She argued that terminology such as delay or deviance gives an incorrect impression of deficient word recognition skills in adults, and suggested that the term arrest better characterizes the situation. Other writers concur with this view (Ben-Dror et al., 1991; Francis, Shaywitz, Steubing, Shaywitz, & Fletcher, 1996).

Dyslexia has, since it was first described, been seen as unexpectedly poor skill in reading, existing concomitantly with unimpaired function in other areas, particularly intellectual capacity. As Stanovich (1988) pointed out, one of the problems with definitions of reading disability, as with definitions of learning disability in general, has been that they have tended to encompass general (horizontal) processes such as linguistic awareness, comprehension and metacognitive functioning; in other words processes which relate in many ways to overall intellectual functioning. In his view, if characteristics of intellectual ability are controlled for, reduced skill in these areas highlights the
consequences of lack of reading experience, the so called "Matthew Effects". They are the result of reading disability, not its cause. The results are cumulative. Good readers read more, thereby gaining more reading skill, more word recognition skill, more vocabulary and more general knowledge, leaving poor readers in their wake (Stanovich, 1986). In his view, from the perspective of the theory of modularity (Fodor, 1983), the real answer lies at the level of vertical processing, especially in deficient, encapsulated, phonological processes (Stanovich, 1988). Definition of reading disability has, in the clinical field, become intimately tied to the notion of unexplained discrepancy between aptitude and achievement.

Including an IQ test to assess ability is standard practice in assessment even though the practice has been the focus of strong debate (Wong, 1989). Siegel (1989a, 1989b, 1992) argued persuasively that children with reading disabilities score lower on IQ tests because such tests are biased against them, relying, as they do, on exposure to vocabulary, facts, and memory. She emphasised that they measure specific factual knowledge. She stated in her rebuttal to criticism of her position (Siegel, 1989b): "I believe we should abandon the IQ test...The IQ test is a sacred cow that the L.D. field is not willing to abandon." (p.518).

She suggested that the assumption underlying the discrepancy definition, namely that intelligence can be measured separately from achievement, is false. She explained this by reducing the factors to a simple formula:

"I.Q. (X) - Reading Level (Y) = Discrepancy (Z)" (p.518)

X and Y must be independent; otherwise Y could be expressed in terms of X. Thus, it is clear that X and Y are assumed to be independent of each other. She provided considerable support for the view that this was not the case. Stanovich (1989) stated that he found the "decision to base the definition of a reading disability on a discrepancy with measured IQ is...nothing short of astounding." (p.487).
He pointed out that, despite repeated admonitions that the diagnosis of reading disability should be multi-dimensional, the key feature in actual educational practice remained a measured discrepancy (Stanovich, 1991a). The use of IQ discrepant measures has resulted in a belief that those with dyslexia are always of average or above average intelligence, often very bright (Stanovich, 1994b).

Several studies have failed to substantiate the validity of aptitude-achievement discrepancies in identifying reading disability (Fletcher et al., 1994; Francis et al., 1996; Lyon, 1995; Pennington et al., 1992; Stanovich & Siegel, 1994). Other writers have linked the difficulty in accurate assessment of learning disability in general to the definitions in current use, which do not appear to be open to empirical investigation (Kavale & Mundschenk, 1991; Swanson, 1991). Tal and Siegel (1996) argued that reading disability should be defined on the basis of reading skills alone. Despite this barrage of criticism, discrepancy methodologies have been institutionalized legally in many jurisdictions in the United States, and continue to be used at the postsecondary level (Shaw, Cullen, McGuire, & Brinckerhoff, 1995).

Stanovich (1989, 1991a) suggested that an alternative assessment measure for dyslexia might be to measure the difference between reading comprehension and listening comprehension. Assuming that the core deficit of dyslexia lies in deficient phonological processing, the listening comprehension of readers with dyslexia should be superior to their reading comprehension, since linguistic skills should show little, if any, impairment. In the "simple view" of reading, Gough and Tunmer (1986) and Hoover and Gough (1990) supported this notion and pointed out that if listening comprehension levels differ from reading comprehension levels, then decoding skills must be deficient. Mosberg and Johns (1994) found that there was no significant difference in the untimed reading and listening comprehension skills of undergraduates with dyslexia in comparison to their
peers without dyslexia. The only significant difference between the two groups was in timed reading.

In the last twenty years a considerable body of research has focused on the role of phonological coding in deficient reading skill. This primary process in the acquisition of reading is now considered the likely core deficit in dyslexia (Bruck, 1990; Gough & Tunmer, 1986; Rack et al., 1992; Share & Stanovich, 1995; Shaywit, 1996, 1998; Shaywit, Fletcher, & Shatwit, 1996; 1998; Siegel, 1988; Snowling, 1996; Stanovich, 1990; Vellutino, 1977). This skill has primarily been measured by assessment of decoding skills through the use of orthographically correct nonwords (Bruck, 1990; Rack et al., 1992; Shaywit, 1996, 1998; Siegel, 1992; Snowling, 1980, 1996; Stanovich, 1988; Stanovich & Siegel, 1994). Spelling ability has also been seen as indicative of phonological ability (Bruck, 1993; Bruck & Waters, 1990; Lennox & Siegel, 1993). A number of writers have linked spelling ability to exposure to print (Bruck, 1993; Holmes & Ng, 1993; Stanovich & West, 1989). It has been found that decoding skill tends not to improve with reading age (Aaron, 1987; Bruck, 1990, 1992; Pennington et al. 1990; Snowling, 1980; Snowling, Goulandis, & Defty, 1996).

Increase in reading age has therefore been attributed to growth in the use of orthographic skills and semantic processing (Rack, 1985; Siegel et al., 1995; Snowling, 1980). A number of writers have suggested that some degree of independence is likely to exist between phonological and orthographic skills (Barker et al., 1992; Castles & Coltheart, 1993; McBride-Chang, Manis, Seidenberg, Custodio, & Doi, 1993; Rack et al., 1992; Stanovich & Siegel, 1994). While phonological processes are important, they are not necessarily exclusive. Dyslexic readers seem to acquire better word recognition skills than would be expected from their phonological ability. Siegel et al. (1995) found that, compared to their peers, elementary school children
with dyslexia were significantly better at using the orthographic route to read words. They suggested these children may be using more of a visual rather than a phonetic strategy to read words.

Nevertheless, Bruck (1990) proposed that adults with dyslexia had not developed accurate orthographic images of multi-syllabic words and therefore, despite a deficit in phonological coding skill, they continued to rely on phonological segmentation ability and context clues to read unfamiliar words. This is reminiscent of the patterns seen in beginning readers. Despite their difficulties, many of Bruck's college students achieved high scores on reading comprehension tests, something she attributed to high I.Q. levels.

Proponents of the "phonological representations hypothesis" (McDougall et al., 1994; Swan & Goswani, 1997) have suggested that readers with dyslexia have, not deficient phonological processes per se, but inaccurate underlying mental representations of phonological codes. This would seem to be consistent with work which has identified difficulty processing speech at the phoneme level among dyslexic children (McBride-Chang, 1995a; Manis et al., 1997; Tallal, Miller, & Bedi, 1996). Inaccurate speech perception is likely to result in inaccurate phonological code storage.

The dual-route model has provided a framework for discussion of word recognition processes (Coltheart, 1978). Two parallel routes for reading single words out loud, the direct (lexical/orthographic) and indirect (sub-lexical/phonologic) routes, are seen to act simultaneously but independently, with the direct route providing faster access. In assessment situations, Rack et al. (1992) suggested that the most sensitive test for measuring whether readers use orthographic or phonologic processes in reading is one which compares irregular word reading with nonwords, especially when regular word reading differences between groups are insignificant. Efficiency of the
sub-lexical route can be measured by the accuracy of reading nonwords, and the lexical route by reading real, but irregular, words. Real words that conform to regular spelling-sound correspondence rules are seen to be accessible by either route. If subjects are more successful at reading regular words and nonwords than they are at reading irregular words, which they try to pronounce (incorrectly) using regular grapheme-phoneme rules, they could be said to favour the indirect route. For example they may pronounce "glove" to rhyme with "cove" or "flood" to rhyme with "mood" (Coltheart, Curtis, Atkins, & Haller, 1993, p. 591). The attempt to pronounce irregular words using standard grapheme phoneme rules has been termed the "regularity effect". Equal ability on both types of words would be seen as indicative of almost exclusive use of the direct route. Normal beginning readers use both routes, with reliance on the sub-lexical route being superseded by use of the lexical route as word knowledge increases.

Based on comparisons with children and adults who have "acquired dyslexia", and using the dual-route model, two subtypes of dyslexia have been proposed, surface dyslexia and phonological dyslexia (Castles & Coltheart, 1993). In terms of dual-route theory, phonological dyslexics should not show preferred use of the sub-lexical route because of its impairment, preferring the orthographic route, evidenced by superior ability reading irregular words and reduced ability to read nonwords. In contrast, because of deficits in the lexical route and the resultant dependence on phonetic patterns, surface dyslexics tend to try to read irregular words using grapheme-phoneme correspondence rules rather than stored orthographic patterns. They should illustrate this by an ability to read nonwords more accurately than irregular words (Bryant & Impey, 1986).

Castles and Coltheart (1993) conducted a study with elementary school children and were able to isolate children who could be classified as either surface or phonological types. They asserted that close to 30% of dyslexic children can be expected to have difficulty with using one
process in the absence of any difficulty using the other. A third group, the largest group, showed impairment of both routes, but with differential levels of difficulty. Readers without a disability showed no difficulty reading any category of words presented.

Manis, Seidenberg, Doi, McBride-Chang, and Petersen (1996) carried out a similar study and also isolated the two sub-types but accounted for the differences within the framework of the single route, connectionist model of reading. They emphasised that deficits in both areas of processing (76.5%) are most characteristic of children with dyslexia, with only 19.6% showing a distinct deficit in one skill or the other. Their group of surface dyslexics did not seem to differ significantly from younger, word recognition level matched controls, indicating, perhaps, that surface dyslexia is a developmental lag phenomenon rather than an "arrest". They suggested that surface dyslexia is perhaps, indicative of either a visual-perceptual deficit or a computational resource issue. They cautioned that few studies have been able to relate visual deficits to reading skill. They also argued that single word reading performance is insufficient evidence with which to identify two distinct groups. Inclusion of a broader range of tasks could clearly provide more supportable evidence of distinct sub-types.

Stanovich, Gottardo, and Siegel (1997), in a similar study which included a re-conceptualization of the Castles and Coltheart (1993) data, found that, over a number of tasks, surface dyslexics did not appear as a distinctive group when matched with reading age controls, but phonological dyslexics did. They hypothesised that surface dyslexia may therefore simply be a symptom of developmental lag, but phonological dyslexia persists. They suggested that the group of early readers who showed deficits on both skills may eventually emerge as phonological dyslexics. Since they also posited that there may be a relationship between poor use of the orthographic route
and low levels of exposure to print, presumably the likelihood that surface dyslexics would be found in the university population is slight.

Hanley and Gard (1995), in a case study of two undergraduates, reported evidence of distinct dual route patterns, one phonological, and one surface. Ben-Dror et al. (1991) found some of the subjects in their sample of university students showed characteristics of surface dyslexia, while others resembled phonological dyslexics. Goulandris and Snowling (1991) described a case study of surface dyslexia that they linked to a visual memory deficit. However, Bryant and Impey (1986) found that both surface and phonological patterns were present in normal readers and were therefore not characteristic of dyslexia. Rack et al. (1992) asserted that a sample of poor readers could contain both types, thereby averaging out the results of the mean data when comparisons were made with normal readers. Both they and Murphy and Pollatsek (1994) felt there was little evidence for discrete subtypes, and suggested that a continuum model was more appropriate.

Rack et al. (1992) cautioned that preference for use of the phonological route does not imply efficiency of the process. Both Ben-Dror et al. (1991) and Bruck (1992) concluded that college level dyslexic readers have impaired ability in using both routes and continue to use the sub-lexical route despite its inefficiency, because they have not developed accurate mental representations of whole words. Landerl, Frith, and Wimmer (1996) found the same pattern in children with dyslexia. They proposed this as evidence that there is less automatic coactivation between the orthographic and phonemic mental representations in readers with dyslexia, and that this might be a problem central to this group.

Rack et al. (1992) emphasised the necessity of looking at groups of poor readers on an individual basis to see if distinct types occur, keeping in mind that explanations for such occurrences should not violate the assumption of specificity. Ben-Dror et al. (1991) and Castles and
Coltheart (1993) also suggested perusal of data at the individual rather than the group level since both processes will, to some degree, be operating. Castles and Coltheart suggested differences should not be seen in the light of certain dyslexics using or not using a particular process, but from the perspective of level of skill; and not from the position of determining the use of one or other discrete routes, but from judging the differing contributions of both.

The use of context to discern meaning has not been found to be efficacious in the recognition of words by good readers, but it has been shown to be used by poor readers (Nation & Snowling, 1998a; Stanovich, 1980; Stanovich, 1986). Bruck found that dyslexic children (1988) and college age dyslexic subjects (1990) relied on context clues, and Ben-Dror et al. (1991) also found that college level students with dyslexia were able to use context efficiently, especially when reading difficult words. However, Rack et al. (1992) pointed out that use of context to augment poor phonological skills, does not necessarily indicate superior skill in the method.

Speed of naming has also been identified as a key component of efficient, automatized, word recognition. Poor word recognition skills prevent automatization, an essential part of an efficient comprehension process. Inefficiency produces a potential overload in working memory capacity. Denckla and Rudel (1976) devised a measure to assess the speed with which a familiar name is retrieved from permanent memory. The RAN (Rapid Automatized Naming) requires timed and accurate reading out-loud of familiar digits, letters, colours or objects.

As with all reading processes, if a construct is to be used as an indicator of reading disability, it is important to know whether it can be measured independently. In the case of a timing deficit, a number of writers have proposed this to be the case (Bowers, 1988, 1991, 1995; Bowers, Steffy, & Tate, 1988; Bowers & Swanson, 1991; Korhonen, 1995; Nicolson & Fawcett, 1994; Wolf, 1991, 1997; Wolf & Obregon, 1992; Wolf & Segal, 1992; Wolff, Michel, & Ovrut, 1990). Bowers
(1991) suggested that naming speed, auditory analysis and vocabulary ability are measures of,
respectively, orthographic, phonological and semantic processes.

Biemiller (1977-8) related letter naming speed to reading simple text, and found that
children who read letters slowly, read words proportionately more slowly, while good readers could
identify words and letters equally quickly. He attributed the ability to read words as fast as letters to
skill in the extraction of orthographic structure. He also found that words out of context were read
more slowly than the same words in context, presumably a reflection of the efficacy of semantic
ability.

Bowers and Wolf (1993a, 1993b) and Wolf (1997) identified readers who had single
deficits, either in nonword reading or naming speed, and children with both deficits. All groups
were poor readers, but the double deficit group exhibited the poorest skills. They hypothesised that
subtle visual processing deficits, or deficits at the junction of integration of visual and phonological
processes may be deficient. They have proposed that a second core deficit in the form of a timing
deficit should be considered in the etiology of dyslexia.

While naming speed ability is likely to change with increases of memory span related to age
(McDougall et al., 1994), adults with dyslexia have also been found to retain slow rates of digit and
letter naming speed, and are less accurate in their recall (Wolff et al., 1990; Korhonen, 1995). In
contrast, Chiappe et al. (1997), using a number of timing measures, found only a continuous digit
naming task was predictive of reading ability. They suggested that this is indicative, not of a
separate impaired timing process, but specifically of an impaired word-retrieval system. Bruck
(1990) found dyslexic adults had slower reaction times in nonword and irregular word naming.
Other writers have confirmed this (Ben-Dror et al., 1991; Lovrich et al., 1997; Watson & Brown,
1992). Naming speed therefore remains a fruitful area for investigation especially with adult dyslexics.

A further issue that has been addressed by a number of writers is the relationship of exposure to print to various components of the reading process. The concept of the "Matthew Effects" (Stanovich, 1986), the theory that the more people read the better readers they become, has been used to suggest explanations for a number of differences apparent in dyslexic readers. Stanovich and West (1989) found that degree of print exposure was linked to orthographic processing skills, which in turn, were a factor in the level of individual spelling and reading ability. West and Stanovich (1991) and Stanovich and Cunningham (1992), in studies of undergraduates, found that differences in vocabulary knowledge and cultural literacy could also be linked to print exposure. In addition they were able to show that such exposure was related to the amount of informational knowledge exhibited by an individual, challenging the widely held view that knowledge acquisition is only a function of cognitive ability. Therefore children and adults, in situations where print is accessible, are likely to develop a greater knowledge base than those in more deprived situations (Stanovich, 1993; Stanovich & West, 1993; Stanovich, West, & Harrison, 1995; Wagner & Stanovich, 1996; West, Stanovich, & Mitchell 1993).

The latter groups of authors have detailed a number of mechanisms by which print exposure could result in cognitive development, namely experience with novel written language structures unavailable in speech, exposure to low-frequency vocabulary and more complex syntactical structures, and augmentation of world knowledge. Stanovich (1993) asserted, "If 'smarter' means having a larger vocabulary, and more world knowledge in addition to the abstract reasoning skills encompassed within the concept of intelligence...then reading may well make people smarter." (p. 170). A poor knowledge store and a poor vocabulary store limit cognitive activity. Rack et al.
(1992) hypothesised that deficient phonological processing does not, in and of itself, determine that the person will remain a poor reader, and suggested that sufficient exposure to print might be one of the factors which would assist dyslexic readers to develop compensatory abilities to overcome their difficulties. Murphy and Pollatsek (1994) attributed differential lexical and sub-lexical reading of children on the extreme of their sample to differences in exposure to print.

There is considerable support, therefore, for the idea that environmental factors such as exposure to print can have a significant influence on the development of orthographic skill, vocabulary, world knowledge and ultimately cognitive development. University students with dyslexia must, generally, have developed adequate cognitive skills, and have certainly been exposed to more than average quantities of at least a particular type of print. It would be interesting to discover whether this is reflected in their reading skills.

Recently, a number of writers have discussed the evidence for two groups of poor readers, those who are poor decoders and those who are adequate decoders but poor comprehenders (Nation & Snowling, 1997, 1998a, 1998b; Stothard & Hulme, 1992, 1995). Poor comprehenders seem to exhibit a generalized linguistic processing deficit since they have both poor reading and listening comprehension skills. This would be consistent with the "simple view" of reading (Gough & Tunmer 1986; Hoover & Gough, 1990). Presumably if reading comprehension is the product of listening comprehension and decoding ability, a deficit in either ability would reduce reading skill (Nation & Snowling 1998a, 1998b). Poor comprehenders have also been found to have difficulty reading exception words and, in general, to have weaker word recognition skills than would be predicted from their average decoding skill. They seem less able than readers with decoding deficits to take advantage of context clues because of diminished semantic processing ability (Nation & Snowling, 1998a).
The work of cognitive psychologists is, essentially, observational and deductive. Studies in physiological fields, such as neurology and genetics, have begun to focus on the search for a potential physical basis for the deficits defined by this careful empirical observation. Autopsy work, studies with event rated potential techniques, and brain scanning methods using Positron Emission Tomography and Functional Magnetic Resonance Imaging, all appear to have begun to confirm that the people with dyslexia exhibit evidence of some differences in both brain structure (Bigler, 1992; Filipek, 1995; Galaburda, 1993, 1997; Hynd, Marshall, Hull, & Edmonds, 1995; Kershner & Micallef, 1991; Lampl, Barak, Gilad, Eshel, & Sarova-Pinhas, 1997; Naylor, Wood, & Harter, 1995; Riccio & Hynd, 1995, 1996; Rumsey et al., 1997) and in brain activation rates when performing phonologically based reading tasks (Lovrich et al., 1997; Njioiktjien, 1994; Petersen, Fox, Posner, Mintun, & Raichle, 1988; Petersen, Fox, Snyder, & Raichle, 1990; Salmelin, Service, Kiesila, Uutela, & Salonen, 1996; Shaywitz et al., 1998). Use of fMRI scanning technique is especially useful because it is non-invasive. No other current process is able to give equivalent functional information (Peoppel & Rowley, 1996).

