The Effectiveness of Oral Expression through the use of Continuous Speech Recognition Technology in Supporting the Written Composition of Postsecondary Students with Learning Disabilities

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(ABSTRACT)

A large number of individuals who are identified as having learning disabilities have deficits in written expression. Existing theory and research indicate that for those individuals oral expression not only precedes, but also exceeds their written expression capabilities. As a result, dictation has been investigated as an accommodation for these individuals. Research in this area indicates that dictation does tend to increase quality, length, and rate of production of written expression. This mode, however, has a number of shortcomings, including difficulties caused by social skills deficits and a loss of independence. Additionally, for universities providing this accommodation, the annual cost of providing a transcription service is high. Speech recognition has the potential to overcome these shortcomings, but presently little research has been conducted to investigate the advantages and disadvantages of this mode of writing.

The purpose of this study was to examine the compensatory effectiveness of oral expression through the use of continuous speech recognition technology on the written composition performance of postsecondary students with learning disabilities. This writing mode was compared to a popular accommodation involving oral expression, using a human transcriber to create a verbatim transcription, and to a common visual-motor method of writing, using a keyboard without assistance.

Analysis of the data revealed that students with learning disabilities in the area of written expression wrote significantly higher quality essays at a faster rate using the transcription and speech recognition modes of writing than they did using the keyboarding method of writing. There was no significant difference in the length of essays across the three treatment groups.

This study suggests that current continuous speech recognition technology can offer postsecondary students with learning disabilities a method to write that is superior to keyboarding as indicated by measures of quality and rate of production. Since the speech recognition technology does not have the limitations of the transcription process (i.e., loss of independence and high cost), it may be the best alternative for postsecondary students with learning disabilities in the area of written expression to maximize their oral language strengths to more efficiently produce better quality writing.

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DEDICATION

This work is dedicated to my grandparents, Gladys and Hunter Lee. Often when I look into my son's smiling face or feel the warmth of his hug, I am reminded of their love. This legacy will always be their greatest gift to me.

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I. INTRODUCTION

Due to legal mandates requiring accommodations for students with disabilities (Section 504 of the Rehabilitation Act of 1973; The Americans with Disabilities Act of 1990), a number of compensatory strategies have been developed to support the 80 to 95% of adults with learning disabilities who report significant problems with writing (Blalock, 1981; Mangrum & Strichart, 1984; Stanovich, 1986; Vogel & Moran, 1982). The most popular strategy at the postsecondary level, having a student dictate work to someone who then transcribes the information, is supported by theory and research asserting that the oral expressive (auditory-motor) language performance (e.g., speaking) precedes and exceeds the written expressive (visual-motor) performance (e.g., keyboarding and handwriting) of students with learning disabilities (Bereiter & Scardmalia, 1987; De La Paz & Graham, 1997; Graham, 1990; MacArthur & Graham, 1987). It has also been shown, however, that social problems experienced by some individuals with learning disabilities may negatively affect their ability to work with a human transcriber (Higgins & Raskind, 1995). Additionally, this strategy is very costly and promotes a loss of independence (De La Paz & Graham, 1997; Higgins & Raskind, 1995). Furthermore, dictation using a tape recorder does not allow the individuals producing the composition to easily review their work and use that information to build on their ideas (MacArthur & Graham, 1987; Reece, 1992; Reece & Cummings, 1996).

Over the past three to four years, speech recognition technology has advanced in quality and decreased in cost to the point that it is now a viable means of allowing postsecondary students with learning disabilities to independently produce written composition by means of oral expression. Speech recognition systems operate in conjunction with word processing programs to allow the user to produce written text through speech. Using the new “continuous speech” recognition systems, the user dictates (without pausing between words) into a head-mounted microphone, and the system converts the spoken words to electronic text, which is displayed on the computer monitor.

Aside from three reports (De La Paz, 1999; MacArthur, 1999; Raskind & Scott, 1993) and a research study (Higgins & Raskind, 1995), little effort has been made to consider or assess the effectiveness of oral expression through the use of speech recognition technology in helping students with learning disabilities compensate for written expressive language difficulties. There has also been little, if any, research in this area with postsecondary students using the new continuous speech systems.