Studies in genetics and familial transmission have begun to describe possible patterns of hereditability in dyslexia (Casto, Pennington, Light, & DeFries, 1996; Gilger, Hanebuth, Smith, & Pennington 1996; Knopik, Alarcon, & DeFries, 1997; Olson, Fosberg, & Wise, 1994; Olson, Wise, Conners, & Rack, 1990; Olson, Wise, Conners, Rack, & Fulker, 1989; Pennington, 1995, 1997; Pennington et al., 1992; Pennington & Smith, 1988, 1997; Plomin & DeFries, 1998; Reynolds et al., 1996; Smith, Kelley, & Brower, 1998). Genetic susceptibility to dyslexia has been linked to chromosomes 6 and 15 (Grigorenko et al., 1997). This study also confirmed that phonemic awareness (linked to chromosome 6), is a central mechanism in dyslexia, as is single word reading (linked to chromosome 15), though not that these are the only factors. Pennington (1997)
commented that this does not mean that the identified chromosomes can be termed "the dyslexia genes" since they simply show susceptibility for cognitive disruption.

Even though the main consensus in the field continues to be that deficient phonological coding processes are the proximal cause of dyslexia, groups of researchers persevere in the search for further deficits. While recent work in genetics and neurology seems to support the consensus in the field, this may be because neurologists and geneticists are utilizing in their search, phonological coding stimuli developed by cognitive psychologists (Pennington, 1997). Further research in these related fields may suggest that reading disability is a heterogeneous syndrome involving, in addition to a phonological coding deficit, a timing mechanism, a general linguistic deficit, a visual memory deficit or combinations of two or more such factors. As with all scientific investigation, it is important to keep an open mind about cause and effect.
CHAPTER 4: THE PRESENT STUDY

4.1 Theoretical Context of the Study

It is inherent in the concept of education at the university level that students have at least average cognitive ability and a strong history of educational achievement at the school level. It may be assumed, because of past academic success, that these students are unlikely to show evidence of being poor readers. Yet this is not necessarily the case. University students can be poor readers for a number of reasons. They may be students studying in a second language, or mature students who for a myriad of reasons did not benefit from a solid formal education at the school level. They may have acquired a reading disorder as the result of some sort of brain injury, or come from a cultural background where reading has not been valued.

However, there appear to be a significant number of students for whom the only explanation of difficulty appears to be some manifestation of dyslexia. Whether they have received a prior formal diagnosis or not, they are likely to have experienced some difficulty with reading since childhood (Bruck, 1990). In fact, it is not uncommon for students to be formally diagnosed for the first time at the university level (Carlton & Walkenshaw, 1991). Presumably their good cognitive skills have permitted them to cope at lower levels of education, but the literacy demands of the university curriculum (Carson, Chase, Gibson, & Hargrove, 1992; Hughes & Smith, 1990; Johns, 1981) frequently render those strategies inadequate. However, it has been suggested that university students only show reading comprehension deficiencies in timed situations (Mosberg & Johns, 1994; Runyan, 1991; Weaver, 1994).

Over the last twenty years, increasing numbers of university students have been provided with accommodations on the basis of a diagnosis of reading disability (Brinckerhoff, 1991;
Despite this trend, in comparison to school level readers, there is very little systematic knowledge about why they have difficulty reading (Hughes & Smith, 1990). Both Aaron (1989) and Bruck (1990) cited this lack as a reason for their interest in studying this group. Much of the work that has been carried out has centred on the role of service provision, achievement comparisons with peers, or on strategies to enhance skills.

The "simple view" of reading (Gough & Tunmer, 1986; Hoover & Gough, 1990) provides a parsimonious framework for an investigation of the factors critical to the reading comprehension process. The "simple view" contends that reading comprehension is the product of linguistic ability, as measured by listening comprehension, and decoding ability. It has been suggested that any discrepancy between listening and reading comprehension levels should be seen to be the result of reduced decoding skills (Stanovich, 1991). However, Nation and Snowling (1997, 1998b) pointed out that the concept of the "simple view" implied that the alternate position should not be ignored. Poor reading comprehension in the presence of good decoding skills should be indicative of poor listening comprehension skills. An investigation of these abilities among university students with and without dyslexia, both directly, and through the measurement of related skills, would give a clear illustration of whether students at the university level conform to observations which have, for the most part, been developed in studies of younger readers.

Comprehension of both listening and reading has been portrayed as a unitary process (Aaron, 1989; Daneman, 1991; Gernsbacher & Faust, 1991; Jackson & McClelland, 1979; Sticht, 1984; Sticht & James, 1984; Townsend, Carrithers, & Bever, 1987). If such a supposition is correct, and decoding ability is the factor that creates any differential between the two skills, students with dyslexia should perform at listening comprehension levels which are comparable to their peers.
(Aaron, 1989; Aaron & Joshi, 1992; Carlisle, 1991; Horowitz & Samuels, 1985; Samuels, 1987; Stanovich, 1991a). In addition, if the two skills are unitary in nature, they should have comparable upper limits in terms of the rate of presentation of the material and level of comprehension (Aaron, 1989; Carver, 1973; Sticht, 1968; Sticht, Beck, Hauke, Kleiman, & James, 1974). Jester and Travers (1966) found that college students had differential comprehension skills at different speeds; listening was optimal at 200 words per minute, but reading at 300 words per minute.

Danks and End (1987), using simultaneous reading and listening to text tasks, tested upper level elementary school children. They found that scores increased over levels obtained when reading text alone, perhaps because the children were receiving the information from two modalities and were able to use their cognitive resources more efficiently. There seems to be little information on whether differences exist in optimal rates of presentation for older students with dyslexia, and whether they benefit from listening with or without text.

Stanovich (1988) suggested that without adherence to the notion of specificity the concept of reading disability was unsupportable. The majority opinion in the reading field is that this specificity is based in phonological coding deficits (Bruck, 1990; Gough & Tunmer, 1986; Rack et al., 1992; Share & Stanovich, 1995; Siegel, 1988; Shaywitz, 1996; Shaywitz, 1998; Shaywitz, Shaywitz, et al., 1998; Snowling, 1996; Stanovich, 1991; Vellutino, 1977). Such deficits are generally measured using tests of word recognition. Lists of orthographically correct nonwords, regular, and irregular words, measure ability to recognize and decode different types of words (Berndt et al., 1994; Brown & Watson, 1994; Bruck, 1990; Coltheart & Leahy, 1992; Seidenberg et al., 1984; Treiman et al., 1990; Treiman et al., 1995). Phonological awareness (McBride-Chang, 1995a; Wagner et al., 1997) and spelling performance (Bruck & Waters, 1990; Castles et al., 1997; Lennox & Siegel, 1993; Treiman, 1984) are further abilities which seem to be related to poor
phonological coding skills and appears to correlate with reading level. Poor spelling ability appears to continue into adulthood (Bruck, 1993; Holmes & Ng, 1993).

Bruck (1990) suggested that, at the postsecondary level, a latency component should always be included in assessments of word recognition ability because this was the factor that clearly distinguished students with a reading disability. On tests of reading words and nonwords, she found a significant difference in the response times of university students with dyslexia and their peers without reading problems. Other researchers have also found this speed differential with adults (Ben-Dror et al., 1991; Lovrich, et al., 1997; Watson & Brown, 1992).

Students who demonstrate evidence of a phonological coding deficit would be classified, in terms of the dual-route theory of word recognition (Castles & Coltheart, 1993; Coltheart, 1978; Coltheart, Curtis, Atkins & Haller, 1993) as "phonological dyslexics". Their deficient sub-lexical processing ability is believed to force reliance on orthographic (lexical) word recognition strategies, with the result that their exception word reading should be considerably more efficient than their ability to read nonwords. "Surface dyslexics" are thought to demonstrate the opposite pattern; deficient processing using the lexical route, illustrated by a preference for use of phonologic strategies. Students with surface dyslexia should have most difficulty reading irregular words, because they try to read them by using the sub-lexical route, a demonstration of the "regularity effect" (Bryant & Impey, 1986). Rack et al. (1992) suggested that some degree of independence probably exists between the two routes, while Siegel et al. (1995) found that children with dyslexia appeared to have orthographic ability which is superior to their peers without disabilities. This is unexpected given their poor phonological ability.

The possibility that children develop differential phonological and orthographic skills is supported in the literature (Barker, Torgesen, & Wagner, 1992; Castles & Coltheart, 1993;
McBride-Chang, Manis, & Wagner, 1996; Stanovich & Siegel, 1994). However it has been suggested that surface dyslexia is a developmental issue, something children outgrow (Bryant & Impey, 1986, 1992; Manis et al., 1996; Murphy & Pollatsek, 1994; Rack et al., 1992; Stanovich, Siegel et al., 1997). Ben-Dror et al. (1991) found a large regularity effect in university students with dyslexia, an indication, despite its inefficiency, of use of the sub-lexical route. Certainly this would not support the development of an efficient mental lexicon of orthographic representations. Bruck (1992) argued that college level students with dyslexia remain impaired in both routes, the sub-lexical because of phonological impairment, and the lexical because of the poor development of mental representations. This could perhaps be related to low levels of exposure to print.

Degree of print exposure has become a focus of interest in the reading and reading disability field because of its apparent relationship to vocabulary knowledge and reading skill, and ultimately to levels of cognitive ability (Cunningham et al., 1990; Stanovich, 1986, 1993; Stanovich & Cunningham, 1992; Stanovich & West, 1989, 1993; Stanovich et al., 1995; West & Stanovich, 1993; West et al., 1993). It has been linked to orthographic knowledge, which, in turn has been linked to spelling ability and vocabulary knowledge. University students with dyslexia are an interesting group to investigate from this perspective. They may have experienced lower exposure to print while they were growing up simply because they disliked reading, or they may have enjoyed reading despite their difficulties. They would generally be considered to have good cognitive skills, and they could be presumed to have adequate exposure to print. However, if they differ from their peers without disability in levels of exposure to print, then perhaps this can be related to lower levels of word recognition and vocabulary ability and ultimately to lower levels of reading comprehension.
Naming speed has received consideration as an independent core deficit in reading disability (Bowers, 1988, 1993, 1995a, 1995b; Bowers et al., 1988; Bowers & Wolf, 1993b; Denkla & Rudel, 1976; Korhonen, 1995; Nicolson & Fawcett, 1994; Perfetti, 1985; Wolf, 1991; Wolf & Obregon, 1992; Wolf & Segal, 1992; Wolff, Michel, & Ovrut, 1990). Bowers (1993) found that timing mechanisms could be identified as an independent factor in the reading of connected text. Accurate and automatic word recognition is an essential element of fluent reading, and there is some evidence that readers can show indication of a single deficit in either timing or phonological coding, or a double deficit. This latter group of readers tends to have the poorest comprehension skills (Bowers & Wolf, 1993a; Wolf, 1997).

Chiappe et al. (1997) suggested that, with the exception of digit naming, naming speed tests did not show any relationship to adult reading comprehension levels. This lack of result may be a demonstration of a "floor" effect suggested by Biemiller (1977-8). Adult readers may simply have reached their maximum speed of oral reading. However, Chiappe et al. interpreted their result as implying that timing mechanisms do not constitute a separate deficit but are a reflection of an impaired word retrieval system. Given the small number of previous studies that have focused on adults, the relationship of timing mechanisms to adult reading comprehension ability deserves further investigation.

Biemiller (1977-8) found that letter naming speed could be related to word naming speed and to the speed of reading words in context. He suggested that adult readers read words out of context either at the same rate or slightly faster than they do letters, while they read words in context faster than they read single words. He found that, in adult readers, approximately 54% of the variance in reading text can be accounted for by these two factors (42% for letters and 12% for words). This is lower than the percentage of variance he identified for younger readers,
something he attributed to the possibility of the "floor" effect mentioned above. He also suggested that, compared to good readers, poor readers may be less efficient users of orthographic information. This would result in slower letter and word reading times. "If poor readers have less orthographic structure available to them, their identification times will be longer because they do not 'know' exactly or partially what letters or features they are dealing with." (Biemiller, 1977-8, p. 247). Ehri (1997) suggested that it might be difficult for poorer readers to benefit from gathering individual letters and chunking them into parts of words and whole words, something which would speed up the encoding process. However, Siegel et al. (1995) found in a study of younger readers, that, compared to children without dyslexia, children with dyslexia demonstrated superior orthographic ability. Issues related to the role of speed in adult reading are therefore worthy of further investigation.

In summary, if the "simple view" of reading, and the prevailing views of the core deficit of dyslexia are correct, compared to their peers without a reading disability, students with poor reading comprehension skills should show evidence of reduced phonological skill but adequate listening comprehension skill. Students who show evidence of both poor listening and reading comprehension skill should show evidence of adequate phonological coding skill. Aspects present in beginning readers that persist into adulthood would seem to constitute an arrest in development of skill rather than a delay (Ben-Dror et al., 1991; Bruck, 1990a, 1992; Francis et al., 1996). The question remains whether reading disability is a homogeneous condition, distinct from the continuum of all readers (Crowder & Wagner, 1992; Ellis, 1985; Spear-Swerling & Sternberg, 1994; Stanovich, 1988, 1990, 1993; Stanovich & Siegel, 1994; Tal & Siegel, 1996), or whether it is a more heterogeneous condition than has previously been suggested.
Hypotheses Developed From the Theoretical Context

**Reading Comprehension.** That, in untimed situations, students with reading disability achieve reading comprehension levels equal to their peers without a disability.

**Listening Comprehension.** In accordance with the "simple view" of reading, certain students with a reading comprehension disability can demonstrate equality with those without a reading disability on listening comprehension tests, and that differences between listening and reading comprehension skills can be accounted for by a discrepancy in phonological coding ability. In accordance with the "simple view" of reading, certain students with a reading comprehension disability can demonstrate adequate phonological coding ability but reduced listening comprehension skills. Impaired reading comprehension ability improves when simultaneously reading and listening to text. That all students with a reading disability will exhibit reduced vocabulary knowledge and this can be correlated with tasks that measure levels of exposure to print.

**Reaction Times (Speed).** That students with a reading disability have slower word recognition times than their peers. That students will read letters and words at the same rate, and that slow naming time for letters is related to a slow reading rate for words. Because of the context effect, single words will be read significantly more slowly than words in context. There is no evidence for a separate timing deficit in adult readers.

**Subtypes.** That reading disability in adults is a heterogeneous condition with evidence of identifiable subtypes. In particular, participants demonstrating deficits considered characteristic of the subtypes defined as phonological and surface dyslexia will be discernible.
4.2 Setting of the Study

This study was conducted entirely at McGill University, where the author is Director of the Office for Students with Disabilities. The Ethical Review Certificate approved by the University of Toronto was accepted by the Department of Graduate Studies and Research at McGill without further review. McGill is a large, selective admission institution, one of the so-called Canadian "Big Ten" medical-research universities. Undergraduate acceptance criteria are strictly adhered to with a minimum 75% average from high school or CEGEP being necessary for admission. Many faculties and programmes demand higher averages. There is no differential admissions process for students who declare a reading disability prior to acceptance. There is, therefore, an expectation of a certain level of homogeneity in terms of prior school success. Admission at the mature student level (older than 23 years of age) is permitted for students with less traditional backgrounds, but normal university standing policies are applied to these students. If they do not succeed within a year, they are generally refused permission to re-register. Therefore, by third year, they are relatively indistinguishable academically from regular entry students. The Division of Continuing Education admits people on a considerably less stringent basis, and not into full-time degree programmes. In an attempt to preserve the maximum homogeneity, no students from this division were included in the study.

Since it is situated in Montreal, McGill has a significant percentage of French first language students (20.6%). Students with a mother tongue other than English or French constitute 25.8% of the population. The remaining 53.6% list English as their first language, though many of these students are fluently bilingual and may have received their education in French in Québec or elsewhere. The total student population in the winter (January) 1998 semester numbered 28,473,
66.5% being from Québec, 20.1% from elsewhere in Canada, 3.1% from the United States, and 10.3% were international students from countries other than the United States. McGill is therefore a large, urban, multi-lingual, multi-cultural university, and apart from a probable greater preponderance of francophones, its students are likely to resemble those at other similar anglophone universities elsewhere in the country. A small number of students were recruited from Concordia University, also an anglophone university in Montreal. Concordia is a large urban, multi-cultural, multi-lingual university. It does not have professional faculties such as medicine and law and falls within the "large, comprehensive" classification of Canadian universities. Admission standards are considerably more flexible than those utilized at McGill. In order to preserve as much homogeneity as possible, all students included in the study were CEGEP graduates, and had a proven success record at Concordia.

4.3 Participants

The students who took part in this study, for the most part, attend or have recently graduated from McGill University. Unlike many studies of university students with a reading disability which test only undergraduates, this study included a number of graduate students, including several students who are studying at levels beyond the master's degree (Doctorate, Medical Residency, post-Master's degree Law, and post-Master's degree Medicine). These students are a particularly interesting group because of their proven high levels of academic achievement. Five undergraduate students (four with a reading disability and one control participant) were recruited from Concordia University.
Students who had a diagnosis of reading disability had been diagnosed either at a previous level of education, or while they were at university. McGill does not offer diagnostic services, but a number of students had undergone a screening process at McGill before being referred to an external agency for a full diagnostic assessment. This group of students was recruited because they were registered with the Office for Students with Disabilities at McGill, or with the respective department at Concordia. One of the Concordia students was recruited individually as a control subject but scored at the 12th percentile on the definitional reading comprehension test, and despite a highly successful academic record, reported a previous history of slower than average reading. On the advice of the author's supervisor she was included in the sample of students with a disability. Likewise, one McGill student with an early diagnosis of reading difficulty scored at the 88th percentile of the timed portion of the definitional reading comprehension test, and was placed in the control group.

The students responded to a letter, sent by the author to all students who could qualify for the study on the basis of reports filed with the service, explaining the purpose of the project (Appendix One, pp.158-159). They returned a signed permission slip in a stamped return envelope. All but six of the potentially eligible students answered in the affirmative, thereby providing a broad range of university years and academic disciplines. Initial contacts with the Concordia students were made by staff at their service and those students who expressed interest in the study were mailed the same request letter. Except for one student, all students were first language English speakers. The one exception, a McGill graduate student, had had all his education in English. None had previous histories of difficulty with other sensory disabilities or with brain trauma.

The control group was recruited on an ad hoc basis either from the student employee and volunteer pool of the Office for Students with Disabilities at McGill, or were friends of participants.
All except two were first language English speakers. The two exceptions, both graduate students, had had all their education in English. They were all given or sent a copy of the same request letter and signed the same permission slip. No student in either group was paid for their participation. They all willingly volunteered their time.

Forty-five students with reading disability were given the initial tests. Forty-one of these were included in the final data analysis. Two left McGill before the second testing session took place, one found the first session traumatic and did not wish to continue, and one was not included when it became apparent that his reading problems could be related to numerous factors (mature student, 60 years of age, education only to grade six in a rural, non-Canadian setting, with no intermediate educational experience). Twenty-one control participants were recruited and 20 are included in the data analysis. One left McGill before the second testing session.

Experimental Groups. The experimental groups (N = 61) were defined according to performance on the timed Reading Comprehension subtest of the Nelson-Denny Reading Test (Brown, Fishco, & Hanna, 1993), Form G. Percentile scores rather than raw scores were used for the analysis of this standardized test because it was felt that, given the diversity of age and university year of the students, the normed data provided a more reliable comparison. Percentiles also provide a readier comparison to scores used in clinical settings. Choice of a reading comprehension level that defines reading disability and is not based on arbitrariness is complex. Using Form E and F of the same test, Runyan (1991) reported that her sample of students with reading disability obtained a mean percentile score of 12.81, while Weaver (1993) reported a mean percentile score of 22 for her group. Neither gave a range of scores. Cunningham et al. (1990) used raw scores rather than percentiles and decided that a raw score of 26 or below defined less skilled readers. However, it is known that students with a reading disability can
develop compensatory strategies by this level of education and can score quite highly on standard reading comprehension tests. Bruck (1990) divided her sample group into good comprehenders and poor comprehenders. A similar framework was adopted in the present study, and cut-off percentile scores of below the 15th percentile and at or above the 15th percentile were used to define two groups of readers with a previous identification of reading disability. The group falling below the 15th percentile were designated Lower Reading Disabled (LRD) and those at or above the 15th percentile as Higher Reading Disabled (HRD).

Table 1
*Nelson-Denny Reading Test (Form G), Comprehension Subtest: Mean Percentile Scores (Standard Deviations in Parenthesis)*

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRD (n=20)</td>
<td>5.3 (3.9)</td>
</tr>
<tr>
<td>HRD (n=21)</td>
<td>31.1 (12.2)</td>
</tr>
<tr>
<td>CG (n=20)</td>
<td>73.9 (18.5)</td>
</tr>
</tbody>
</table>

Note. (LRD = below 15th percentile; HRD = at or above 15th percentile; CG = control group.

Table 2
*Sample Characteristics*

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean Age</th>
<th>Median Year</th>
<th>Mean Year</th>
<th>% Female</th>
<th>% Male</th>
<th>Median EIQ</th>
<th>Mean EIQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRD</td>
<td>27.1</td>
<td>4.5</td>
<td>4.4</td>
<td>65%</td>
<td>35%</td>
<td>115</td>
<td>114</td>
</tr>
<tr>
<td>HRD</td>
<td>23.4</td>
<td>3.0</td>
<td>2.9</td>
<td>54%</td>
<td>46%</td>
<td>115</td>
<td>112</td>
</tr>
<tr>
<td>CG</td>
<td>25</td>
<td>4.0</td>
<td>4.3</td>
<td>60%</td>
<td>40%</td>
<td>123</td>
<td>124</td>
</tr>
</tbody>
</table>

Note. Age in years.
Year = current year of university: 1-4 = undergraduate; 4 and above = graduate
EIQ: Estimated I.Q. computed using Wechsler Adult Intelligence Scale-Revised (Wechsler, 1981), Vocabulary and Block Design subtests, after a formula proposed by Tellegen and Briggs (1967).
Block Design subtest standard mean scores LRD group 11.9, HRD group 12, CG 12.5
Fifty percent of the students in the LRD group were studying at the graduate level, while five percent of the HRD group were graduate students. The equivalent figure for the control group was 35%.

Table 3
Faculty Distribution

<table>
<thead>
<tr>
<th>Faculty</th>
<th>LRD Group (n=20)</th>
<th>HRD Group (n=21)</th>
<th>Control Group (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Undergraduates</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arts</td>
<td>7</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>Science</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Engineering</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Fine Arts</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Music</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Management</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Postgraduates</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medicine</td>
<td>4</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Law</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Arts</td>
<td>2</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Science</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Education</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Note. Students from the professional faculties (Law and Medicine) all had at least one previous degree from another university, so have been designated graduate level.

Geographic distribution (Table 4) makes it clear that the likelihood that the students read with difficulty as a result of characteristics inherent in a particular provincial or national educational system is remote.
Table 4
High School Locations

<table>
<thead>
<tr>
<th>High School Region</th>
<th>Reading Disability (n=41)</th>
<th>Control Group (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quebec</td>
<td>13 (LRD 8/HRD 5)</td>
<td>8</td>
</tr>
<tr>
<td>Ontario</td>
<td>17 (LRD 6/HRD 11)</td>
<td>4</td>
</tr>
<tr>
<td>Atlantic Provinces</td>
<td>3 (HRD)</td>
<td>2</td>
</tr>
<tr>
<td>Prairie Provinces</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>B.C.</td>
<td>1 (LRD)</td>
<td>1</td>
</tr>
<tr>
<td>United States</td>
<td>7 (LRD 5/HRD 2)</td>
<td>2</td>
</tr>
<tr>
<td>Other Country</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

4.4 Experimental Tasks and Procedures

Reading Comprehension

Reading comprehension was measured using the Nelson-Denny Reading Test, Form G, Comprehension sub-test (Brown et al., 1993). It was administered in both a timed and untimed format. The test consists of one one-page passage and six half-page passages, followed by a set of multiple choice questions. Standard administration procedures were used. Students were not instructed about the amount of time they had, but told that it was timed and the examiner would be asking them to mark their place on the answer sheet at some stage. This took place at the 20 minute mark, the standard time for test administration. When this point was reached, students who had not finished the test were permitted to continue until they had completed it. The total time taken was recorded. Scores were calculated using the standard procedure, utilizing norms appropriate for the university level (e.g. Grade 13 for 1st year students; Grade 16 for 4th year and graduate students. The test does not provide norms above the undergraduate level). The norms
provided on the test for extended time administration were not used because many students took longer than permitted by those norms (32 minutes).

**Listening Comprehension**

Listening comprehension was measured in four ways:

- **Listening with text under timed and untimed conditions.**

  To maintain a comparison with the reading comprehension test, the Nelson-Denny Reading Test, Reading Comprehension subtest, Form H, was recorded onto a tape cassette. The speaking rate for the passage sections was approximately 150 words per minute. Slight pauses were provided between each question. Tapes were played back on a General Electric four-track tape recorder. Total tape time for reading both the passages and the questions was 29 minutes. Students were instructed to read and listen to the tape at the same time. They were given the choice of listening with or without earphones. Students were able to pause the tape and to rewind if they desired, in order to parallel reading conditions where rereading is possible. Progress at the 20 minute mark was recorded, and the students were then permitted to continue until they had finished, at which point total time taken was recorded. A number of students took less than the 29 minutes to finish the test, indicating that they must have been reading ahead, especially on the final set of questions. This applied to one student (5%) in the LRD group, four (19%) in the HRD group and 12 (60%) of the control group. A number of the control group reported that they disliked the tape and found it very frustrating to listen to.

- **Listening without text at two different speeds.**

  To measure how students comprehended without text, both forms (Forms G and H) of the Woodcock Reading Mastery Test-Revised (Woodcock, 1987), Passage Comprehension subtest
were recorded onto cassette tape. This is an untimed cloze type test. The reader indicated the space by saying the word "blank". Students responded orally with an appropriate word. Form G was recorded at approximately 115 words per minute, and Form H was recorded at approximately 195 words per minute. Students were permitted to pause the tape while they thought of an answer. They were permitted to rewind the tape for each question once. The action was recorded on the test sheet, but only first time answers were counted. Testing on both forms was commenced at item 33. Results were calculated in the standard manner. Raw scores, standard scores and percentile scores were recorded.

Phonological Awareness

Phonological awareness was measured using the Auditory Analysis Test developed by Rosner and Simon (1971). The test is included in Appendix Two (p.162). It consists of forty words, from which the students were asked to delete single phonemes from the start or end of a word, single phonemes from blends, or syllables. The examiner introduced the task by using three examples. No repetitions were permitted. Words become increasingly more difficult from beginning to end. Total raw scores, percentage total scores, and odd/even raw scores were computed. The split half reliability (Spearman-Brown corrected) of odd/even items for the whole group (N = 61) was .71, (LRD, r = .92; HRD, r = .82; CG, r = -.06). The lack of reliability in the control group data is due to a ceiling effect.

Spelling

Spelling has been shown to be related to phonological ability. Spelling was measured using the Wide Range Achievement Test, (WRAT-3) (Wilkinson, 1993), Tan Form, Spelling subtest. This test, which is not timed, requires the student to write down the spelling of forty dictated words of increasing complexity. Each word is read out loud by the examiner, repeated in
a sentence, and re-read. The entire test was administered in the standard manner, except that inclusion of the word in a sentence was begun at item 30. Item 12 was also included in a sentence because its form is ambiguous. Scoring was according to standardized norms, and the grade equivalent, standard, and percentile scores were recorded.

**Word Recognition Skills**

Word recognition skills were measured with a number of tasks, using both standardized tests and experimental tasks.

**Phonological coding skill.** This was first measured using the Woodcock Reading Mastery Test-Revised (Woodcock, 1987), Form G, Word Attack subtest, which was administered in its entirety and scored according to standard administration. Students were shown a series of nonwords and asked to pronounce them out loud. It was emphasised that pronunciation should sound as if it was an English word, since a number of the words on the test could be pronounced as if they were French words. Both standard and percentile scores were recorded.

**Word identification skill.** This was first measured using the Woodcock Reading Mastery Test-Revised (Woodcock, 1987), Form G, Word Identification sub-test, which was administered beginning at item 74 and scored according to standard test administration. Students are shown a series of words and asked to read them out loud. Both standard and percentile scores were recorded.

**Experimental Words and Nonwords**

**Letter strings.** A list of 81 letter strings in alphabetical order was administered. Twenty pronunci able nonwords were contained in the list. Real words were a mix of regular, irregular
and unusual words, gleaned from Jared and Seidenberg (1990) and Zimmerman, Broder, Shaughnessy and Underwood (1977). Different categories of words were not used as part of the assessment for the present study, and are mentioned simply to emphasise that a variety of word forms were employed. Students were instructed to silently read the words and mark only those they were sure were words. Scores were calculated by counting the percentage correct minus the percentage of nonwords marked. The list is included in Appendix Two (p. 163).

Experimental words. To permit the separate assessment of lexical and sub-lexical processes, three lists of 30 words, regular, irregular, and pronounceable, orthographically legal nonwords, taken from Castles and Coltheart (1993), were administered. According to Castles and Coltheart, regularity was determined using established norms. The list of experimental words is included in Appendix Two (p. 164).

In the present study the words were entered as separate lists onto a computer database and presented in lower case letters in the centre of a computer screen attached to a Pentium computer. Response latencies were measured with a timing mechanism attached to the computer which recorded the difference in milliseconds between the onset of the stimulus on the screen and the first vocalization. A voice operated relay interfaced with the computer via a small microphone. The stimulus disappeared at the point of vocalization. The stimulus onset interval was approximately 2 seconds. Students were instructed that they would be seeing three separate lists of words. The characteristics of each list were explained and the students were instructed to say each word out loud as quickly but as accurately as possible using English pronunciation. A set of six practice words were administered at the start (words, that, have, no, meaning, whatsoever). There was a pause between each list. All times which were related to mechanical errors were recorded and excluded from the analysis. These amounted to one percent or less of
the total responses, distributed across all word groups. The LRD group recorded 25/1800 (1%) mechanical errors, the HRD recorded 20/1890 (1%), and the control group recorded 4/1800 (0%). The effect is therefore insignificant in terms of the final computed averages. Average latencies were computed for each set of words per individual.

All pronunciation errors were recorded. Strict criteria were applied to the pronunciation of non-words (Gottardo, Chiappe, Siegel, & Stanovich, 1996). That is, all vowel and consonant pronunciations had to match those in some real word (gead/read not gead/geadd; toud/loud not toud/rude). Raw score correct responses and percentage error rates were both recorded. Types of errors were not recorded.

**Vocabulary Knowledge and Exposure to Print**

**Vocabulary**

Vocabulary was measured using two standardized tests, the Peabody Picture Vocabulary Test-Revised (Dunn & Dunn, 1981), Form L, and the Wechsler Adult Intelligence Scale-Revised (Wechsler, 1981), Vocabulary subtest.

**Peabody Picture Vocabulary Test.** Students were given a word and asked to identify correctly one of four pictures that illustrated the word. Administration began at item 110. Scoring was according to standardized norms. Standard, percentile and grade equivalent scores were recorded. While this test is good from the perspective that it does not demand good expressive verbal skills, it is somewhat open to the influence of guessing and elimination. The student has a minimum of one in four chance of guessing a right answer, which probably limits the test's usefulness as a single measure of vocabulary.
The Vocabulary subtest of the Wechsler Adult Intelligence Test-Revised. This test was administered according to standard procedures. It demands verbal skills, because the student is simultaneously presented with a visual and verbal image of a word, and asked for a definition. Standard score equivalents of raw scores were recorded.

Exposure to Print

Exposure to print was measured using an Author Recognition Checklist (ARC) and a Magazine Recognition Checklist (MRC) similar to one used by Stanovich and Cunningham (1992) and Stanovich et al. (1995) (Appendix Two, pp.165-166). These two inventories contain, in one case, a list of authors, and in the other case, a list of magazine titles. Participants were discouraged from checking off names at random both in the instructions and by the inclusion of nonwords, names and titles which are invented. Students were instructed to mark all the names or titles they recognized. They were cautioned against guessing and told they did not need to have read the work, they simply needed to know of the author or magazine. The ARC contains 86 items of which 45 are real; the MRC contains 94 items, of which 60 are real. Scoring was the percentage of correct items checked minus the percentage of nonwords checked. Both the raw scores and the percentage scores were recorded.

Speed Tests

Rapid Automatized Naming

Rapid Automatized Naming (RAN) (Denkla & Rudel, 1976) was measured using a set of 50 single digits arranged horizontally in five rows of ten digits on an eight by eleven inch sheet of paper (Appendix Two, p.167). The student was handed the sheet and asked to begin reading the digits out loud on the command of "GO". The result was timed on a hand held digital
stopwatch in seconds. Errors were also recorded, though they were not used in the data analysis because only one student made any errors.

**Biemiller Test**

Biemiller (1981) developed a test for young children consisting of a set of single letters, two passages, and two sets of words, from the passages arranged in random order. Since the original test passages were designed for very young children they were not used for this age and educational level. Two passages were taken from age appropriate reading material, one from Shapiro (1993, p.105) and one from Shaywitz, (1996, p.98). The letter section consisted of 50 randomly ordered single letters arranged horizontally on a page in three rows (Appendix Two, p.168). Passage One (Appendix Two, p.169) consisted of 98 words, and Passage 2 (Appendix Two, p. 170) of 77, more complex, words. A set of 50 words from each passage were arranged in random order (Appendix Two, pp.169-170). The test was administered in the following order: Letters, Passage One, Words from Passage One, Passage Two, Words from Passage Two. Reading times were measured using a hand held digital stopwatch. The results were converted to seconds per letter for the individual letters, and seconds per word for the other items.

**Intake Questionnaire**

An intake questionnaire was also completed by each student (Appendix One, p. 160).
Administration Procedures

All tests were administered by the author. Session One tests were administered individually, or in groups of up to four people. Session Two tests were administered on an individual basis. Depending on the student, each session lasted from between one and two hours. Tests were administered in the following order:

Session One. Intake Questionnaire; Nelson Denny Reading Test, Reading Comprehension subtest (Form G); Letter Strings; Author Recognition Checklist; Magazine Recognition Checklist; Wide Range Achievement Test-3 (Tan Form), Spelling subtest; Nelson Denny Reading Test, Reading Comprehension subtest (Form H), simultaneous reading and listening on tape.

Session Two. Woodcock Reading Mastery Test-Revised (Form G), Passage Comprehension subtest recorded on tape at 115 words per minute; Woodcock Reading Mastery Test-Revised (Form G), Word Attack subtest; Woodcock Reading Mastery Test-Revised (Form G), Word Identification subtest; Peabody Picture Vocabulary Test; Rosner Auditory Analysis Test; RAN digits; Biemiller: Letters, Passage One, Words One, Passage Two, Words Two; Wechsler Adult Intelligence Test-Revised, Vocabulary subtest; Wechsler Adult Intelligence Test-Revised, Block Design subtest; Woodcock Reading Mastery Test-Revised (Form H), Passage Comprehension subtest recorded onto tape at 195 words per minute; Castles and Coltheart (1993) Experimental Words Reaction Time Test.

The few students who requested it, were given a short break during Session Two.
CHAPTER 5: RESULTS

Percentile scores were used for analysis of standardized tests because it was felt that, given the diversity of age and university year of the students, this data provided both a more reliable comparison than raw scores, and a good comparison to scores used frequently in clinical practice. Differences between the groups, computed using standard scores, remained the same. An alpha level of .05 was used for all statistical analysis. A correlation table for the principal variables used in the study is included in Appendix Three (pp. 171-178).

5.1 Reading and Listening Comprehension

The mean percentile scores for all reading and listening comprehension tests are provided in Table 5. On the untimed reading comprehension test, an ANOVA indicated there was no significant difference between the groups (F (2,58)=3.39, p < .05). The conclusion therefore would seem to be that, given sufficient time, the reading comprehension skills of students in the LRD and HRD groups are not significantly different from the group without dyslexia. It should be noted, however, that when the two RD groups are collapsed together, an ANOVA does indicate that the RD groups differ significantly from the control group (F (1,59) = 6.7, p< .01). The mean scores of the LRD group are 13.6% lower than the control group, while the HRD group scores are 11.5% lower.

On the timed simultaneous reading and listening to text comprehension test, an ANOVA indicated significant differences between the groups (F (2,58) = 6.15, p < .01). Dunnett's C Test indicated that there was a significant difference between the LRD and the control group. The
mean scores of the LRD group were significantly lower than those of the control group. No other group comparisons were significant.

On the untimed simultaneous reading and listening to text comprehension test, an ANOVA indicated there was no significant difference between the groups (F (2,58) = 2.4, ns). However, as with the untimed reading comprehension test, when the groups are collapsed together an ANOVA indicates that the RD group scores are significantly lower than those of the control group (F (1,59) = 4.5, p < .05). The LRD group mean score, is 11.2% lower than the control group, while the HRD group, mean score, is 8.4% lower.

On the listening comprehension without text test at 115 words per minute condition, an ANOVA indicated significant differences between the groups (F (2,58) = 6.7, p < .01). A modified LSD (Bonferroni) test indicated that the LRD group mean scores were significantly lower than the mean scores for both the HRD and the control group. No other group comparisons were significant.

On the listening comprehension without text test at 195 words per minute condition, an ANOVA indicated significant differences between the groups (F (2,58) = 7.23 p < .001). A modified LSD (Bonferroni) test indicated that there was a significant difference between the control group and both the LRD and the HRD groups. The mean scores of these groups were significantly lower than those of the control group. No other group comparisons were significant.

Since the format of the two listening without text tests diverged significantly from the standard administration, ANOVAs were also applied to the raw scores of the three groups. The results did not differ from the previous results for the listening condition at 115 words per minute (F (2,58) = 4.87, p< .01). However for the listening condition at 195 words per minute a significant difference was indicated between only the LRD group and the control group.
The LRD group score was the lowest of the three groups. This would imply that members of this group have significantly impaired listening comprehension skills at both slow and fast speeds of delivery, while the HRD group and the control group score at comparable levels.

Table 5
Reading and Listening Comprehension: Mean Percentile Scores (Standard Deviations in Parenthesis)

<table>
<thead>
<tr>
<th>Condition</th>
<th>LRD Group (n=20)</th>
<th>HRD Group (n=21)</th>
<th>CG (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading One</td>
<td>5.3 (3.9)</td>
<td>31.1 (12.2)</td>
<td>73.9 (18.5)</td>
</tr>
<tr>
<td>Reading Two</td>
<td>70.1 (20.1)</td>
<td>72.2 (16.9)</td>
<td>83.7 (16.1)</td>
</tr>
<tr>
<td>Listening One*</td>
<td>7.2 (11.2)</td>
<td>13.1 (13.1)</td>
<td>24.9 (22.2)</td>
</tr>
<tr>
<td>Listening Two</td>
<td>65.5 (17.7)</td>
<td>68.3 (18.3)</td>
<td>76.7 (14.9)</td>
</tr>
<tr>
<td>Listening Three</td>
<td>43.7 (24.4)</td>
<td>64.9 (23.1)</td>
<td>67.0 (19.5)</td>
</tr>
<tr>
<td>Listening Four</td>
<td>33.1 (25.9)</td>
<td>41.4 (29.6)</td>
<td>63.4 (22.0)</td>
</tr>
</tbody>
</table>

Note. Reading One, timed (at 20 mins); Reading Two, untimed; Listening One, with text, timed (at 20 mins); Listening Two, with text, untimed; Listening Three, without text, 115 wpm; Listening Four, without text, 195 wpm.

*Note that the scores in this category should be interpreted keeping in mind that the amount of material covered at the 20 minute mark is constrained by the speed of the tape.

Mean Raw Scores: Listening Three. LRD 56.8 (4.4); HRD 59.9 (4.2); CG 60.3 (3.1).
Listening Four. LRD 53.5 (5.4); HRD 55.5 (5.2); CG 59.4 (3.7)

In terms of extra time taken to complete the reading comprehension test, an ANOVA indicated significant differences between the groups (F (2,58) = 46.4, p < .001). Dunnett's C Test indicated that all groups were significantly different from each other. The LRD group was slowest of the three groups, while the control group was the fastest. In terms of the extra time
taken to complete the listening comprehension with text condition, an ANOVA indicated significant differences between the groups \( (F(2,58) = 17.4, p < .001) \). Dunnett’s C Test indicated that the LRD group took significantly more time than both the other two groups. No other group comparisons were significant. Table 6 details the extra time in minutes, and the percentage of extra time, taken by each group to complete the reading, and reading while listening to text, conditions.