Purpose of the Study

The purpose of this experimental study is to examine the compensatory effectiveness of oral (auditory-motor) expression through the use of continuous speech recognition technology on the written composition performance of postsecondary students with learning disabilities. This writing mode is compared to the popular accommodation of oral expression, using a human transcriber to create a verbatim transcription, and to a common visual-motor method of written expression, using a keyboard without assistance.

The review of literature for this study consists of six primary categories. The first category presents an overview of the area of learning disabilities and includes definitions, identification procedures, and characteristics. The second category discusses the dictation research involving individuals with learning disabilities. The third category looks into the nature of the social deficits that may be a limiting factor when individuals with learning disabilities use human dictation services. The fourth category explores the area of speech recognition technology and discusses its history, current status and applications. The fifth category reviews the research in the area of speech recognition technology and disabilities. The sixth category discusses the assessment of written expression and ties this in with the assessment methods used in the previous research on dictation and speech recognition technology. The review also includes an overall summary and synthesis of the literature.

Review of Related Literature

Learning Disabilities

Definitions

Samuel Kirk (1963) was among the first to introduce the term "learning disability" to describe the specific learning deficits of a group of individuals. He used this term to describe a delayed development or disorder in one or more of the processes of speech, language, reading, spelling, writing, or arithmetic. According to Kirk, a learning disability resulted from a possible cerebral dysfunction and/or emotional or behavioral disturbance and not from retardation, sensory deprivation, or any cultural or instructional factor.

Although Kirk's definition of a learning disability was very broad, the term did establish a frame of reference for thinking about individuals with specific learning disorders. The term did not specify a cause, such as brain damage or minimal brain dysfunction (Lerner, 1997). Instead, it focused attention on psychological process disorders and how they interfered with academic performance, which laid the foundation for educational interventions (Kavale, 1991).

Once Kirk introduced the term, others began to build on his ideas in offering their own definitions. Barbara Bateman (1965) identified underachievement as an important component of learning disabilities. Her definition reads as follows:

> Children who have learning disorders are those who manifest an educationally significant discrepancy between their estimated intellectual potential and actual level of performance related to basic disorders in the learning process, which may or may not be accompanied by demonstrable central nervous system dysfunction and which are not secondary to generalized mental retardation, educational or cultural deprivation, severe emotional disturbance, or sensory loss (p. 220).

It wasn't long after these initial attempts to define the term "learning disability" that the federal government began its own investigation. In 1969, the National Advisory Committee on Handicapped Children, chaired by Samuel Kirk, offered the following definition to Congress:

> The term "Children with specific learning disabilities" means those children who have a disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, which disorder may manifest itself in an imperfect ability to listen, think, speak, read, write, spell or do mathematical calculations. Such disorders include such conditions as perceptual handicaps, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia. The term does not include children who have learning

problems which are primarily the result of visual, hearing or motor handicaps, of mental retardation, of emotional disturbance, or of environmental, cultural or economic disadvantage (U.S. Office of Education, 1977, p. 65083).

This definition, which reflects a medical orientation based on brain injury research, was subsequently adopted as the federal definition of a learning disability. It served as the basis for the 1969 Learning Disabilities Act and, in 1975, was included in the Education for All Handicapped Children Act, Public Law 94-142 (Smith, 1991). It also appeared in the 1990 Individuals with Disabilities Education Act (IDEA) (PL 101-476), and it is in the 1997 reauthorization of IDEA (Lerner, 1997).

The current federal definition of learning disabilities also includes an operational component (U.S. Office of Education, 1977). The government's operational definition asserts that a student has a specific learning disability if (1) the student does not achieve at the proper age and ability levels in one or more specific areas when provided with appropriate learning experiences and (2) the student has a severe discrepancy between achievement and intellectual ability in one or more of these seven areas: a) oral expression, b) listening comprehension, c) written expression, d) basic reading skill, e) reading comprehension, f) mathematics calculation, and g) mathematics reasoning (Kavale & Forness, 2000; Lerner, 1997). The federal government stipulates that states may write their own definitions, but they can be no narrower, or more exclusive, than the federal criteria (Smith & Strick, 1997; Smith, 1991).