Table 6
Reading and Listening Comprehension, Time (mins) and Percentage of Extra Time

<table>
<thead>
<tr>
<th>Condition</th>
<th>LRD Group (n=20)</th>
<th>HRD Group (n=21)</th>
<th>CG (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading, total time</td>
<td>38.5</td>
<td>26.9</td>
<td>20.5</td>
</tr>
<tr>
<td>Reading, % extra time</td>
<td>92%</td>
<td>34%</td>
<td>2.0%</td>
</tr>
<tr>
<td>Listening, total time</td>
<td>38.6</td>
<td>30.2</td>
<td>27.0</td>
</tr>
<tr>
<td>Listening, % extra time</td>
<td>93%(33%*)</td>
<td>51%(4%*)</td>
<td>35%(-6%*)</td>
</tr>
</tbody>
</table>

Note. Extra time from normed condition (20 minutes)
* = Percentage related to total running time of tape (29 minutes)

Table 7 details the results of within group paired t-tests for the percentile scores on the two reading conditions, the two listening with text conditions, and the two listening without text conditions. Timed reading scores are significantly different from untimed scores for all groups. On the two simultaneous reading and listening tests, timed scores are significantly different from untimed scores for all groups. In terms of the two listening without text conditions (115 and 195 wpm), results were significantly different for the LRD and HRD groups but not for the control group. The control group is therefore not affected by the difference in speed of delivery of the text (115 wpm and 195 wpm) whereas the LRD group had difficulty at both speeds and the performance of the HRD group deteriorated at the faster speed.
Summary.

In the untimed situation, there appears to be no significant difference between the reading comprehension levels of any of the groups. This supports previous findings. However there is an evident actual difference, and when the RD groups are collapsed together that difference is statistically significant. This indicates that, even with additional time, when compared to the control group, the RD groups are disadvantaged in reading comprehension ability.

The difference observed in the timed reading comprehension condition between the LRD group and the control group remains in the timed listening condition. By contrast, the HRD group scores are not significantly different from the control group. The initial results support the hypothesis that there is no significant difference in the skills of any of the groups in an untimed listening with text condition. However, once again, when the groups are collapsed together a significant difference between the two RD groups and the control group is evident. This is not consistent with the hypothesis that listening comprehension is unimpaired in students who have a reading disability.
On the timed simultaneous reading and listening to text test, the distinction in skills which was evident in the timed reading situation between the HRD group and the control group, appears to diminish. However, both the HRD and control groups' mean percentile scores are lower on the listening test. This is likely to be a reflection of the amount of text covered by each group in the timed condition. This amount was constrained by the speed of the tape. Compared to the reading comprehension test, a lower number of questions had been answered by the 20 minute mark. Lower scores may also reflect a higher error rate in answers, together with the effects of any re-listening to the material or pausing of the tape. The final times recorded appear to indicate that some members of the control group were reading ahead of the tape. In fact, a number of them finished in the range of nine minutes before the actual tape. At the end of the test several of the control group expressed frustration at the constraining nature of the speed of taped delivery.

The distinction between the LRD group and the control group did diminish somewhat with the combined reading and listening to text format. The mean scores of the LRD group are 11.2% lower than the control group on the untimed listening compared to 13.6% on the untimed reading. The HRD group also performed somewhat better on the listening test with mean scores 11.5% lower than the control group on the reading test and only 8.4% on the listening test. However, in terms of efficacy, the taped text appeared to some extent to diminish the comprehension skill of all three groups. This was not entirely unexpected for the control group since they are all skilled readers, and the tape may have provided more interference than assistance. It was unexpected for the RD groups, since input from two modalities should assist comprehension. It is difficult, therefore, to assert that any of the groups benefited from taped text.
since all group scores on the untimed conditions were lower with the taped text than they were with just the reading comprehension test.

Speed is clearly a critical issue for the LRD group. In terms of the time required to approach comparable reading and listening comprehension levels, it is apparent that this group is significantly different from the other two groups. They required almost double time in the reading condition. Given that the tape took 29 minutes of running time, they required 33% more time when simultaneously reading and listening to text. By contrast, the HRD group required only 33% of additional time to approach a similar level of reading comprehension, and only four percent of additional time beyond the tape length of 29 minutes, in the reading and listening situation. The control group required almost no additional time (2%) to finish the reading test, and, on average, finished this test before the 29 minutes provided by the tape. This means they were reading ahead of the tape. Calculated from the normed 20 minute level, the percentage of additional time required by the LRD group is again close to double time (93%) while the HRD group requires 51% more time.

In the two listening without text conditions, the LRD group members were again distinct from their peers, achieving significantly lower scores than either of the other two groups even when the speed of delivery was relatively slow (115 wpm). At this speed the HRD group and the control group achieved equivalent levels of comprehension. Therefore the HRD group results on this test support the hypothesis that, on listening comprehension, dyslexic students perform equally with those without dyslexia. The LRD group results do not support this hypothesis. Once again there clearly appear to be additional factors limiting listening comprehension ability in this group.
At the faster speed (195 wpm), the LRD group suffered a further reduction in listening comprehension performance. When calculations were made using means of percentile scores, in comparison to the control group, the HRD group also demonstrated a significantly lower level of achievement in listening comprehension performance at this speed of presentation. Calculations using raw scores did not, however, distinguish this difference. Using raw scores, compared to both other groups, only the LRD group proved to be significantly different from the control group. Both the RD groups achieved significantly lower scores at the faster speed of presentation, but the control group scored no differently at either rate of presentation.

The HRD group's reduction in performance at the faster rate may be reflective of a capacity overload in terms of word retrieval ability, as information is delivered at a rapid rate. The format of the test should be considered in assessing this possibility. A cloze listening test demands the involvement of several abilities. These include receptive language ability, working memory capacity, word retrieval ability, vocabulary knowledge and, for some questions on this test, support provided by general knowledge of a non-Canadian context. Correlations between the two listening conditions and the two vocabulary tests for the RD groups are, in fact, significant (LRD group, (115 wpm) PPVT: \( r = .79, p < .01 \), WAIS-R Vocabulary: \( r = .47, p < .05 \); (195 wpm) PPVT: \( r = .70, p < .01 \), WAIS-R Vocabulary: \( r = .53, p < .01 \)). (HRD group, (115 wpm) PPVT: \( r = .45, p < .05 \), WAIS-R Vocabulary: \( r = .64, p < .01 \); (195 wpm) PPVT: \( r = .76, p < .01 \), WAIS-R Vocabulary: \( r = .73, p < .01 \)). Compared to the control group, both of the RD groups scored lower on vocabulary knowledge, though results indicate no significant difference between the RD groups themselves. Despite this lower result, both groups achieved above average mean scores, particularly on the WAIS-R vocabulary test (12.9 for the LRD group and 12.1 for the HRD group, 15.6 for the CG). Since both conditions used parallel forms of the same test, it
seems unlikely that vocabulary knowledge could have been a factor in the differential levels of performance on the two listening tests.

In terms of memory capacity, it is possible that the control group was able to use memory capacity for comprehension more efficiently than the other two groups because other tasks demanded less. The HRD group clearly had little deficiency at the slower speed where all abilities appear to have remained intact. However they showed evidence of a deficit under speeded conditions, and a capacity deficit seems the most plausible explanation for this set of reduced scores.

Speed of presentation is clearly a consideration in terms of level of listening comprehension. However, the hypothesis that speed of listening comprehension would be optimal at approximately 200 words per minute was not supported for either of the RD groups, though the control group results showed no significant difference between the 115 wpm and the 195 wpm conditions.

The findings on all of these tests raise questions about the potential for some sort of additional deficit in the LRD group. They are clearly slower to reach equivalent levels of comprehension in timed situations. Yet, the two listening without text tests were not timed. The LRD group seems to be both reading and listening disabled. In short, in terms of the "simple view" of reading, the LRD group appear to have impaired listening skills. They should demonstrate adequate phonological coding skills. On the other hand, the HRD group demonstrates listening skill that is more equivalent to that of the control group. In terms of the "simple view" of reading, the place to investigate their impaired reading comprehension scores is within the domain of phonological coding skills.
5.2 Word Recognition Skills

**Phonological Coding Ability**

**Phonological Awareness.**

On the Rosner Auditory Analysis Test (Rosner AAT, Appendix Two, p. 162) raw scores, an ANOVA indicated significant differences between the groups ($F(2,58) = 3.35, p < .05$). A modified (Bonferroni) LSD test indicated that there was a significant difference between the HRD group and the control group. No other comparisons were significant. HRD scores were the lowest of the three groups. These results appear to confirm that, compared to the control group, the LRD group does not exhibit reduced phonological awareness skills.

Table 8
**Rosner AAT: Mean Raw Scores Out of a Maximum Score of 40 (Standard Deviations in Parenthesis)**

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean Raw Score (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRD (n=20)</td>
<td>35.4 (4.4)</td>
</tr>
<tr>
<td>HRD (n=21)</td>
<td>34.3 (5.5)</td>
</tr>
<tr>
<td>CG (n=20)</td>
<td>37.7 (2.1)</td>
</tr>
</tbody>
</table>

*Note.* Both the LRD and the HRD groups contained one outlier at the low end.

**Spelling Ability**

Spelling is an ability that is thought to be closely related to phonological coding ability. It was measured using the Wide Range Achievement Test (WRAT 3), Spelling subtest. Means and standard deviations for each group are detailed in Table 9.
Table 9
WRAT 3 Spelling Subtest: Mean Percentile Scores (Standard Deviations in Parenthesis)

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean Percentile Scores (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRD (n=20)</td>
<td>67.3 (18.2)</td>
</tr>
<tr>
<td>HRD (n=21)</td>
<td>52.8 (25.1)*</td>
</tr>
<tr>
<td>CG (n=20)</td>
<td>84.4 (10.7)</td>
</tr>
</tbody>
</table>

Note. *Mean excluding four low end outliers is 62.9 (14.4)

On the percentile spelling scores an ANOVA indicated significant differences between the groups (F (2,58) = 14.2 p < .001). Dunnett's C Test indicated that the control group's higher score was significantly different from both the LRD and the HRD groups. No other group comparisons were significant. While there is no significant difference between the means of the two RD groups, the LRD mean score is relatively higher. It should be noted that there are four outliers in the HRD group (3rd, 8th and 14th (two) percentiles; 19% of total group, n = 21). These reduce the overall mean score for the group. However, analysis of the mean data excluding these outliers does not alter the relative position of the HRD group. In terms of grade equivalent scores, 95% of the control group score at the post high school level and 5% at the high school level; 55% of the LRD group score at the equivalent of the post high school level, compared to 23% of the HRD group, while 40% of the LRD group score at the equivalent of the high school level compared to 57% of the HRD group. The remaining case in the LRD group, scores at the grade eight level, while the four remaining cases in the HRD group, score at the grade seven (two), grade six and grade five equivalents. This would seem to confirm that, in general, the LRD group is less impaired in spelling ability than the HRD group.
Decoding Ability.

Decoding ability was initially measured using the Woodcock Reading Mastery-Revised, (Form G) Word Attack subtest, which was administered and scored according to standardized norms. An ANOVA indicated significant differences between the groups \( F(2,58) = 12.73, p < .001 \). A modified (Bonferroni) LSD test indicated that there was a significant difference between the control group and both the HRD and LRD groups. Both the RD group means were lower than the control group. No other comparisons were significant. The HRD group means are the lowest of the groups.

Table 10
Woodcock Reading Mastery Test-Revised, Word Attack Subtest: Mean Percentile Scores (Standard Deviations in Parenthesis)

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean Percentile Scores (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRD ( n=20 )</td>
<td>59.7 (26.7)</td>
</tr>
<tr>
<td>HRD ( n=21 )</td>
<td>43.0 (26.7)*</td>
</tr>
<tr>
<td>CG ( n=20 )</td>
<td>80.4 (16.1)</td>
</tr>
</tbody>
</table>

Note. *Mean computed without three low end outliers is 49.6 (22.7)

This result should be interpreted with some caution since the group \( n = 21 \) contained three outliers, one at each of the first, second, and seventh percentiles (14% of the groups). However, the HRD mean score remains lower even once these cases are removed from the computation of the mean. The LRD group \( n = 20 \) contains only one low end outlier at the eighth percentile and three at the high end (92nd, 93rd and 98th percentile, 15% of the group).

A second test of decoding ability utilized a set of 30 nonwords from Castles and Coltheart (1993, Appendix Two, p. 164). An ANOVA indicated significant differences between the groups \( F(2,58) = 6.6, p < .01 \). Dunnett's C Test indicated that there was a significant difference
between both the HRD and the control group, and the LRD group and the control group. No other comparisons were significant. The HRD group's mean score was the lowest, indicating that this group made more errors reading nonwords. The LRD group's scores were higher than those of the HRD group, but lower than those of the control group. (Note: a Scheffé test, in contrast, indicated that the LRD group did not differ significantly from either group. However, the group variances were not homogeneous, so this result must be treated with caution).

Table 11
Experimental Nonwords. Mean Scores of Correct Response out of a Maximum Score of 30 (Standard Deviations in Parenthesis)

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean Scores (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRD (n=20)</td>
<td>25.7 (2.9)</td>
</tr>
<tr>
<td>HRD (n=21)</td>
<td>23.7 (5.3)</td>
</tr>
<tr>
<td>CG (n=20)</td>
<td>27.95 (2.1)</td>
</tr>
</tbody>
</table>

Whole Word Recognition

Whole word recognition skills were assessed with a number of measures. The Woodcock Reading Mastery Test-Revised (Form G), Word Identification subtest, was administered and scored according to standardized norms.

Table 12
Woodcock Reading Mastery Test-Revised. Word Identification Subtest: Mean Percentile Scores (Standard Deviations in Parenthesis)

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean Percentile Scores (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRD (n=20)</td>
<td>51.1 (25.1)</td>
</tr>
<tr>
<td>HRD (n=21)</td>
<td>43.1 (21.5)*</td>
</tr>
<tr>
<td>CG (n=20)</td>
<td>69.8 (14.5)</td>
</tr>
</tbody>
</table>

*Mean computed excluding four low end outliers is 50.8 (15.8)
An ANOVA indicated significant differences between the groups \( (F(2,58) = 8.8, p < .001) \). Dunnett's C Test indicated that both the LRD group and the HRD group means were significantly lower than the control group. No other comparisons were significant. While both RD groups are relatively impaired in comparison to the control group, the HRD group appears, once again, to be more impaired than the LRD group. However four outliers (19%) compress the mean score. Computing the mean without these cases gives a figure that differs little from the LRD group.

Two other tests, using 30 regular and 30 irregular words from Castles and Coltheart (1993; Appendix Two, p. 164), also measured word recognition ability. Means and standard deviations are given in Table 13. A third test used 81 letter strings, 61 of which were real words (Appendix Two, p. 163). The mean percentage of correct answers and standard deviations are also given in Table 13. On the regular words, an ANOVA indicated significant differences between the groups \( (F(2,58) = 4.4, p < .025) \). Dunnett's C Test indicated that the HRD group made significantly more errors than the control group but the LRD group did not. No other group comparisons were significant.

Table 13
Regular and Irregular Words, Mean Scores of Correct Responses out of a Maximum of 30; Letter String Scores, Mean Percentage Correct (Standard Deviations in Parenthesis)

<table>
<thead>
<tr>
<th>Group</th>
<th>Regular Words Mean Scores (SD)</th>
<th>Irregular Words Mean Scores (SD)</th>
<th>Letter Strings Mean Percentage Correct (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRD (n=20)</td>
<td>29.7 (0.5)</td>
<td>25.4 (2.7)</td>
<td>77.2 (12.4)</td>
</tr>
<tr>
<td>HRD (n=21)</td>
<td>29.2 (1.4)</td>
<td>25.3 (2.6)</td>
<td>73.4 (11.2)</td>
</tr>
<tr>
<td>CG (n=20)</td>
<td>30 (0.0)</td>
<td>28.3 (1.6)</td>
<td>88.5 (5.6)</td>
</tr>
</tbody>
</table>

On the irregular words, an ANOVA indicated significant differences between the groups
(F (2,58) = 10.2, p < .001). Dunnett's C Test indicated that both the LRD and the HRD group scores were significantly different from those of the control group. Both groups made more errors than the control group, but not more than each other, when reading irregular words.

On the letter strings an ANOVA indicated significant differences between the groups (F (2,58) = 12.02, p < .001). Dunnett's C Test indicated that both the LRD and HRD group scores were significantly lower than the control group. No other group comparisons were significant. The HRD group had the lowest mean score.

Within group t tests indicated that for all groups, regular word reading scores were significantly different from both irregular and nonword scores:

Regular versus Irregular Words: LRD (t (19) = -7.1, p < .001); HRD (t (20) = -7.69, p < .001);
CG (t (19) = -5.0, p < .001). Regular versus Nonwords: LRD (t (19) = -6.5, p < .001);
HRD (t (20) = -5.7, p < .001); CG (t (19) = -4.3, p < .001).

It is clear from Table 13 that there was a ceiling effect for the regular words. Some caution should therefore be exercised in the interpretation of these results. However, these data appear to show that all groups read regular words better than either irregular or nonwords.

Within group t tests of Woodcock Reading Mastery Test-Revised, Word Attack subtest versus Woodcock Reading Mastery Test-Revised, Word Identification subtest percentile scores, and Irregular Word versus Nonword raw scores, determined that there was no significant differences between the sets of scores for the HRD and the LRD groups on these variables. The control group had significantly higher scores on the Word Attack subtest compared to their scores on the Word Identification subtest (Word Attack versus Word Identification: LRD (t (19) =1.9, ns); HRD (t (20) = -.2, ns); CG (t (19) = 3.2, p < .01) (all two-tail).

Irregular Words versus Nonwords: LRD (t (19) = -.4, ns); HRD, (t (20) = 1.8, ns);
CG (t (19) = .62, ns) (all two-tail). Some caution should be exercised when interpreting the results of the non-standardized tests because the nonword scores of the LRD and the HRD groups deviate somewhat from a normal distribution, as do the irregular word scores of the control group.

Reaction Times

On the reaction times for reading experimental words, the mean scores for the times are given in Table 14.

Table 14
Mean Reaction Time Scores in Seconds for Experimental Words (Standard Deviations in Parenthesis)

<table>
<thead>
<tr>
<th>Group</th>
<th>Reaction Times, Regular Words (SD)</th>
<th>Reaction Times, Irregular Words (SD)</th>
<th>Reaction Times, Nonwords (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRD (n=20)</td>
<td>.72 (.26)</td>
<td>.98 (.5)</td>
<td>1.28 (.7)</td>
</tr>
<tr>
<td>HRD (n=21)</td>
<td>.60 (.11)</td>
<td>.78 (.2)</td>
<td>.93 (.3)</td>
</tr>
<tr>
<td>CG (n=20)</td>
<td>.52 (.07)</td>
<td>.61 (.1)</td>
<td>.69 (.1)</td>
</tr>
</tbody>
</table>

For the reaction times on regular word reading, an ANOVA indicated there was a significant difference between the groups (F (2,58) = 6.9, p < .01). Dunnett's C Test confirmed that the control group reaction times were significantly faster than those of both the LRD and HRD groups. No other group comparisons were significant. (Note: A modified (Bonferroni) LSD test indicated that there was a significant difference between only the LRD group and the control group. However, the group variances were not homogeneous, which makes the results of this test more questionable).

For the reaction times on irregular word reading, an ANOVA indicated there was a significant difference between the groups (F (2,58) = 7.3, p < .01). Dunnett's C Test indicated
that the reaction times of the control group were significantly faster than those of both the LRD and HRD groups. No other group comparisons were significant. (Note: A modified (Bonferroni) LSD test indicated that there was a significant difference between only the LRD group and the control group. However, the group variances were not homogeneous, which makes the results of this test more questionable).

For the reaction times on nonword reading, an ANOVA indicated that there was a significant difference between the groups (F (2,58) = 6.74, p < .01). Dunnett's C Test indicated that the reaction times of the control group were significantly faster than those of both the LRD and the HRD groups. No other group comparisons were significant. (Note: A modified (Bonferroni) LSD test indicated there was a significant difference between only the control group and the LRD group. However, the group variances were not homogeneous, which makes the results of this test more questionable).