Mercer (1996) conducted a survey of the 51 state Departments of Education in the U.S. and found that 71% base their definitions of learning disabilities on the federal government's definition. He also found that 47% of those states, including Virginia, use the federal guidelines without modification. The remaining states use what was referred to as a "different" definition for learning disabilities, where two or more components were added or removed from the federal guidelines.

Although never enacted into law, in 1981 the National Joint Committee on Learning Disabilities (NJCLD) revised the federal definition and agreed on the following:

> Learning disabilities is a general term that refers to a heterogeneous group of disorders manifested by significant difficulties in the acquisition and use of listening, speaking, reading, writing, reasoning or mathematical abilities. These disorders are intrinsic to the individual, presumed to be due to central nervous system dysfunction, and may occur across the life span. Problems in self-regulatory behaviors, social perception, and social interaction may exist with learning disabilities but do not by themselves constitute a learning disability. Although learning disabilities may occur concomitantly with other handicapping conditions (for example, sensory impairment, mental retardation, serious emotional disturbance) or with extrinsic influences (such as cultural differences or insufficient or inappropriate instruction), they are not the result of those conditions or influences (National Joint Committee on Learning Disabilities, 1994, p. 65-66).

This definition intended to demonstrate that learning disabilities occur across the life span and set out to clarify the term "basic psychological processes." This was done through the assertion that underachievement is due to a neurological dysfunction within the individual (Kavale & Forness, 2000; Smith, 1991). The NJCLD definition is very popular and has been accepted by the Council for Learning Disabilities, the International

Reading Association, The Division for Children with Communication Disorders, the Orton Society, and the American Speech-Language-Hearing Association (Lerner, 1997).

Shortly after the NJCLD developed their definition, the U.S. Congress commissioned The Interagency Committee on Learning Disabilities (ICLD) to develop an updated definition of learning disabilities. In 1987, the committee offered a definition very similar to the NJCLD definition with the addition of social skills as an identified deficit. The definition also adds attention deficit disorders to the exclusion clause (Lerner, 1997). The ICLD definition was never enacted into law.

Hammil (1993) notes that, although the search for a definition of learning disabilities has been both difficult and controversial, the most influential definitions are in fundamental agreement on most issues. Each makes reference to a central nervous system dysfunction, psychological processing difficulties, difficulty in academic learning tasks, a discrepancy between achievement and potential, and the exclusion of other causes. He argues that since such a strong relationship exists among the definitions, a consensus is near.

Currently, the most widely used definitions are the ones put forth by the federal government and the National Joint Committee on Learning Disabilities (Lerner, 1997; Smith, 1991; Smith & Luckasson, 1992). Even though the federal government, through PL 94-142, provides guidelines for the current definitions of learning disabilities, researchers continue to work toward a more precise classification of the term.

Identification and Prevalence

Students who qualify for special education services due to a learning disability are required to meet certain criteria developed by the states and school districts in which they live. Most states and school districts have detailed eligibility requirements for educational programs designed for these students. These criteria are usually based on either the federal government's or National Joint Committee on Learning Disabilities' definition (Smith & Luckasson, 1992).

As reflected in the operational component of the federal definition of learning disabilities, professionals generally agree that students who have had sufficient opportunities to benefit from instruction meet one of the necessary criteria to be identified as having a learning disability if they show severe discrepancies between expected and actual achievement. As a result, many states and school districts have developed discrepancy formulas to help in the identification of students with learning disabilities (Forness, Sinclair, & Guthrie, 1983; Frankenberger & Harper, 1987; Kavale & Nye, 1981). These formulas measure the difference between an individual's potential, as measured by a standardized intelligence test, and that person's actual academic achievement, as determined by a standardized achievement test.

An evaluation's outcome, ultimately, is influenced by the way different localities interpret federal law. Although "a severe discrepancy" between achievement and intellectual potential must be shown to exist before a learning disability can be identified, each state is left to define for itself the meaning of a "severe discrepancy" (Smith & Strick, 1997). As a general rule, in order to be judged severe, "a discrepancy needs to be unusually large when compared to the typical variability of the majority of individuals of that age, intelligence, and background" (Smith, 1991, p. 54). States usually determine how large a discrepancy they will recognize in making the decision of whether to provide services. The cutoffs are generally determined in one of three ways: (1) by setting a difference of a particular number of standard score points between ability and achievement, (2) by establishing a percent by which achievement must deviate from the expected achievement for one's intellectual potential, or (3) by setting the number of grade levels an individual must fall behind his or her current grade level (Smith, 1991; Smith & Luckasson, 1992).

An evaluation for learning disabilities must not only prove that there is a significant gap between an individual's potential to learn and his or her actual performance in one or more specific academic areas; it must also determine that the child has had adequate learning opportunities and investigate and rule out a variety of other possible causes of underachievement. Therefore, it is not possible for a single test to provide all of the information needed to make these judgments. As a result, the law requires public school districts to use multidisciplinary teams of professionals in the identification process. These teams are also required to use a variety of assessment methods (Kavale & Forness, 1995).

Currently, there appears to be very little research that looks at the diagnostic assessment practices and procedures for students with learning disabilities at the postsecondary level. Carlton and Walkenshaw (1991) surveyed thirty-five 2- and 4-year college programs that provide support services for college students with learning disabilities. All the programs in the sample required similar documentation for students with a previous learning disability diagnosis, including a psychoeducational assessment and/or an Individualized Education Program (IEP) from the previous school. Few schools requested the administration of specific tests, but most had a requirement that the evaluation take place within the past 3 years.

As indicated by the numerous operational definitions used by states and school systems to identify students with learning disabilities, there is no agreement on a nationally consistent and measurable method of determining whether a student has a learning disability (Smith & Luckasson, 1992). Professionals and researchers continue to investigate alternative methods of assessment for identification purposes in order to develop a more universally acceptable operational definition (Kavale & Forness, 1995). This lack of a common operational definition has made the generalizability of research findings problematic (Reid, Hresko, & Swanson, 1996). Hammil (1993) notes that, until an acceptable operational definition is developed for use throughout the country, researchers need to thoroughly describe and attempt to control variability in their population selections.

At the elementary, secondary, and postsecondary level, the number of individuals identified as having a learning disability depends, to a large degree, on the criteria used to determine eligibility for services. Since each state uses its own operational definition, the prevalence of individuals identified varies from state to state. Even so, national figures are fairly consistent. The 1996 figures revealed that the average prevalence among states was 4.36% of the school age population (ages 6-21) and all states identified between 2.35% and 7.23% of the school age population as having a learning disability (U.S. Department of Education, 1997).

Since the passage of Public Law 94-142 in 1975 and the subsequent reauthorizations, the population of individuals identified as having a learning disability has steadily increased. In the first year the law was implemented (1977-78), about 800,000 children had received services under the category of learning disabilities (Lerner, 1997). By the 1995-96 school year, the total had increased to over 2.6 million. Learning disabilities now account for 51.2% of all students with disabilities ages 6-21 who are enrolled in school (U.S. Department of Education, 1997).

Some argue that the substantial increase in the numbers of individuals identified with a learning disability is due to the confusion over a definition and appropriate criteria for identification (Kavale & Forness, 2000) Others, however, attribute the increase, in part, to professionals' growing recognition of the condition of learning disabilities and their attempts to deal with it (Hammil, 1992). In either case, it is obvious that more investigation is needed to fully understand the meaning of the prevalence figures.

<u>Theoretical Framework and Characteristics</u>

The information-processing theory is the primary model used to characterize the deficits exhibited by individuals with learning disabilities (Bernstein & Tiegerman, 1993; Reid et al., 1996; Swanson, 1989). The model looks at cognitive processes that underlie observable performances and provides a useful framework for understanding these deficits (Swanson, 1989).