In terms of the regular words, the LRD group took 37% longer than the control group to read the words, while the HRD took only 14% longer. All groups were faster at reading this set of words. On the Irregular words the LRD group took 59% longer than the control group to read the words, while the HRD group took 26% longer. On the nonwords, the LRD group took 70% longer than the control group to read the words, while the HRD group took 35% longer. All groups took longest to read nonwords. The LRD group showed a regularity effect in the response times as they did in the accuracy scores (LRD .263; HRD .175; CG .062, based on differences between the means).

Within group t tests (two-tail) indicated, for all groups, that the time differences for reading regular words versus both irregular and nonwords was significantly different.

LRD (Reg. vs. Irreg. t (19) = -7.1, p < .001; Reg. vs. Non. t (19) = -6.5, p < .001).
HRD (Reg. vs. Irreg. t (20) = -7.6, p < .001; Reg. vs. Non. t (20) = -5.7, p < .001).

CG (Reg. vs. Irreg. t (19) = -5.0, p < .001; Reg. vs. Non. t (19) = -4.3p < .001).

Within group t tests (two-tail) indicated, for all groups, that the time differences for reading irregular and nonwords were significantly different: LRD (t (19) = 3.93, p < .001); HRD (t (20) = 7.1, p < .001); CG (t (19) = 6.9, p < .001).

Summary

Word recognition skills, phonological awareness and phonological coding skills of the HRD group are poorer than those of the control group on all tests. The LRD group also score at significantly lower levels than the control group except on phonological awareness (Rosner AAT), and the reading of the experimental regular words. The mean scores of the LRD group on the Woodcock Reading Mastery Test-Revised, Word Attack subtest, though significantly lower than those of the control group, were within the average range of the standardized test norms. On the reading of nonwords LRD group scores were also significantly less accurate than the control group, though one post-hoc statistical test indicated that the two groups were not significantly different in accuracy levels reading nonwords. The phonological skills of the LRD group therefore appear to be significantly less impaired than those of the HRD group. Some members of the group score above the 90th percentile on the Word Attack subtest. Even taking into account the outliers that depress the mean, the HRD group scores less accurately on the Word Attack subtest. Even on the spelling test the majority of the LRD group scored at the appropriate postsecondary level. This was not true for the HRD group.

Across all the word recognition tests, the HRD group demonstrates, in relative terms, less accurate skills than the LRD group. This is true for phonological awareness, decoding,
orthographic skills, and spelling (Rosner AAT, Word Attack subtest, Word Identification subtest, experimental regular, irregular and nonwords, letter strings, and the WRAT-3 spelling subtest). The HRD and LRD group means only approach equality on the irregular word reading, though the two groups do not differ significantly in statistical terms on the WRAT-3 spelling subtest, the Woodcock Reading Mastery Test-Revised, Word Attack subtest, or Word Identification subtest, the experimental nonwords, or the Letter Strings. This is an interesting finding given that what appears to be a significant impairment does not appear to translate into the poorest reading comprehension scores. Conversely, given their deficient reading comprehension scores, it is surprising that the LRD group appear to have a more limited deficit than the HRD group in phonological coding and orthographic skills. The reading deficit experienced by the poorest comprehenders cannot therefore be easily explained by the poorest word recognition and phonological coding skills.

In terms of the reaction time data, for all three types of words, both the LRD and HRD groups read words significantly more slowly than the control group, though they did not differ from each other. The LRD group was relatively slower at reading all types of words, however. They were slower but more accurate than the HRD group at reading nonwords, and read irregular word more slowly but with equivalent accuracy.

In terms of within group measures, all groups read regular words more accurately than other types of words. In fact a ceiling effect is apparent in the results of the control group. There was no significant within group differences for the LRD and HRD groups in reading irregular or nonwords, or on either the Woodcock Reading Mastery Test-Revised, Word Attack subtest or Word Identification subtest. However, in relative terms, the LRD group appeared to be at more disadvantage on the Word Identification subtest than they are on the Word Attack subtest. The
HRD group had the most difficulty reading nonwords while the LRD group had, marginally, the most difficulty reading irregular words. In terms of reaction times, within group comparisons indicated that all groups read regular words most quickly followed by irregular words. All groups took longest to read nonwords. Once again, there is an indication that some sort of speed deficit may be involved in the word recognition process of the LRD group. Out of the three groups, the LRD group showed the largest regularity effect in terms of word accuracy and reaction time.

It should be noted that the control group scored significantly higher on the Word Attack subtest than they did on the Word Identification subtest. Yet they were able to identify high numbers of real words on the letter strings. Both these tests require both phonological coding and orthographic skills. However, they did not have to pronounce the letter strings as they were required to do on the Word Identification subtest. They therefore may have stored more visual images of words than they know how to accurately pronounce.

Therefore, in general, these data support the hypothesis that some students with a previous diagnosis of reading disability have, compared to their peers, reduced levels of phonological coding ability. The students in the LRD group can be distinguished from the students in the HRD group by their more proficient word recognition and phonological coding skills. They appear to have unimpaired phonological awareness and regular word reading ability. In addition, on the standardized test of decoding ability, these students do not score below average on the normed percentile scores. In terms of the "simple view" of reading, it appears to be supportable that the LRD group has relatively intact decoding skills but impaired listening comprehension ability, while the HRD group has impaired decoding ability but unimpaired listening comprehension ability.
5.3 Vocabulary Levels

Vocabulary was measured using two tests, the Peabody Picture Vocabulary Test (PPVT) which demanded that students point to one of four pictures which illustrate a word which is read to them, and the Vocabulary subtest of the Wechsler Adult Intelligence Scale-Revised (WAIS-R) which demands a verbal definition of a word provided visually. Using two types of tests ensures that inability to express ideas verbally does not confound the results. Correlation coefficients for the two tests were as follows: LRD, $r = .55, p < .05$; HRD, $r = .77, p < .01$; CG, $r = .60, p < .01$.

Table 15 gives the means and standard deviations for the vocabulary tests.

Table 15
**PPVT, Mean Percentile Scores, and WAIS-R Vocabulary Subtest Mean Standard Scores (Standard Deviations in Parenthesis)**

<table>
<thead>
<tr>
<th>GROUP</th>
<th>PPVT Percentile Means (SD)</th>
<th>WAIS-R Vocabulary Standard Scores (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRD (n=20)</td>
<td>61.6 (21.4)</td>
<td>12.9 (2.6)</td>
</tr>
<tr>
<td>HRD (n=21)</td>
<td>62.3 (20.7)</td>
<td>12.1 (2.3)</td>
</tr>
<tr>
<td>CG (n=20)</td>
<td>83.2 (16.1)</td>
<td>15.6 (2.2)</td>
</tr>
</tbody>
</table>

On the PPVT, an ANOVA indicated significant differences between the groups ($F (2,58) = 7.9, p < .001$). A modified LSD (Bonferroni) test indicated that the LRD and the HRD group scores were both significantly lower than those of the control group. No other group comparisons were significant. On the WAIS-R Vocabulary subtest, an ANOVA indicated significant differences between the groups ($F (2,58) = 12.4, p < .001$). A modified LSD (Bonferroni) Test indicated that both the LRD and the HRD group scores were significantly lower than those of the control group. No other group comparisons were significant. It is clear
that both the LRD and the HRD groups have significantly reduced vocabulary levels compared to their peers. Though their vocabulary knowledge is good compared to the average population, these differences may put them at a disadvantage at this level of education. Since the scores of both the RD groups are not significantly different from each other, differences in word knowledge cannot account for differences between these two groups in reading or listening comprehension ability.

5.4 Exposure to Print

It has been suggested that differential levels of exposure to print may result in differential levels of vocabulary and orthographic knowledge. Two inventories, the Author Recognition Checklist (Appendix Two, p. 165) and the Magazine Recognition Checklist (Appendix Two, p. 166) were used to measure the degree of print exposure in the three groups. The Author Recognition Checklist and the Magazine Recognition Checklist were correlated at the following levels CG (r = .78, p < .001); LRD (r = .57, p < .01); HRD (r = .75, p < .001).

For the Author Recognition Checklist, an ANOVA indicated that there were significant differences between the groups (F (2,58) = 20.87, p < .001). Dunnett's C Test indicated that the control group scores were significantly higher than those of both the LRD and the HRD groups. No other group comparisons were significant. For the Magazine Checklist, an ANOVA indicated significant differences between the groups (F (2,58) = 5.7, p < .025). A modified (Bonferroni) LSD test indicated that the scores of the control group were significantly higher than those of both the LRD and the HRD groups. No other group comparisons were significant.
Table 16
Author and Magazine Recognition Checklists, Mean Percentages of Correct Answers (Standard Deviations in Parenthesis)

<table>
<thead>
<tr>
<th>Group</th>
<th>Author Recognition Checklist (SD)</th>
<th>Magazine Recognition Checklist (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRD (n=20)</td>
<td>43.7 (16.3)</td>
<td>56.5 (13.5)</td>
</tr>
<tr>
<td>HRD (n=21)</td>
<td>38.0 (14.6)</td>
<td>54.1 (12.8)</td>
</tr>
<tr>
<td>CG (n=20)</td>
<td>65.5 (11.6)</td>
<td>66.7 (11.5)</td>
</tr>
</tbody>
</table>

These results provide evidence that both the RD groups appear to have had significantly less reading experience than their peers without a reading disability, something which may account, in part, for their poorer word knowledge in terms of both phonological and orthographic skills, and their vocabulary knowledge. To determine whether print exposure levels correlate with word recognition and word knowledge skills, correlation coefficients were computed for author and magazine percentage scores and the following variables: PPVT percentiles and WAIS-R Vocabulary standard scores, Letter String percentage scores, the Word Identification subtest percentile scores, and WRAT-3 Spelling subtest percentile scores.

The results were as follows at the .05 level, (two-tail): For the LRD group the Author Recognition Checklist correlated positively with only the WAIS-R Vocabulary score ($r = .53$, $p < .01$), while the Magazine Recognition Checklist correlated with none of the variables. For the HRD group, the Author Recognition Checklist correlated positively with both the PPVT ($r = .5$, $p < .025$; WAIS-R Vocabulary ($r = .6$, $p < .01$), and with the Letter Strings ($r = .5$, $p < .01$), while the Magazine Recognition Checklist correlated positively with only the Letter Strings ($r = .4$, $p < .05$). For the control group, the Author Recognition Checklist correlated positively with only the Letter Strings ($r = .6$, $p < .01$), while the Magazine Recognition Checklist did not
correlate positively with any of the variables. The experimental words were not included in this exercise because they are not normally distributed. There is therefore some evidence that the print exposure indices are related to level of word knowledge, especially in the HRD group. Their lower levels of vocabulary and word recognition may well be related to less reading experience.

5.5 Speed of Naming

Speed of naming was tested using a set of non-standardized tests. The initial test used was the RAN test (Denkla & Rudel, 1976) of rapid, automatized naming. The variable was measured using a single digit rapid naming task timed in seconds (Appendix Two, p. 167). An ANOVA indicated that there was no significant difference between the groups (F(2,58) = .3, ns). An ANOVA with the RD groups collapsed into one group also indicated no significant difference between the groups (F(1,59) = .41, ns). An error rate is also recorded on this test but was not entered into the analysis since only one student out of the total group (N = 61) made any errors. An ANOVA of a RAN type test using letters instead of digits (Biemiller, 1981; Appendix Two, p. 168) also indicated no significant difference between the groups, (F(2,58) = 1.9, ns). An ANOVA with the RD groups collapsed into one group also indicated no significant difference between the groups (F(1,59) = 3.5, ns). This appears to indicate that these students show no evidence of a timing deficit. Chiappe et al. (1997) also found little evidence of a RAN effect with adults, though they did find a correlation between the digit version of the RAN used in this study and adult reading comprehension levels. The fact that no effect is evident with this group of students might mean that such a deficit is a developmental issue, apparent only in younger
readers. Or it might be reflective of the "floor effect" described by Biemiller (1977-8). These students may simply have reached their maximum level of oral reading speed for single digits and letters.

**Biemiller Test**

Table 17 shows the means for the Biemiller Test (based on Biemiller, 1981; Appendix Two, pp. 168-170) expressed per second for reading out loud letters, words out of context and within context (passages).

<table>
<thead>
<tr>
<th>Group</th>
<th>Letters (SD)</th>
<th>Passage 1 (SD)</th>
<th>Words 1 (SD)</th>
<th>Passage 2 (SD)</th>
<th>Words 2 (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRD (n=20)</td>
<td>.40 (.9)</td>
<td>.36 (.09)</td>
<td>.50 (.14)</td>
<td>.34 (.08)</td>
<td>.49 (.11)</td>
</tr>
<tr>
<td>HRD (n=21)</td>
<td>.42 (.11)</td>
<td>.34 (.08)</td>
<td>.49 (.13)</td>
<td>.32 (.06)</td>
<td>.50 (.11)</td>
</tr>
<tr>
<td>CG (n=20)</td>
<td>.36 (9.7)</td>
<td>.29 (.05)</td>
<td>.42 (.10)</td>
<td>.28 (.03)</td>
<td>.43 (.07)</td>
</tr>
</tbody>
</table>

Correlation coefficients for the relationship of scores for letters per second to scores for words per second are as follows:

Total Group (N = 61): Words One r = .81, Words Two r = .81 (p< .01, two-tail)

LRD: (n = 20) Words One, r = .93, Words Two, r = .85; HRD: (n = 21) Words One, r = .48, Words Two, r = .88; CG: (n = 20) Words One, r = .56, Words Two, r = .59

Two 2 (condition) X 3 (group) ANOVAs with repeated measures were used to compare the mean differences for both Passage One and Passage Two, for reading words in (passage) and out of context. For Passage One there was a significant main effect for group, F (2,58) = 3.9, p < .05, and for condition, F (2,58) = 173.9, p< .001. There was no interaction effect. Similarly, for
Passage Two there was a significant main effect for group, $F (2,58) = 3.9$, $p < .025$, and for condition, $F (2,58) = 307.3$, $p < .001$. There was no interaction effect. On both passages, all groups read words out of context more slowly than words in context.

Follow-up $t$ tests for both Words One and Words Two indicated that, for both conditions, there was a significant difference between both the LRD group and the control group, and the HRD and the control group.

Words One: LRD vs. CG: $t (38) = 2.11$, $p < .05$; HRD vs. CG: $t (39) = 2.1$, $p < 05$ (two-tail).
Words Two: LRD vs. CG: $t (38) = 2.17$, $p < .05$; HRD vs. CG: $t (39) = 2.45$, $p < .025$ (two-tail).

The LRD and HRD group times were not significantly different for either set of words.

Follow-up $t$ tests for both Passage One and Passage Two, reading in context condition, indicated significant differences between the control group and both the LRD and HRD groups.

Passage One LRD vs. CG: $t (38) = 3.18$, $p < .01$; HRD vs. CG: $t (39) = 2.46$, $p < .025$ (two-tail).
Passage Two LRD vs. CG: $t (38) = 3.01$, $p < .01$; HRD vs. CG: $t (39) = 2.27$, $p < .05$ (two-tail).

The LRD and HRD group times were not significantly different for either passage. The control group therefore reads words both in and out of context more quickly than either the LRD or HRD groups.

Within group $t$ tests (two-tail) confirmed that, for all groups, the reading words in context times were significantly faster than the reading words out of context times.

LRD Group: P1/W1 $t (19) = -7.3$, $p < .001$; P2/W2 $t (19) = -10.00$, $p < .001$.
HRD Group: P1/W1 $t (20) = -6.99$, $p < .001$; P2/W2 $t (20) = -9.39$, $p < .001$.
CG Group: P1/W1 $t (19) = -10.05$, $p < .001$; P2/W2 $t (19) = -12.83$, $p < .001$. 
It is clear from these data that the hypothesis that reading words out of context takes longer than reading words in context holds true for this older group just as it did for younger age groups.

According to Biemiller (1981) good readers take about the same amount or slightly less time to read words out of context than they do letters, while less able readers take substantially more time to read words than they do to read letters. Being able to read words as fast as letters is reflective of the ability to use orthographic structure. A significant difference between letter and word reading times is therefore reflective of difficulty using this process. However, for this sample, using words which were more complex than those used in Biemiller's original test, within group t tests (all two-tail) of differences between letter and word reading times indicate that, for all groups, the time taken to read the individual letters is significantly shorter than reading words.

LRD Words 1 vs. Letters, t (19) = -6.85, p < .001; Words 2 vs. Letters, t (19) = 6.6, p < .001;
HRD Words 1 vs. Letters, t (20) = 5.67, p < .001; Words 2 vs. Letters, t (20) = 7.12, p < .001;
CG Words 1 vs. Letters, t (19) = 2.91, p < .01; Words 2 vs. Letters t (19) = 3.87, p < .001.

Even so, as Table 17 shows, for these older students, a differential relationship does exist between the amount of time taken by each group to read words and letters. For Words One and Words Two respectively, the LDR group takes .09 and .10 seconds longer to read words compared to letters, the HRD group .07 and .08 seconds longer, and the CG group .06 and .07 seconds longer. The LRD group may therefore be demonstrating evidence that their use of the orthographic route is somewhat impaired.
Summary

No apparent timing deficit was measured with the RAN single digit and the Biemiller single letter naming tests. Biemiller (1977-8) reported adult letter reading times of .30 per second. The students in this study took longer than his sample to read the same letters used in his test (the LRD group took 25% longer, the HRD group took 29% longer and the control group took 16% longer). Biemiller also suggested that, as children develop good reading skills, letter reading and word reading times converge, with word reading times often becoming faster than letter reading times. Using more complex words than those used by Biemiller, this finding was not duplicated in the present study. All groups read letters significantly more quickly than they read words.

However, in conformity with Biemiller's (1977-8) findings, on the timed tests of reading words in and out of context, the RD groups did show that, though they took no longer than each other, they performed significantly more slowly than the control group on both tasks. Therefore, compared to the control group, as Biemiller suggested, they may be demonstrating a reduction in ability to use orthographic structure. Also in agreement with Biemiller, all groups took a shorter time to read words in the passages, thereby illustrating the use of context to assist in word recognition. However, compared to their own times to read words in context, the LRD group took 28% longer to read the Passage One words out of context, while the HRD and control groups both took 31% longer. Similarly, compared to the time they took to read the words in context, the LRD group took 31% longer to read the Passage Two words out of context, while the HRD group took 36% longer and the control group took 35% longer.

Therefore, the LRD group appears to benefit less from context. They may be relatively disadvantaged when reading connected text. This observation would seem to be consistent with the difficulties they experienced on the Nelson-Denny Reading Test, Reading Comprehension
subtest. However, reading these test passages did not necessarily measure comprehension since no measure of this was included. In this test situation the students read each passage followed by the words out of context from the same passage. This may have created a priming effect. Even so, it is important to remember that the LRD readers still took longer than the control group to read the individual words. This happened even though their word recognition ability, as measured by other tests used in this study, is not dramatically impaired. The impaired word recognition ability of the HRD group reported above seems to be confirmed by a speed deficit on the Biemiller test.

5.6 Summary of Hypotheses

**Reading Comprehension.** The results on the untimed reading comprehension test were somewhat ambiguous. While the performance levels of the individual groups were not statistically different, the scores of the amalgamated RD groups were lower than those of the control group. The scores of the two RD groups approached the scores of the control group, but the relative disadvantage of the RD groups remained even in the untimed situation. The hypothesis that the scores would be equal was therefore not supported. The amount of time taken to achieve these scores was significantly different for the LRD and HRD groups. The LRD group required close to double time while the HRD group needed closer to time and one half.

**Listening Comprehension.** The hypothesis proposed by the "simple view" of reading, that the listening comprehension ability of students with reading disability would be shown to be unimpaired, and equal in performance level to students without a reading disability, was only partially supported. The situation proved to be quite complex. The HRD group's listening comprehension ability approached that of the control group, especially when the rate of
presentation of material approximated normal speaking speed. Analysis using the percentile scores of the tests indicated that their ability deteriorated at the faster speed of presentation. However, when the raw scores were used for analysis, this deterioration was not apparent. The control group were unaffected by speed of presentation. In terms of listening comprehension, the LRD group results contradicted the initial premise of the "simple view", since there is sufficient evidence to suggest that they are not proficient listeners. The LRD group does seem to demonstrate reduced listening comprehension ability in conjunction with better phonological ability than was demonstrated by the HRD group. The hypothesis that reading comprehension ability would improve with simultaneous reading and listening to text was not supported. In fact, all three groups performed better on the untimed reading than they did on the untimed simultaneous reading and listening test.