The conceptual model provided by the information-processing theory makes it possible to systematically describe the way individuals process information. It is based on the idea that individuals have an innate capacity to make sense of their experiences.

According to the theory, it is necessary for an individual to integrate a number of processes in order to sensibly work with experiences. These processes include the acquisition, organization, retention, retrieval, and output of information (Reid et al., 1996).

According to information-processing theory, auditory, visual, and tactile stimuli are transmitted to the brain. Once in the brain, perception, attention, and memory reconstruct, organize, and store the information. Cognitive development occurs in stages as the individual acquires and refines strategies for more effectively processing the environmental stimuli. The individual becomes better able to attend to and select important attributes of the perceived information and to hold more than one piece of information in memory in order to facilitate organization and storage (Swanson, 1989). Once the information is stored, it can be output in a variety of observable behaviors, many of which involve gross, fine, and oral motor movements (Smith & Strick, 1997)

Information-processing theorists note that individuals may differ from one another cognitively in two areas. They may differ in the basic structure of their information-processing systems, or they may differ in the information processing skills that are learned as a result of experience. Structural differences operate outside the conscious control of the individual and include such things as the capacity of short-term memory, the speed of operations of various processes, and the integration of these processes. Skill differences, on the other hand, might include such things as the content and organization of long-term memory and the methods that an individual uses to think (Reid et al., 1996). Although better strategies can help with the ability of the information processing system to work with data, the physical structure of the system, especially if this system has defects, imposes limitations in its overall capacity in terms of attention, selection, organization, storage, and retrieval of the data (Swanson, 1989).

The primary assumption that underlies the application of the information-processing approach to the study of individuals with learning disabilities is that these individuals have an intellectual ability that exceeds their information-processing systems. In the individual who is learning disabled, some information-processing components are not operating effectively for certain tasks. These problems consist of both defects in the system structure and in processing skill deficits (Reid et al., 1996; Stanovich, 1986).

Although individuals with learning disabilities are considered to be a heterogeneous group, the common set of information-processing problems that these individuals experience is reflected in the recognition of several general characteristics. Bernstein and Teigerman (1993) identify and describe some of the literature's most mentioned characteristics as follows:

1. Hyperactivity – inappropriate excessive motor activity such as tapping of finger or foot, jumping out of seat, or skipping from task to task
2. Attention deficits – distraction by irrelevant stimuli or perseveration…[where] attention becomes fixed upon a single task or behavior that is repeated over and over
3. Motor deficits – general coordination problems resulting in awkward or clumsy movements
4. Perceptual-motor deficits – difficulty in integrating a visual or auditory stimulus with a motor response

5. Language deficits – delays in speech and difficulty in understanding and/or formulating spoken language
6. Impulsivity – lack of reflective behavior
7. Cognitive deficits – deficits in memory and concept formation
8. Orientation deficits – poorly developed spatial or temporal concepts (p. 329).

It is not uncommon for individuals with learning disabilities to exhibit many of the identified characteristics. Furthermore, some characteristics, such as hyperactivity, may be more likely to be exhibited at different age levels (Lerner, 1997).

The characteristics associated with individuals who have learning disabilities correlate to a number of academic deficits. The majority of individuals with learning disabilities have deficits that affect both language comprehension and production. These language deficits are generally classified into two broad categories: oral language and written language (Bernstein & Tiegerman, 1993; Lerner, 1997; Reid et al., 1996).

Language is an integrated system including oral (listening and speaking) and written (reading and writing) components. The acquisition of language follows a general sequence of development, with listening and speaking preceding reading and writing. The components of the system, though, are interdependent. What a child learns about the language system through oral language provides a knowledge base for reading and writing, and what the child learns about language through writing improves reading and oral language (Smith & Strick, 1997). Since individuals develop the oral skills of listening and speaking first, they are considered the primary language system. Reading and writing are considered the secondary language system, since they actually involve using symbols of symbols (Lerner, 1997).