**Word Recognition.** The hypothesis that students with reading disability would exhibit significantly reduced levels of phonological awareness, word recognition and word knowledge, was also only partially supported. The HRD group did fall into this category. However the same case cannot be made conclusively for the LRD group. They appeared to have no deficit in phonological awareness and their decoding ability approached that of the control group. The LRD group and the control group also read regular words equally well. Both of the RD groups, did, however, exhibit lower levels of both word knowledge and exposure to print.

**Reaction Times (Speed).** In terms of the hypothesis that students with reading disability would exhibit slower reaction times on word recognition tasks, this was supported for both RD groups. The LRD group demonstrated the longest reaction times. All groups took longest to read nonwords. However, there was no evidence for a timing deficit as measured by the RAN test of digits, or the Biemiller test of letters. Using more complex words than those suggested by
Biemiller, these students did not read letters and words at equal speed. All groups read letters more quickly than words. All groups read words in context faster than isolated words, a demonstration of the context effect. However, both of the RD groups read both passages and words significantly more slowly than the control group. The LRD group appears to show evidence of the slowest speed of reading the various stimuli out loud.
5.7 Subtypes of Phonological and Surface Dyslexia

In order to explore whether subtypes of surface and phonological dyslexia can be identified in an adult population, a regression based, scatter plot procedure utilized by a number of previous writers (Castles and Coltheart, 1993; Manis et al., 1996; Stanovich et al., 1997) was applied to the data. The set of irregular and nonwords from Castles and Coltheart (1993) used in this study (Appendix Two, p. 164) and in the other three studies, together with the percentile scores of standardized tests, were utilized. The presence of students who had the potential to be identified as surface dyslexics would challenge the notion that this is a developmental condition. The Woodcock Reading Mastery Test-Revised, Word Attack subtest percentile scores were plotted against Woodcock Reading Mastery Test-Revised, Word Identification subtest percentile scores and vice versa; and nonword raw scores were plotted against irregular (exception) word raw scores and vice versa (Figures 1 to 4). A regression line and 95% confidence limits were established using the control group scores. The expectation with this method is that phonological dyslexics will be identified as an outlier when nonwords are plotted against exception words, and when Word Attack subtest scores are plotted against Word Identification subtest scores, but will place within normal limits when exception words are plotted against nonwords. Surface dyslexics should be defined in the opposite condition.

Figure 1 (percentile scores) identifies eight phonological dyslexics (19% of the total RD group, n = 41), while Figure 2 (percentile scores) identifies five surface dyslexics (12%). Figure 3 (experimental word raw scores) identifies seven phonological dyslexics (17%), while Figure 4 (experimental word raw scores) identifies twelve surface dyslexics (29%). This latter proportion (29%) of surface dyslexics is consistent with that found by other researchers in younger Sample groupss (Castles and Coltheart, 1993, 30.2%; Manis et al., 1996, 29.4%;
Stanovich et al., 1997, 22.1%). The number of phonological dyslexics is, however, much smaller than in the other studies (19% and 17% as opposed to 54.7% in Castles et al., 33.3% in Manis et al., and 25% in Stanovich et al.). Only two cases (4 and 18) are identified as surface dyslexics on both standardized and experimental word conditions, and only two cases (27 and 40), as phonological dyslexics. Only one case (21), falls as an outlier for both the surface and phonological conditions on the experimental words (though lies right on the confidence limit in both situations), but occurs in neither group on the standardized tests. Two cases (3 and 24) appear as phonological dyslexics on the standardized tests but as surface dyslexics on the experimental words. However, case 3 is right on the confidence limit in the phonological condition, but scores as the most extreme of all outliers in the surface dyslexia condition. In terms of group membership, on the standardized tests, six phonological dyslexics fall in the HRD group, and only two in the LRD group, and on the experimental words, six phonological dyslexics fall within the HRD group and only one in the LRD group. In terms of surface dyslexia, on the standardized tests, four fall within the LRD group as opposed to one from the HRD group, while on the experimental words, seven fall within the LRD group, four within the HRD group, and one within the control group. This adds support to the data reported above that the HRD group show more classic phonological coding characteristics of dyslexia while the LRD group presents a more complex picture of deficit. However, it is important to remember that the majority of all cases in the RD groups fall within the 95 % confidence limits of the control group.
Figure 1. Performance, measured by percentile scores, on the Woodcock Reading Mastery Test-Revised, Word Attack subtest, plotted against performance, measured by percentile scores, on the Woodcock Reading Mastery Test-Revised, Word Identification subtest, for members of high (HRD) and low (LRD) groups, and of the control group (CG). The regression line and 95% confidence limits were derived from the CG data. Outliers are indicated by their case numbers.
Figure 2. Performance, measured by percentile scores, on the Woodcock Reading Mastery Test-Revised, Word Identification subtest, plotted against performance, measured by percentile scores, on the Woodcock Reading Mastery Test-Revised, Word Attack subtest, for members of high (HRD) and low (LRD) reading disability groups, and of the control group (CG). The regression line and 95% confidence limits were derived from the CG data. Outliers are indicated by their case numbers.
Exception Words

Figure 3. Performance, as measured by raw scores, on nonword reading, plotted against performance, as measured by raw scores on exception word reading, for members of high (HRD) and low (LRD) reading disability groups, and of the control group (CG). The regression line and 95% confidence limits were derived from the CG data. Outliers are indicated by their case number.
Figure 4. Performance, as measured by raw scores on exception word reading, plotted against performance, as measured by raw scores on nonword reading, for members of high (HRD) and low (LRD) groups, and of the control group (CG). The regression line and 95% confidence limits were derived from the CG data. Outliers are indicated by their case numbers.
These results therefore challenge the hypothesis that surface dyslexia is a developmental condition that dissipates as orthographic skills become more developed. On the contrary, in this group of students, the procedure applied to the experimental words identifies more students with surface dyslexia than it does the phonological type (eleven versus seven). On the standardized tests there are marginally more phonological dyslexics (eight versus five). Nevertheless, in both conditions, some cases are identified as the surface subtype. This is true even if only those who appear as the subtype on both sets of stimuli are included. Using this criterion, only two cases are identified for each subtype.

It would seem, therefore, that for some students, orthographic processing problems remain more severe than phonological processing problems. However, this exercise was carried out with chronological age controls rather than reading age controls. Stanovich et al. (1997) found in a similar simulation study that surface dyslexics disappeared when the confidence intervals were derived from reading level controls, though the phonological dyslexics remained. They also pointed out that "Virtually any data set that displays this pattern of relationships will reveal subtypes of poor readers with the characteristics that have been described by Castles and Coltheart (1993), Manis et al. (1996) and our investigation." (p. 124). However their simulation was based on the assumption that, by definition, students with dyslexia have a phonological coding deficit but no deficit in orthographic coding. This was not actually the case with the current experimental group, since they also read exception words significantly less well than the control group. A few students who continue to show relative difficulty utilizing the lexical route in comparison to the sub-lexical route do seem to remain at this age and level of education, and, in this study, they seem more likely to fall into the group who were the slowest readers.
5.8 Whole Group Analysis

To determine whether there is a combination of factors, which might predict membership in the three groups defined in this study, a discriminant function analysis was conducted on the whole group. In order to avoid a tautologous argument, timed reading comprehension was not included in the analysis. In order to maintain the stability of the procedure, Stevens (1996) cautioned against using a large number of variables. On the basis of indicators defined by study test results, eight variables were chosen: total time taken on the reading comprehension test; reaction times for reading regular, irregular and nonwords; WRAT-3 Spelling subtest percentiles; nonword raw scores; Rosner AAT percentages; and Woodcock Reading Mastery Test-Revised, Word Attack percentiles. The overall Wilk's lambda was significant (.17) chi-square (df = 16, N = 61) = 98.05, p< .001, indicating that overall, the factors were predictive. Also, the residual Wilk's lambda was significant (1.5), chi-square (df = 7, N = 61) = 35.15, p< .001. These results indicate that the predictors differentiated significantly among the three groups.

For the first discriminant function, the amount of time taken to read and the three reaction time scores, all had positive relationships. For the second discriminant function, WRAT-3 Spelling subtest percentiles, and Woodcock Reading Mastery Test-Revised, Word Attack subtest percentiles, nonword reading raw scores, and Rosner AAT percentage scores all had a positive relationship. On the basis of these results the first function appears to represent speed and the second to represent phonological coding ability. Assuming homogeneity of covariance matrices, the procedure classified 87% of cases correctly, 90% of the LRD group, 76.2 % of the HRD group and 95% of the control group. Using Box's M Test to discount assumptions of homogeneity of covariance of matrices, 90% of group membership was predicted (90% for LRD group, 86% for HRD group, and 95% for the control group) with a kappa of .80 (p< .001).
Table 18
Pooled Within-Group Correlations Between Discriminating Variables and Canonical Discriminant Functions

<table>
<thead>
<tr>
<th>Variable</th>
<th>Function 1</th>
<th>Function 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading total time</td>
<td>.84*</td>
<td>.26</td>
</tr>
<tr>
<td>Irregular words RT</td>
<td>.34*</td>
<td>.06</td>
</tr>
<tr>
<td>Nonwords RT</td>
<td>.33*</td>
<td>.02</td>
</tr>
<tr>
<td>Regular words RT</td>
<td>.33*</td>
<td>.08</td>
</tr>
<tr>
<td>Spelling percentiles</td>
<td>-.26</td>
<td>.61*</td>
</tr>
<tr>
<td>W.A percentiles</td>
<td>-.27</td>
<td>.57*</td>
</tr>
<tr>
<td>Nonword raw scores</td>
<td>-.18</td>
<td>.42*</td>
</tr>
<tr>
<td>Rosner AAT percentiles</td>
<td>-.16</td>
<td>.26*</td>
</tr>
</tbody>
</table>

Note. * denotes largest absolute correlation between each variable and either discriminant function. Reading total time = total amount of time taken to finish the Nelson-Denny Reading Test, Reading Comprehension subtest. RT = reaction time. W.A. = Woodcock Reading Mastery Test- Revised. Word Attack subtest.

The procedure reassigned two of the LRD group (case 5 and case 14) to the HRD group, and three of the HRD group (cases 22, 23, and 30) to the LRD group. One of the control group (case 50) was reassigned to the HRD group. The LRD group and the control group are therefore the most stable in terms of the predictor.
As Figure 5 illustrates, while well grouped around the centroid, the HRD group does tend to have a more continuous distribution with the other two groups. The majority of the HRD group falls into the sector defined as low on phonological processing and average on speed. The LRD group falls within the sector which defines adequate phonological processing but requiring most time, while the control group are clearly high on phonological functions and on speed. This adds some support to the idea that the LRD group does have a distinctive deficit related in some way to speed, rather than phonological processes per se.
Summary

In terms of whether, on both independent and composite component measures, students with dyslexia form a single distinct group, the answer remains somewhat ambiguous. On the one hand, there are a large number of elements on which the two RD groups do not differ significantly. However there are other elements where this does not seem to be the case. What is interesting is that the relationship between word recognition processes and reading comprehension ability is not a linear one for the RD group. The poorest group of readers does not have the poorest word recognition skills. They do, however, show evidence of both a speed deficit and a listening comprehension deficit. In this sense there are indications that more than one type of reading disability group exists. The discriminant function analysis appears to support this.

In terms of responding to the notion that university students with dyslexia have skills that are arrested rather than delayed, both the LRD and HRD groups show significantly low scores compared to the control group on a variety of tasks. These tasks appear to constitute a syndrome of difficulties that have clearly persisted into adulthood. Given their age and successful academic history, developmental issues are unlikely to be the source of these students' difficulties with reading comprehension and word recognition tasks. It seems safe to conclude that their skills are indeed arrested rather than delayed.

However, it is important to keep in mind that there is a considerable range of individual difference among the groups. Ultimately, both the discriminant function and the scatter plot exercises would seem to confirm Ellis's (1985) contention that the overall pattern of reading disability is one of a continuum with the general population of readers.
CHAPTER 6: DISCUSSION

The results of this study appear to have confirmed parts of the theoretical framework which has developed in the field of reading disability, and, perhaps, added some weight to other more contentious viewpoints, most of which have been developed through the study of younger readers. Other assumptions have been challenged by the present results. In terms of the widespread acceptance in the field that decoding is the core deficit in dyslexia, (Bruck, 1990; Gough & Tunmer, 1986; Rack et al., 1992; Share & Stanovich, 1995; Shaywitz, 1996, 1998; Shaywitz, Fletcher, & Shaywitz, 1996; 1998; Siegel, 1988; Snowling, 1996; Stanovich, 1990; Vellutino, 1977), there is certainly support for this concept in terms of its persistence into adulthood. Compared to their peers without a reading disability, many of the readers who had a previous history of reading problems showed evidence of depressed performance on the various phonological coding measures such as word decoding, spelling, and phonological awareness. However, the results do not present unambiguous support for this being the core deficit in all reading comprehension difficulty. They do not illustrate a clear linear connection between poor phonological coding skills and poor reading comprehension levels. The group of readers with the poorest reading comprehension performance did not appear have the poorest decoding skills.

It is important to note that, while the majority of students with a previous history of reading difficulty scored at or below the 30th percentile on the timed Nelson-Denny Reading Test, Reading Comprehension subtest, not all the students with a previous history of reading difficulty performed at below expected levels on this test. Given that they were defined as a group by their unexpectedly low scores below the 15th percentile on this subtest, the entire LRD group can be excluded from this consideration. However, the HRD group results presented a
more heterogeneous picture. The mean score for the group on the reading comprehension subtest was at the 31st percentile. While the majority of this group (57%) scored between the 15th and 30th percentile on the reading comprehension test, a score that would still qualify as an unexpectedly low score for students at the university level, the remaining students scored between the 30th and the 45th percentile. Two outliers scored at the 54th percentile and the 61st percentile, and simply on the basis of the reading comprehension scores, would not have been out of place within the control group. Two possibilities arise in terms of these outliers. Either they have been misdiagnosed or they fall into the category of compensated readers described by Bruck (1990) and Gallagher, Laxon, Armstrong, and Frith (1996). The control group achieved a mean at the 74th percentile on the reading comprehension test, but the range of scores attained by group members stretched from the 35th percentile to the 94th percentile. Nevertheless, 80% of the control group score above the highest score (61st percentile) attained by the best performance of a reading disability group member.

It was expected that, with unlimited time, all groups would attain comparable reading comprehension scores. In the untimed situation, the differences between all the group means on this test were, in fact, diminished to the point where they were not statistically different. However when the RD groups were collapsed together, the means were significantly lower than those of the control group. In actual terms the mean scores of the RD groups are 11-13% lower than those of the control group. It is clear that, while extra time helps all the students approach comparable reading comprehension proficiency, even with extra time, the RD groups remain less proficient at reading comprehension performance. It is important to emphasise that the final reading comprehension levels achieved by the RD groups are a function of time as well as performance ability. The time taken to achieve these reading comprehension results varies
between the groups. The LRD group took almost twice as long as the control group to achieve similar comprehension results, while the HRD group took only one third as long. The LRD group is clearly more severely disadvantaged in timed situations.

A relatively simple answer to the differences in comprehension performance between the three groups would be that they differ in level of vocabulary knowledge. Given the cloze format of the tests, this might be especially true for the listening comprehension assessments. Perhaps the LRD group simply has a smaller store of word meanings from which to draw. Yet, in terms of performance on the vocabulary tests, both the LRD and HRD groups have equivalent levels of knowledge, and while lower than the control group, their vocabulary scores, especially on the WAIS-R are above average. Word knowledge cannot therefore account for either the difference in reading comprehension levels between the LRD and HRD groups, or the difference in scores on the cloze listening comprehension test. Similarly, both of the RD groups demonstrated scores on the exposure to print measures that were equivalent. Differences between these two groups, in terms of word knowledge as a result of differential exposure to print, also cannot be used to explain any differences in word recognition ability.

A major question therefore arises, as to whether there is more than one process reflected in the span of timed reading comprehension scores achieved by the students who have a reading disability. Do the LRD and HRD groups really reflect the presence of two different subtypes of reading disability, or are they simply a continuum of one group, and indeed of all readers? If they can be defined as two groups, is a separate speed deficit, or some other sort of timing deficit interacting with word recognition skills? Is there evidence for the subtypes proposed by the dual-route model? The "simple view" of reading proposes that reading comprehension is the product of two elements, listening comprehension and decoding ability. This has proven to be a useful
framework for the investigations undertaken in this study. It has also proven to be helpful in the
discussion of the test results.

The HRD group defined in this study demonstrated patterns of performance on the
relevant tests which appear to support the familiar interpretation of the "simple view", that a
deficit in decoding ability, in the presence of unimpaired listening comprehension ability,
explains poor reading comprehension performance. Group members achieved listening
comprehension scores which, at least on material delivered at normal speaking speed, did not
differ from those of the control group. Even on the speeded delivery, their performance was
superior to that of the LRD group. In fact, when the comparative results are computed using raw
scores rather than normative data, the HRD group did not differ significantly in performance
from the control group on the faster delivery condition either. The same proved to be true on the
timed and untimed "reading while listening to text" condition. In terms of decoding ability, the
HRD group attained only a mean score at the 43rd percentile on the Woodcock Reading Mastery
Test-Revised, Word Attack subtest. Compared to the control group, they also attained
significantly lower accuracy rates when reading regular, irregular and nonwords, when spelling,
and when demonstrating phonological awareness ability. There is, therefore, substantial evidence
to support the contention that the HRD group does have impaired decoding ability, but
unimpaired listening comprehension ability. In terms of the "simple view", their reduced timed
reading performance (a mean score at the 31st percentile on the timed, Nelson Denny Reading
Test, Reading Comprehension subtest) could be accounted for by poor decoding skills.

However, the inverse of the "simple view" seems more applicable to the LRD group.
Under timed conditions on the Nelson-Denny Reading Test, Reading Comprehension subtest,
group members achieved a mean score at only the 5th percentile. Yet they achieved a mean
percentile score at the just below the 60th percentile on the Woodcock Reading Mastery Test-Revised, Word Attack subtest. While this latter result is significantly lower than that of the control group, (CG mean score was at the 80th percentile) it is, nevertheless, well within the average range of the standardized test norms. The group also scored at levels comparable to the control group on tests of phonological awareness and the reading of regular words. Compared to the HRD group, they scored relatively higher on spelling ability, and nonword reading. At the same time, they exhibit significantly reduced listening comprehension skills when compared to both the control group and the HRD group. This performance occurs even in an untimed situation where material is delivered at normal speaking speed (115 wpm.). The LRD students therefore appear to show evidence of reduced listening comprehension ability and may be demonstrating a general linguistic processing deficiency, not a phonological coding one. Nation and Snowling (1997, 1998a, 1998b) described such a group of "poor comprehenders".

Therefore two key features appear to distinguish the LRD group, poor listening comprehension skills, and slow speed. The nature of the speed deficit is, however, unclear. The presence of a separate timing deficit, in the form of a deficient automatized recall mechanism, has been proposed as a cause of reading disability (Bowers, 1988, 1991, 1995; Bowers, Steffy, & Tate, 1988; Bowers & Swanson, 1991; Korhonen, 1995; Nicolson & Fawcett, 1994; Wolf, 1991, 1997; Wolf & Obregon, 1992; Wolf & Segal, 1992; Wolff, Michel, & Ovrut, 1990). Wolf (1997) described the timing deficit as the gap between each stimulus. A delay in moving from one stimulus to another would naturally reduce automaticity. An increase in the complexity of a task exacerbates the deficit. Bowers (1991), Bowers and Wolf (1993a), and Wolf (1997), have proposed that impaired readers can be divided into three groups, those with poor phonological skills, those with a timing deficit, and those with a double deficit. Their poorest comprehenders
showed evidence of both a timing deficit and a phonological deficit. The poor comprehenders of the LRD group could therefore be reflecting the presence of just such a double deficit. However, they do not seem to have a particularly severe phonological deficit. They also did not appear to have difficulty performing on the RAN types of tests (Denkla & Rudel, 1976) usually used to measure a timing deficit. The results on the test using digits and the test using letters demonstrated no significant difference in performance between the groups, though as Biemiller (1977-8) pointed out, this may be a reflection of an adult population having reached its maximum oral reading speed. Or it may mean that the specific timing deficit measured in younger children is a developmental issue and disappears with age and reading experience. Chiappe et al. (1997), testing an adult sample using various RAN tests, also did not find substantial evidence for a separate timing deficit. It is also possible that the RAN measures, used to identify a timing deficit in children, are simply not sufficiently complex to tap the deficit in this older population. Nicholson and Fawcett (1994) found that the largest increases on reaction time measures occurred on complex lexical decision tasks.