Through initial experiences with oral language, children learn about the linguistic structures of language, expand their vocabulary, and become familiar with different types of sentences. Children develop these skills by learning words, hearing stories and songs, and recognizing repeated sentences in books (Bernstein & Tiegerman, 1993).

Through an information-processing perspective, children acquire oral language through the perception of auditory stimuli in the form of language experiences. These experiences are then processed and integrated into the child's existing information structure, or schema. Through these language experiences, children strengthen, add to, or change their schema and cognitive structure. This schema, then, serves as the basis for subsequent output of language in the form of speech (Reid et al., 1996).

The development of abilities in the language hierarchy relies on the initial intactness of oral language. Therefore, aspects of functioning that affect the oral language system will also affect the written language system (Reid et al., 1996).

The ability to write requires the related abilities of all the previously acquired language skills, including listening, speaking, and reading. As children become familiar with the auditory structure of language, they develop a phonological awareness of the language (or the recognition that words are made up of sound elements), which serves as the basis for word recognition skills in reading. In the reading process, individuals construct meaning from writing by drawing on the existing knowledge and experiences acquired through oral language (Lerner, 1997). In the writing process, individuals use experiences primarily with visual stimuli, usually in the form of reading, to develop their schema and cognitive structures, which, in turn, provides the needed input to produce writing (Bernstein & Tiegerman, 1993; Lerner, 1997; Reid et al., 1996).

Due to its complexity and sophistication, the ability to write is considered to be the most difficult of the language skills to acquire. Writing requires a number of resources beyond that of oral language. It is a representation of language that is much more abstract than oral language. Writing is not a direct expression of experience, but is an arbitrary representation of the established oral language system (Bernstein & Tiegerman, 1993; Lerner, 1997). Furthermore, the conventions of writing have different rules than those of speech, "which demand more formal use of complete syntactic conventions, such as connectives and embedded clauses…and also demand more cohesiveness, less redundancy, and fewer examples or illustrations" (Bernstein & Tiegerman, 1993, p. 342).

Individuals who write must also be able to perform the complex motor act of producing words, which is typically accomplished through handwriting and keyboarding. These writing modes require the integration of a number of processes including attention, visual memory and perceptual-motor skills (Lerner, 1997).

The complex oral and written language system can be further broken down into two sub-categories: receptive and expressive language. Listening and reading are referred to as receptive language processes, while speaking and writing are understood to be expressive language processes (Adler, 1988). Mykleburst (1973) further classified the expressive categories of language, speaking and writing, as auditory expressive and visual expressive processes, respectively. Oral expression is primarily based on auditory receptive processes and uses various cognitive activities to integrate the auditory input stored in memory with the motor output of speaking. Written expression follows developmentally from oral expression and consists primarily of cognitive activities that integrate the visual input stored in memory with the motor output of writing.

Oral expressive language problems encountered by individuals with learning disabilities often result from auditory processing deficits. These problems include deficiencies in vocabulary acquisition, disorders of grammar or syntax, and delayed speech. Difficulty with vocabulary acquisition has been attributed to deficits, or slowness, in processing sounds. Disorders of grammar or syntax have been credited to cognitive difficulties that involve the inability to accurately perceive relationships in the environment, which results in errors when those relationships are coded linguistically (Bernstein & Tiegerman, 1993). Delayed speech is evidenced in word-retrieval problems and has been attributed to improperly coded auditory information, auditory-memory retrieval difficulties, and auditory-motor integration deficits (Lerner, 1997; Reid et al., 1996; Smith & Strick, 1997).

Individuals with learning disabilities who have responded well to remediation in spoken (oral expressive) language at the elementary level often continue to have difficulties with written expressive language (Lerner, 1997). The largest sub-group among the population of individuals with learning disabilities is those identified as having deficits in learning to write. Researchers have reported that approximately 80 to 95% of adults with learning disabilities report significant problems with writing (Blalock, 1981; Mangrum & Strichart, 1984; Stanovich, 1986; Vogel & Moran, 1982). The academic achievement of individuals with learning disabilities in the area of writing is well below the levels of individuals who do not have a learning disability. It is not unusual for teenagers with learning disabilities to average about four-year delays in written expression on standardized achievement tests (Shepard & Smith, 1983).