Reading words and passages does constitute a complex lexical task, and reaction times for word naming did produce some significant results. Perfetti and Hogaboam (1975) suggested that children who were poor comprehenders read single words, especially low frequency words and nonwords, more slowly than their peers. Despite the finding that there was no significant difference between the LRD group and the control group on accuracy for reading the experimental regular words, the LRD group was significantly slower than the control group to reach this accuracy level. The LRD was also the slowest of the three groups when reading the irregular and nonwords but, at least on the nonwords, they had better accuracy rates than the HRD group. In fact, compared to the control group, in percentage terms they took 37% longer to
read regular words, 59.9% longer to read irregular words, and 76.6% longer to read nonwords. Comparable figures for the HRD group were 14.9%, 26.2% and 35.2%. Interestingly, both the LRD and the HRD groups took 20% longer to read nonwords than irregular words, while the control group took only 12% longer, though the HRD group was the least accurate. All these differences proved significant.

The LRD group's slower rate of reading, compared to the control group, was also evident on the Biemiller Test, though there was no significant difference between the performance of the reading disability groups on this test. Both the LRD and the HRD groups read words and passages more slowly than the control group. In terms of the differential between letter and word reading time, the LRD group had the largest difference in time. All groups appeared to benefit from a context effect in that they read words in context faster than they read isolated words from the same passage. The LRD group did seem to benefit less from context reading than either of the other two groups.

However, the discriminant function analysis does provide some confirmatory evidence for speed being, in some way, a defining feature of the LRD group. This statistical procedure proved interesting because, the factors chosen reflected phonological processing and speed, and the sample did divide, essentially, along group lines. There was surprisingly little overlap in terms of reassignment of group membership. This is particularly intriguing given the lack of observed statistically significant difference in the between group scores of the LRD and HRD groups on all the timed tests except the reading comprehension and the "reading and listening to text" condition. The discriminant function considers factors on a case by case basis, and gives a more specific picture of group characteristics than is possible using group means.
In summary, drawing conclusions about a connection between reading comprehension levels and some sort of timing or speed deficit is problematic, because the picture provided by these results is not entirely consistent. The LRD group certainly takes longer to read individual words but they are only relatively, and not statistically significantly, slower than the HRD group. The potential for a timing deficit does not appear using the usual tests that define this process, the RAN tests. Nevertheless, the LRD group is clearly slower at reading connected text. Therefore, the LRD group does seem to demonstrate some effect related to speed, though it is not possible to draw any definitive conclusion about whether this constitutes a separate timing deficit. Since the group does not exhibit a severe phonological coding deficit, its members would not appear to be analogous to the double deficit "poor comprehenders" described by Wolf (1997). It is also important to remember that they performed poorly on two listening comprehension tasks that involved neither text reading, nor time constraints.

Chiappe et al. (1997) hypothesised that slow naming times in adults might be indicative of, not a separate timing deficit, but of a word retrieval problem. The LRD group seems to show some evidence that this notion might describe the difficulties they experience as they try to construct meaning from material presented in either oral or written form. For example, on the listening tests, because of the cloze format, the students had to listen to a passage that contained a blank space, and supply an appropriate word. The task therefore involved understanding and encoding the oral information, constructing meaning and then retrieving an appropriate word to complete the sense of the sentence. No time constraint was involved. The students could take as long as they liked to think of a word. Yet they had difficulty with the task even when the information was presented at regular speaking speed. Both the other two groups were able perform much more efficiently on this task than the LRD group. The LRD group may have had
difficulty encoding the information correctly. They may have experienced a delay in word retrieval, and the entire sentence may have decayed in memory before they could respond. Or they may have experienced both an input and an output problem. What is interesting to consider, however, is that they had no difficulty on the orally presented phonological awareness task, the Rosner AAT. Their scores on this test were equivalent to those of the control group. This may indicate that the LRD group has less difficulty processing orally presented phonological tasks than they do processing semantic ones.

As has been mentioned previously, it has been proposed that poor reading comprehenders have deficits beyond reading ability, and that they demonstrate evidence of a more global linguistic deficit (Stothard & Hulme, 1992, 1995; Nation and Snowling, 1998a). These writers have characterized this as a deficit in listening skills, verbal ability, and receptive language skills. It has also been proposed that readers with phonological dyslexia have, not deficient phonological processes per se, but inaccurate underlying mental representations of phonological codes (McDougall et al., 1994; Swan & Goswani, 1997). This would seem to be consistent with work which has identified difficulty processing speech at the phonemic level among dyslexic children (McBride-Chang, 1995a; Manis et al., 1997; Tallal, Miller, & Bedi, 1996). Inaccurate speech perception is likely to result in inaccurate phonological code storage. If this process is possible for those with phonological coding problems, perhaps it is logical to assume that a similar deficit in semantic coding is possible for those with a more generalized linguistic deficit which includes poor listening skills.

Nation and Snowling (1998b) discussed the importance of the development of, not only phonological coding, but also semantic coding, in the growth of reading skills. Without resort to discussion of a dual-route model, they emphasised the importance of the interaction between
phonologic and semantic ability in the construction of meaning. Using their connectionist model of word recognition, Plaut et al. (1996) have simulated the interdependence of these two processes in reading. As with the LRD group in the present study, Nation and Snowling (1998a) found that their group of poor comprehenders showed no evidence of a deficit when reading regular words. Their participants also had no difficulty reading high frequency words, but they did have difficulty recognising low-frequency exception words, the type of words that are generally read in text with the assistance of semantic support. As Share and Stanovich (1995) pointed out, low frequency words are likely to give poor readers most difficulty, and yet they make up the main content words of a passage. If the LRD group suffer from a generalized linguistic deficit, they may not, as Bruck (1990) suggested of her adult students with dyslexia, have developed accurate orthographic images of multi-syllabic words, or, for that matter, irregular and low frequency words. Lack of adequate semantic coding is likely to result in delayed word retrieval. Confirmation of this hypothesis, in future investigations using a larger number of more carefully chosen low frequency words, would be appropriate.

Plaut et al. (1996), using the connectionist model to show the interaction effect of phonologic and semantic pathways, damaged the semantic pathway of their model in order to see the effect of having the phonologic pathway act alone. They found that they thereby simulated the condition of surface dyslexia. Exception word reading was impaired. If LRD group members do have a deficient semantic process rather than a phonological coding one, they should have better decoding skills than they do orthographic skills. While the instruments used in the present study to assess this ability were not particularly sophisticated, they did indicate a possible orthographic deficit relative to word decoding ability. On the standardized Woodcock Reading Mastery Test-Revised, Word Identification subtest, both the groups with reading disability, once again, scored
significantly below the level of the control group. But no significant difference was observed between scores on the Word Identification subtest and the Woodcock Reading Mastery Test-Revised, Word Attack subtest for either of the two RD groups. In relative terms, the HRD group scored at essentially the same percentile level on both tests, while the LRD group mean score was lower on the Word Identification subtest than it was on the Word Attack subtest (51st percentile as opposed to the 59.7th percentile).

In terms of the results on the experimental words, compared to the control group, both RD groups demonstrated equally reduced ability to pronounce irregular words. However, it is important to recall that the LRD group did not perform significantly differently from the control group on reading regular words. This meant that they showed the greatest regularity effect of all three groups. Nevertheless, in statistical terms, there is no significant between group difference for the two reading disability groups on the accuracy of reading any of the three types of word. There was also no within group difference in the reading of irregular and nonwords. In terms of the word strings, another measure of word recognition, again both the RD groups recognised fewer words than the control group but their scores were not different from each other. Relatively speaking, the lowest reading group actually recognised more words than the HRD group, just as they did on the standardized Word Identification test. In short, the tests used in this study indicated the potential for the LRD group to have a deficit in orthographic processing, but failed to identify a significant deficit in this ability. Clearly further investigation in this area, with better test instruments, should be considered in the future.

The question then arises as to whether the LRD group has elements in common with the subtype described as "surface dyslexics" and whether the HRD better resembles the group termed "phonological dyslexics" (Castles and Coltheart, 1993). These researchers proposed that
word recognition takes place via dual routes, the lexical route for irregular and familiar words, and the sub-lexical route for unfamiliar words. Unlike in the connectionist model, these routes are believed to act separately rather than reciprocally. Phonological dyslexics show an impairment of the sub-lexical route, while surface dyslexics are impaired in using the lexical route. Essentially, the HRD group do resemble the "phonological dyslexics" defined in the Castles and Coltheart (1993) study.

However the LRD group presents a less straightforward match to surface dyslexia. Or perhaps surface dyslexia contains more complexity than simply deficient lexical processing. As a whole, the group had little difficulty reading regular words, found it relatively difficult to read irregular words, and were relatively proficient at reading nonwords. The group does, therefore, approach the profile proposed for surface dyslexia. It is worth repeating, that, in relative terms, on the Woodcock Reading Mastery Test-Revised, Word Attack and Word Identification subtests, the LRD group mean percentile scores indicate that the group members have decoding skills that are less impaired than their word recognition skills. The regression based scatter plots seem to support the trend toward inclusion in a specific group. Even though relatively few of the total group actually falls outside the 95% confidence limits established from the control group scores, the majority of those defined as surface dyslexics, essentially, claim membership in the LRD group. If they are defined as "phonological" types they tend to fall into the HRD group. This exercise was useful because it considered the data on a case by case, rather than a group mean, basis. It is important to remain cautious about jumping to generalised conclusions on the basis of this individual data.

However, it should be noted that, on this exercise, there was not an overwhelming number of either surface or phonological dyslexics identified. In fact, considerably fewer
phonological dyslexics were identified than would be expected in comparison to samples of younger children reported in the literature (Castles & Coltheart, 1993; Manis et al., 1996; Stanovich et al., 1997). Stanovich et al. suggested that surface dyslexia could be linked to low levels of exposure to print. Lack of reading experience could result in the poor development of specific word knowledge, especially orthographic knowledge of exception words. If this were the case, surface dyslexia would be likely to disappear as reading experience increased. However, in this group, there was no distinction in levels of print exposure or word knowledge between the LRD and HRD groups. In addition, the scatter plot produced some evidence for the continuing occurrence of surface dyslexia beyond childhood. The question remains of whether surface dyslexia is simply reflective of a lexical inefficiency, or perhaps the result of a more complex interaction of deficient semantic and visual processes.

Surface dyslexia has been linked to possible visual processing deficits in the initial encoding of exception words (Castles & Coltheart 1993; Manis, et al., 1996). Reading connected text also involves both visual and cognitive processes. The LRD group could simply have difficulty at the level of initial encoding of words and sentences because of a visual processing inefficiency. Certainly a group of researchers continues to pursue the visual deficit hypothesis of reading disability (Eden, VanMeter, Rumsey, and Zeffiro, 1996; Hickey & Guillery, 1981; Kruk, 1991; Livingstone, Rosen, Drislan, & Galaburua, 1991; Lovegrove, Heddle, & Slaghuis, 1980; Lovegrove, Martin, & Slaghuis, 1986; Rayner & Pollatsek, 1993; Slaghuis, Twell, & Kingston, 1996; Watson & Willows 1995; Willows, 1991; Winters, Patterson, & Shontz, 1989). It has been suggested that good readers use the information they obtain from the periphery of the visual field. They are beginning to process the visual features of the next word even as they fixate on the word being processed (Rayner & Pollatsek, 1989). It is therefore possible that the LRD group
members are unable to take advantage of this process because of a deficient fixation process. Perhaps a combination of deficient visual and orthographic processes causes them to read slowly. At this point some researchers seem to accept that some combination of visual and other processes exists in the etiology of dyslexia (Aaron, 1993; Eden et al., 1996; Goulandris & Snowling, 1991; Slaghuis et al., 1996; Watson & Willows, 1995; Willows, 1991). However a visual processing deficit would not explain the LRD group's poor performance on the two listening tests which did not involve the use of text, because no visual stimuli were involved. Their language processing difficulties extend beyond the possibility of a visual processing deficit.

The slow word recognition difficulty experienced by the LRD group must become a cumulative problem when reading text. It is generally assumed that compared to good readers, poorer readers rely more on context to comprehend text, because they use semantic information to compensate for inefficient word recognition ability (Ben-Dror et al., 1991; Bruck, 1990; Daneman, 1993; Stanovich 1980; Stanovich et al., 1981). Nation and Snowling (1998a) suggested that this was probably true for readers with dyslexia. Such readers might compensate for a phonologically based word recognition problem by constructing meaning from context. Essentially they are able to identify words using information gained from partial word decoding mixed with context clues. Studies have confirmed that dyslexic readers can develop superior orthographic skills (Hulme & Snowling, 1992; Siegel et al., 1995; Snowling, Hulme, & Goulandris, 1994). However, Nation and Snowling (1998a) suggested that those with poor general linguistic skills, the "poor comprehenders" are unable to make good use of context facilitation because of a deficit in semantic information processing. Their poorer general linguistic skills make constructing meaning a difficult task. If they experience a general delay in
word retrieval, this lack of automaticity will reduce the ability to construct meaning. They are then very disadvantaged when trying to construct meaning from text.

Finally, to return to the results on the timed reading comprehension test, the LRD group members are poor, slow comprehenders compared to their unimpaired peers. They are also disadvantaged when compared to members of the HRD group. The HRD group would seem to resemble a more classic profile of readers with dyslexia, because members appear to have a deficit in phonological coding. The group was therefore likely to be able to benefit, when reading, from use of partial decoding of words, together with the use of contextual clues to assist in the development of semantic understanding. In contrast, the LRD group, showed less evidence of impaired decoding ability because members demonstrated no impairment in phonological awareness, could read regular words with an efficiency equal to the control group, and had relatively unimpaired phonological coding skills. The LRD group appears, therefore, to have a generalised linguistic processing deficit that is evident in performance on both reading and listening comprehension tests. This may have resulted in the development of a deficient semantic coding process. While the group can decode regular words without difficulty, members are likely to face problems reading low frequency words, the very words that make up the content words of a text. It is possible, therefore, that they are not able to benefit, to any great extent, from such semantic information. Trying to construct meaning from text with this type of deficit would be very likely to result in slow, and perhaps inaccurate reading comprehension.

In short, there are no clear answers to explain the position of the LRD group. The question of whether they experience a separate timing deficit in addition to, or as part of, a general linguistic difficulty, remains. However, it does not seem necessary to invoke the concept of a separate deficit if they do, indeed, have inefficient semantic coding and a related word
retrieval problem. It is important to remember that the LRD group experienced difficulty retrieving words on listening tasks that were not measured in terms of time, as well as on reading tasks. Even when listening at normal speaking speed, when they had as much time as they wished, without penalty, to retrieve the correct word, but they had great difficulty doing so.

The hypothesis that the difficulties experienced by the LRD group arise from a general linguistic deficit which may result in deficient semantic processing, seems at this point to be the most comprehensive explanation of their slow reading comprehension process. If this is the case, the two groups of students with reading disability should be considered as distinct. The HRD group appears to demonstrate the specific core deficit associated with dyslexia, deficient phonological coding ability. The LRD group appears to be more seriously disadvantaged poor comprehenders who have relatively intact phonological skills but poor linguistic skills.

The strength of this study is that it has assessed a wide range of component skills in reading. Other studies of adults have tended to focus narrowly on separate aspects of the reading process. Consideration of this variety of variables has permitted an investigation of how the component parts of reading can interact to produce poor reading ability. The study suggests that the reading disability population is more heterogeneous than was expected in terms, both of the etiology, and of the effect of deficient processes in component skill areas. It is clear that reading skill deficits observed in beginning readers are robust enough to persist into adulthood, and remain a limitation even in a highly educated, otherwise high achieving, academic population.

Limitations of the Study

A number of methodological limitations can be delineated in this study. The most important is the size of the sample groups. While the size of the entire sample (61) is acceptable,
a group sample of 20 is, while statistically acceptable, still small. Collapsing the two disability
groups together for a number of statistical procedures made some difference to the results. Yet
analysis of between group comparison is limited when group sizes are so unequal (RD = 41, 
CG = 20). Furthermore, in a small sample, outliers take on a specific importance in terms of their
influence on the group means. The Woodcock Reading Mastery Test-Revised, Word Attack
subtest results are thus skewed downward by outliers in the HRD group, and skewed upward by
outliers in the LRD group.

Any discussion of semantic pathway or lexical route deficiency should include solid
assessment instruments. The instruments used in this study were not sufficient to give an
unequivocal answer. A defensible list of age appropriate low frequency words should be
included.

Delivery of the "listening with text" condition was not well controlled. Students were
able to read ahead of the tape, rewind the tape, and pause the tape. This makes the times recorded
of little use. Only the untimed comprehension level can be considered as a reliable group
comparison, though the timed scores do give a subjective indication of group difference.

It may be true that the LRD group has a genuine timing deficit. The unimpaired scores on
the RAN may be the result of instrument design. More complex timed tasks may be better
instruments to tease out this deficit among students at this age and educational level.

It would have been useful to include some sort of capacity test in the battery. The
inclusion of the Wechsler Adult Intelligence Scale-Revised, Digit Span subtest and the
California Verbal Learning Test, or an equivalent, would have given information of this sort.
This could have been helpful in further assessing the difficulties experienced particularly by the
LRD group.
Implications of the Results for Postsecondary Service Providers

It is important to explore whether the information gleaned from this study can be applied in a clinical environment to operationalize the concept of reading disability with more specificity than has been the case to date.

Assessment

Reading Comprehension Tests.
As has been discussed in the literature, not all reading comprehension tests measure the same constructs. Choice of testing instrument can have a considerable effect on the conclusions drawn from the results. It is clear from this study that inclusion of a timed reading component is critical to accurate diagnosis of reading disability. Timed performance is the initial key factor that accurately distinguishes students with a reading disability from their peers.

Reading text rather than simply sentences or single words is important at this age level in determining a diagnosis. The poorer readers in this study would probably not have been diagnosed on the Wide Range Achievement Test, Reading sub-test because they could probably have performed well reading single words. Similarly the untimed Woodcock Reading Mastery Test-Revised, Passage Comprehension subtest, involves reading only one sentence and supplying a missing word. Many students at the university level have little difficulty with such a task because the sentences lack complexity, they have unlimited time to read and re-read the sentence, and they can eventually glean the meaning and call on their good vocabulary ability to find an appropriate answer. Extended passages of reading are likely to give a better approximation of real life reading conditions at this educational level.
Listening Comprehension. Listening Comprehension is not frequently included in a test battery. It is certainly not measured at two different speeds of delivery. Yet such tests produced critical individual differences in this study. It is clearly an essential skill to measure. In fact, the converted Woodcock Reading Mastery Test-Revised, Passage Comprehension subtest worked well in this context. Listening without resort to text is also clearly a distinguishing test condition.

Orthographic Skill. It also seems important to include a test of words defined by their orthographic structure. The distinction between regular, irregular, and low and high frequency words ensures measurement and identification of individual differences in word recognition.

Phonological Coding Ability. Nonword tests to measure phonological coding ability are an essential component of the test battery, as is a spelling test that involves the student actually writing the word rather than simply identifying which word is correct. A reaction time component, once some sort of base of normative data is established, is also clearly helpful.

Vocabulary. At least one vocabulary test which involves a test of the student's definitional knowledge would seem essential.

Memory Capacity. Inclusion of a capacity test of verbal memory would seem to be necessary.

Standardized Tests and Diagnosis. Service providers should keep in mind that, even if tests are normed for a university level population, and many are not, students may have developed compensatory strategies which permit them to score quite highly on some tests. It is important to remember that standardized tests are only one way of measuring reading disability, and average or above average results on some tests do not necessarily imply that the student does not have a disability. Canadian service providers have tended not to embrace a discrepancy definition formula for diagnosis. This was clearly a wise decision since it permits the clinician to exercise professional judgement in the interpretation of test results. However, the notion of specificity of
deficit should be respected. Clinicians would be wise to identify specific deficits of the type described in this study, rather than broad categories of "processing problems".

**Accommodations**

**Books On Tape.** On the surface, the listening comprehension test results gave little support to the efficacy of providing taped reading material as a blanket accommodation to all students with reading disability. Despite the widespread belief in its efficacy, it does not seem to improve either speed or accuracy of comprehension for the poor comprehenders. It may be helpful to dyslexic students who can use recorded text to compensate for inaccurate word reading. Though they appear to have a deficit in listening comprehension, the poor comprehenders may benefit from books on tape as a means of constructing semantic meaning. However this would seem to be a very individual decision. Given sufficient time, all the students in this study proved to be more efficient readers than listeners. Anecdotal evidence suggests listening to text may make reading less stressful for some students. This is not an insignificant factor.

**Computers.** Ability to use computers for exams and papers has been a long-standing accommodation for students who have a reading disability. The spell check feature alone, is a boon to dyslexic students. Recommendations on using voice feedback computers need to be considered in the same light for students whose skills approximate those of the poor comprehenders. It may assist them to proof read their work more independently. Once again, such systems might be more useful to the clearly dyslexic group who have significant spelling problems, yet can recognise errors using voice feedback. In general, students with reading disabilities have found computer technology to be an aid to more independent action. Voice recognition computers are a relatively new accessible device that can assist students who are more fluent at producing spoken language than they are the written form.
Extra Time. The provision of extra time to process reading material is clearly of major importance to both groups, but the poorest comprehenders may require more time than the standard "time and one half" that is currently granted.

Notetakers. Both groups are likely to benefit from provision of a notetaker in a lecture situation. As poor listeners, the poor comprehenders clearly may face difficulty taking information in accurately enough to write complete notes. The students with dyslexia are likely to require a notetaker for a different reason. Taking lecture notes requires a succession of processing tasks, from comprehending speech, to retrieving words from memory, to writing the words down, while at the same time comprehending the succeeding speech input. Simply writing the words in a coherent form, given their inability to spell, means they frequently cannot keep up with the speed of information delivery.

Service providers play an important role in the success of university students who have a reading disability. Given the nature of deficits experienced by these students, and the nature and expectations of university communities, it is not difficult for the academic community to measure these students' disabilities rather than their abilities. It is the role of the service provider to ensure that abilities are measured, by providing accommodation and support to each student, and also to professors. Supportable explanations of the cause and consequences of the disability are an essential element of this for both the student and the professor. It is hoped that this study has shed some light on both the possible causes, and the likely manifestations, of having a reading disability. The students who took part in this study and have moved on to careers or higher study, are proof that students who have a reading disability can succeed even in a highly competitive academic milieu.
BIBLIOGRAPHY


Alert (1998). Newsletter of the Association on Higher Education and Disability. 22, 19-34. Columbus, OH.


APPENDICES

Appendix One

Information Letter
Permission Form
Intake Form
October 20th 1997

I am conducting a study which will investigate levels of listening and reading comprehension in students studying at the post secondary level. Its objective is to see whether students who have a reading disability, or who think they might have a reading disability, have comprehension levels that are different from students without it. I would like to invite you to be a participant in this venture.

Your participation will take the form of an interview about your past academic history, and a series of achievement tests in reading comprehension, listening comprehension, spelling, and vocabulary acquisition. Total testing time will be approximately 3 hours, and will take place in two separate sessions. In the presentation of the results of the study only information from the whole group of scores collected will be used. None of your individual scores will be identified in the results. However, you can receive a report of your results if you wish. Testing will be administered on both an individual and a group basis and the results will be stored as confidential information and released to you alone.

You, of course, can withdraw from the project for any reason at any time, and can request that we remove your results from the study at that point. If you have any further questions about your participation, please call me at 398-6009.

Thankyou for considering being part of this project.

Sincerely,

Joan Wolforth M.Ed.
I, ................................, would like to be part of the project which is looking at reading and listening comprehension levels of students studying at the post-secondary level.

Signed: ...................... Date: ....... Phone: .........
<table>
<thead>
<tr>
<th><strong>Intake Form</strong></th>
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<tbody>
<tr>
<td>Name:........................................... Subject Number:........</td>
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<td>Full-Time.............. Part-Time............</td>
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<td>Number of Courses, Current Semester:................</td>
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<tr>
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<tr>
<td>Other Province/Country.............</td>
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<tr>
<td>High School Grad. Date:.. Year........Month ......</td>
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<tr>
<td>High School Grad Average:.... Percent: English Average.....Percent</td>
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<tr>
<td>CEGEP Grad. Programme:..................................</td>
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<tr>
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<tr>
<td>CEGEP Grad. Average:.....Percent:English Average.....Percent</td>
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<td>CEGEP Grad Average, English:........Percent</td>
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<td>Previous Problems with Reading (Non-Diagnosed):YES....NO....</td>
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Appendix Two

1. Rosner Auditory Analysis Test
2. Letter Strings
3. Experimental Words (Castles and Coltheart, 1993)
4. Author Recognition Checklist
5. Magazine Recognition Checklist
6. RAN Digits
7. Biemiller Test: Letters
8. Biemiller Passage One; Words One
9. Biemiller Passage Two; Words Two.
Rosner Auditory Analysis Test

Now I am going to say a series of words that I want you to repeat. Then I will tell you to take part of the
sound off the word and say what is left. We will start with an example of what I mean. "Say 'cowboy'."
Wait for the response. "Now say 'cowboy' without the 'boy' sound." Wait for the response. "Say
'toothbrush'." Wait for the response. "Now say 'toothbrush' without the 'brush' sound." Wait for the
response. "Say sat". Wait for the response. "Say 'sat' without the /s/ sound". If the student fails any of
the practice items, explain the task by giving the correct response. If the items are answered correctly,
then proceed. Testing for all participants ends after five consecutive errors.

Check each item answered correctly.

1. birth(day)___
2. (car)pet___
3. (man)___
4. ro(de)___
5. (w)ill___
6. (l)end___
7. (s)our___
8. (g)ate___
9. to(ne)___
10. ti(me)___
11. plea(se)___
12. stea(k)___
13. bel(t)___
14. (sc)old___
15. (c)lip___
16. (s)mile___
17. (p)ray___
18. (b)lock___
19. (b)reak___
20. s(m)ell___

21. (t)rail___
22. de(s)k___
23. (sh)rug___
24. cr(e)ate___
25. s(m)ack___
26. re(pro)duce___
27. s(k)in___
28. s(w)ing___
29. (st)rain___
30. g(l)ow___
31. st(r)eam___
32. c(l)utter___
33. off(er)ing___ answer, [offing]
34. dy(na)mo___ answer [dimo]
35. auto(mo)bile___answer [autobeel]
36. car(pen)ter___answer [carter]
37. Ger(ma)ny___ answer [journey]
38. lo(ca)tion___ answer [lotion]
39. con(tin)ent___ answer [content]
40. phi(lo)sophy___ answer [fisophy

(some dialects, fihsophy)]
WORD RECOGNITION

Below you will see a list of 81 letter strings. Some of the strings are actual English words and some are not. You are to read through the list and indicate whether or not you think the letter string is a word by putting a check mark next to those you know to be words.

DO NOT GUESS. CHECK ONLY THOSE YOU KNOW TO BE WORDS.

1. absolution__  20. hyplexion__  49. reverent__
  2. aisle__      30. ineffity__  50. rohead__
  3. amoeba__     31. inflect__   60. selement__
  4. angel__      32. inundate__  61. sheal__
  5. answer__     33. irksome__   62. sparkhouse__
  6. arrate__x    34. island__   63. stomach__
  7. asinine__    35. junior__   64. strategem__
  8. audible__    36. lacuna__   65. subjugate__
  9. celloplaty__x 37. languor__  66. substratum__
 10. cellist__    38. metenation__x  67. subtle__
 11. chaos__      39. laudatory__ 68. succede__
 12. chorus__     40. liquor__   69. suflce__
 13. clandestine__ 41. litany__   70. suflse__
 14. colonel__    42. metenation__  71. tenacious__
 15. conecial__x  43. monkey__  72. tradured__x
 16. concurrent__ 44. neotatin__x  73. tuncier__x
 17. conference__ 45. niche__    74. ubiquitous__
 18. connote__    46. nitrous__  75. uniontion__
 19. denotation__ 47. nonquasity__x  76. unmanal__x
 20. denouement__ 48. nuance__  77. vacuum__
 21. disconcert__ 49. optimize__  78. wanderlust__
 22. disler__x    50. pastry__  79. waterfowl__
 23. dropant__x   51. plabege__x  80. xenophobia__
 24. epicurean__  52. polarity__  81. yacht__
 25. eventuate__  53. potomite__x  x = foils (nonwords)
 26. facade__    54. purview__
 27. fusigenic__x  55. ravine__
 28. gustation__  56. receipt__
 29. heuristic__  57. recidivism__

x = foils (nonwords)
## EXPERIMENTAL TEST WORDS (CASTLES & COLTHEART, 1993)

### PRACTICE WORDS

words that have no meaning whatsoever

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<th>NONWORDS</th>
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<td>bowl</td>
<td>giph</td>
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<tr>
<td>victor</td>
<td>regime</td>
<td>hoil</td>
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<tr>
<td>weasel</td>
<td>meringue</td>
<td>toud</td>
</tr>
<tr>
<td>mist</td>
<td>shoe</td>
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<td>infest</td>
<td>indict</td>
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<tr>
<td>cord</td>
<td>wolf</td>
<td>dethix</td>
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</table>
Author Recognition Checklist

Below you will see a list of names. Some of the people in the list are popular writer (of books, magazine articles, and/or newspaper columns) and some are not. You are to read the names and put a check mark next to the names of those individuals who you know to be writers. Do not guess, but check only those individuals who you know to be writers. Remember, some of the names are people who are not popular writers, so guessing can be easily detected.

1. Lauren Adamson
2. Eric Amsel
3. V.C. Andrews
4. Isaac Asimov
5. Margaret Atwood
6. Margaret Azmitia
7. Oscar Barbarin
8. Reuben Baron
9. Gary Beauchamp
10. Pierre Berton
11. Thomas Bever
12. Brian Bigelow
13. Elliot Blass
14. Judy Blume
15. Dale Blyth
16. Hilda Borko
17. Barbara Cartland
18. Agatha Christie
19. Tom Clancy
20. Arthur C. Clarke
21. James Clavell
22. Jackie Collins
23. John Condy
24. Stephen Coonts
25. Edward Cornell
26. Carl Corter
27. Diane Cunce
28. Denise Daniels
29. Robertson Davies
30. Geraldine Dawson
31. Aimee Dorr
32. W. Patrick Dickson
33. Robert Emery
34. Frances Fincham
35. Ian Fleming
36. Martin Ford
37. Robert Fulghum
38. Howard Gardner
39. Stephen J. Gould
40. Andrew Greeley
41. Frank Gresham
42. John Grisham
43. Alex Haley
44. Frank Herbert
45. Tony Hillerman
46. S.E. Hinton
47. Robert Innes
48. John Jakes
49. Erica Jong
50. Frank Keil
51. Stephen King
52. Dean Koontz
53. Judith Krantz
54. Louis L'Amour
55. Margaret Laurence
56. Reed Larson
57. Ursula LeGuin
58. C.S. Lewis
59. Lynn Liben
60. Robert Ludlum
61. Hugh Lynton
62. Franklin Manis
63. Morton Mendelson
64. James Michener
65. James Morgan
66. Scott Paris
67. Richard Passman
68. M. Scott Peck
69. David Perry
70. Anne Rice
71. Mordecai Richler
72. Miriam Sexton
73. K. Warner Schaie
74. Sidney Sheldon
75. Robert Siegler
76. Danielle Steel
77. Mark Strauss
78. Alvin Toffler
79. J.R.R. Tolkien
80. Irving Wallace
81. Alice Walker
82. Joseph Wambaugh
83. Bob Woodward
84. Alister Younger
85. Steve Yussen
86. Paul Zindel

X: CORRECT ANSWERS
Magazine Recognition Checklist

Below you will see a list of titles. Some of them are the names of actual magazines and some are not. You are to read the names and put a check mark next to the names of those that you know to be magazines. Do not guess, but only check those that you know to be actual magazines. Remember, some of the titles are not those of popular magazines, so guessing can be easily detected.

1. Allure ___ 48. Motor Trend ___
2. Architecture Today ___ 49. Mountain and Stream ___
3. Atlantic ___ 50. Music Weekly ___
4. Better Homes and Gardens ___ 51. National Geographic ___
5. Business Week ___ 52. Neuberger Review ___
6. Byte ___ 53. New Yorker ___
7. Car and Driver ___ 54. Newsweek ___
8. Chatelaine ___ 55. Omni ___
9. Consumer Reports ___ 56. Outdoor Life ___
10. Cosmopolitan ___ 57. Outdoor Times ___
11. Digital Sound ___ 58. Pacific World ___
12. Ebony ___ 59. People ___
13. Electrical and Mechanical News ___ 60. Popular Psychology ___
14. Elle ___ 61. Popular History ___
15. Elliot ___ 62. Popular Science ___
16. Esquire ___ 63. Premiere ___
17. Essence ___ 64. Psychology Today ___
19. Field and Stream ___ 66. Reader's Choice ___
20. Flare ___ 67. Reader's Digest ___
21. Fitness Today ___ 68. Recreation Today ___
22. Forbes ___ 69. Redbook ___
23. Galactic Digest ___ 70. Road & Track ___
24. Gentleman's Quarterly ___ 71. Rolling Stone ___
26. Glamour ___ 73. Sassy ___
27. Good Housekeeping ___ 74. Saturday Night ___
28. Guitar World ___ 75. Science Quest ___
30. Health & Life ___ 77. Scientific American ___
31. Home Finance ___ 78. Self ___
32. Hot Rod ___ 79. Seventeen ___
33. House and Garden ___ 80. Software Development ___
34. Hunters ___ 81. Spin ___
35. Illustrated Science ___ 82. Sports Illustrated ___
36. Inside Sports ___ 83. Stock and Bond Digest ___
37. Interview ___ 84. Technology Digest ___
38. Jet ___ 85. The Idler ___
39. Ladies Home Journal ___ 86. Thrasher ___
40. Life ___ 87. Time ___
41. Maclean's ___ 88. Tools and Repair ___
42. Madame ___ 89. Town & Country ___
43. Mademoiselle ___ 90. Urban Scene ___
44. Market Trends ___ 91. Vanity Fair ___
45. McCall's Magazine ___ 92. Vogue ___
46. Modern Family ___ 93. Vox ___
47. Motor Sports ___ 94. Wellesley ___

X: CORRECT ANSWERS
RAN Test: Digits

6 6 2 4 1 8
2 8 4 1 1
6 9 2 2 2
4 6 8 6 4
1 4 4 4 1

8 6 1 1 2
4 1 2 8 4
2 1 6 8 6
8 9 8 8 4
2 1 6 2 1
4 4 2 1 8
Lisa Carl just wanted to see a movie. But in 1988 when the nineteen year old with cerebral palsy wheeled herself to the ticket booth of her neighbourhood theater in Tacoma, Washington, the owner refused to take her dollar bill. "I don't want her in here, and I don't have to let her in," the owner later explained, noting the girl had difficulty speaking and getting around. As Carl told U.S. senators the next year, "I was not crying outside, but I was crying inside. I just wanted to be able to watch the movie like everybody else."

One hundred years ago, a doctor in Sussex, England, published the first description of the learning disorder that would come to be known as developmental dyslexia. "Percy has always been a bright and intelligent boy" wrote W. Pringle Morgan, in the British Medical Journal, "quick at games, and in no way inferior to others of his age. His great difficulty has been - and is now - his inability to learn to read".

Read year learning dyslexia always games quick inferior in hundred doctor intelligent others great learn one Sussex published disorder boy the medical way to age a ago the first dyslexia Percy has bright read inability England the developmental been Pringle Morgan in way to his learn no description as wrote

Appendix Three: Correlation Table of the Principal Variables (N=61)

Key to Variable Names:

Reading 1: Percentile Score, Timed, Nelson-Denny Reading Test, (Form G) Reading Comprehension subtest.
Reading 2: Percentile Scores, Untimed, Nelson-Denny Reading Test, (Form G) Reading Comprehension subtest.
Time 1: Total time taken to complete the Nelson-Denny Reading Test, (Form G) Reading Comprehension subtest.
Time 2: Total time taken to complete the Nelson-Denny Reading Test, (Form H) Reading Comprehension subtest; Simultaneous Reading and Listening.
Listen 1: Percentile Scores, timed, Nelson-Denny Reading Test, (Form H) Reading Comprehension subtest; Simultaneous Reading and Listening.
Listen 2: Percentile Scores, untimed, Nelson-Denny Reading Test, (Form H) Reading Comprehension subtest; Simultaneous Reading and Listening.
Listen 3: Woodcock Reading Mastery Test-Revised, (Form G) Passage Comprehension subtest, listening at 115 wpm, no text.
Listen 4: Woodcock Reading Mastery Test-Revised, (Form H) Passage Comprehension subtest, listening at 195 wpm, no text.
Ros Pct.: Rosner Auditory Analysis Test, Percentage correct.
WA.Tile: Woodcock Reading Mastery Test-Revised, (Form G) Word Attack subtest, percentile scores
WA.SS: Woodcock Reading Mastery Test-Revised, (Form G) Word Attack subtest, standard scores.
WI.Tile: Woodcock Reading Mastery Test-Revised, (Form G) Word Identification subtest, percentile scores.
WI.SS: Woodcock Reading Mastery Test-Revised, (Form G), Word Identification subtest, standard scores.
WTOT.PCT: Letter strings, percentage scores.
SP.Tile: Wide Range Achievement Test, 3, (Tan Form) Spelling subtest, percentile scores.
Irreg. Raw: Experimental irregular words, raw scores.
Reg. RT: Experimental regular words, reaction times.
Irreg. RT.: Experimental irregular words, reaction times.
Non.RT.: Experimental nonwords, reaction times.
Voc. Tile: Peabody Picture Vocabulary Test, (Form L), percentile scores.
PPVT.SS: Peabody Picture Vocabulary Test, (Form L), standard scores.
WAIS. VOC: Wechsler Adult Intelligence Scale-Revised, Vocabulary subtest, standard scores.
Auth.Pct.: Author Recognition Checklist, percentage scores.
Rantime: RAN digit test, time in seconds.
Letters. wps.: Biemiller Letters, per second.
BMP1. wps: Biemiller Passage One, words per second.
BMP2. wps: Biemiller Passage Two, words per second.
BMW1. wps: Biemiller Passage One Words, words per second.
BMW2. wps: Biemiller Passage Two Words, words per second.
## Appendix 3. Intercorrelations among the primary variables

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<td>-0.0783</td>
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<td>-0.1998</td>
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**Note.**
- * Statistically significant at p<.05 level (two-tailed);
- ** Statistically significant at p<.01 level (two-tailed)
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**Note.** * Statistically significant at p<.05 level (two-tailed);** Statistically significant at p<.01 level (two-tailed)
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Note.  * Statistically significant at p<.05 level (two-tailed);  
      ** Statistically significant at p<.01 level (two-tailed)
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**Note:**
- * Statistically significant at p<.05 level (two-tailed);
- ** Statistically significant at p<.01 level (two-tailed)
<table>
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<th>WAIS.VOC</th>
<th>AUTH.PCT</th>
<th>MAG.PCT</th>
<th>RANTIME</th>
<th>LETT.WPS</th>
<th>BMP1.WPS</th>
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<td>-.3130*</td>
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<td>-.2825*</td>
<td>-.2460</td>
<td>.6314**</td>
<td>.6268**</td>
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<td>-.1647</td>
<td>-.1497</td>
<td>.7263**</td>
<td>.8131**</td>
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</table>

Note. * Statistically significant at p<.05 level (two-tailed);
** Statistically significant at p<.01 level (two-tailed)
BMP2.WPS    BMW1.WPS    BMW2.WPS

BMP2.WPS  1.0000
BMW1.WPS  .7561**  1.0000
BMW2.WPS  .7301**  .9142**  1.0000

Note.  * Statistically significant at p<.05 level (two-tailed);
** Statistically significant at p<.01 level (two-tailed)