In addition to the motor aspects of writing (i.e., handwriting and keyboarding), written expressive language involves a number of component skills including the formulation or organization of ideas, vocabulary, syntax, spelling, punctuation, and capitalization (Reid et al., 1996). Students with learning disabilities usually have difficulty with more than one aspect of the writing process (Lerner, 1997; Smith & Luckasson, 1992).

Compared with non-disabled peers, adolescents with learning disabilities often write at a slower pace and have poorer organization (Graham & MacArthur, 1988; Mykleburst, 1973). Other story composition difficulties include "problems with story schema and cohesion (lack of critical components, inclusion of extraneous ideas, and unclear referents), mechanics (punctuation, spelling, and word usage) and modes of production ([motor] aspects of writing)"(Wetzel, 1997, p. 56).

Individuals with learning disabilities often have difficulty with the production process of writing, including both handwriting and keyboarding, due to deficits in the use and integration of cognitive and motor processes. The additional motor requirements of producing text may interfere with composing in a number of ways. Due to the limited capacity of the information processing system, individuals with learning disabilities who have processing difficulties may be forced to attend to the skills of getting language onto paper which may interfere with other cognitive activities such as attending to, organizing and reconstructing information. Searching for a specific key on the keyboard, the cumbersome production of individual letters, or an internal dialogue on spelling a word may disrupt the processes involved in generating content or cause the individual to forget plans and ideas already developed. In addition, the production difficulties in writing may negatively affect motivation and persistence during composition (Bernstein & Tiegerman, 1993).

The writing process may also be affected by the rate of performance in completing the task. In order for writing to be efficient, it must be performed at an appropriate rate. Handwriting and word processing are considerably slower than speaking. The slower rate of writing or typing may not be efficient enough to keep up with the writer's thoughts. This also may interfere with generating content and remembering ideas and text already planned (Bernstein & Tiegerman, 1993; Vogel & Moran, 1982).

Due to the numerous difficulties that individuals with learning disabilities seem to have with the visual expressive (or visual-motor) task of written expression, oral language (e.g., auditory expressive or auditory-motor) may provide a more direct and less demanding method of communicating ideas. For this reason, researchers have explored dictation as a means to circumvent some of the issues individuals with learning disabilities have with written expression.

Learning Disabilities and Transcription Research

Dictation using a human transcriber, who is typically either a full-time staff member or is hired on a per hour basis, is widely used at the postsecondary level as an accommodation for individuals with learning disabilities who have deficits in written expression (Higgins & Raskind, 1995; Raskind & Higgins, 1998; De La Paz, 1999). This method is supported by theory and research that asserts oral (auditory-motor) expressive language performance (e.g., speaking) not only precedes, but also exceeds the written (visual-motor) expressive performance (e.g., keyboarding and handwriting) of students with learning disabilities (Bereiter & Scardmalia, 1987; De La Paz & Graham, 1997; Graham, 1990; MacArthur & Graham, 1987).

The strategy of using dictation seems to be derived from the Language Experience Approach that has been used in language arts instruction for decades (Ashton-Warner, 1986; Wetzel, 1997). This approach involves an activity where the teacher writes down a student's words as the student orally tells a story. As the teacher writes down the story, the student can look at the words as they are being written in order to facilitate the ability to keep track of what has been said and build on this to develop the story (Wetzel, 1997).

Typically, dictation involves a human transcriber who writes down an individual's words as they are being spoken, or a person uses a tape recorder to capture his or her oral expression, which is later transcribed by a human. Dictation, as an accommodation for persons with writing deficits, provides a method to circumvent the mechanics of writing and, as a result, does not normally require the individual to spell, capitalize, or punctuate the composition (De La Paz & Graham, 1997; Graham, 1990; MacArthur & Graham, 1987). Individuals who use a human transcriber dictate their compositions to the transcriber, who then uses handwriting or a keyboard to convert the oral expression into written form. In order to revise the composition, the person dictating the text must either ask the transcriber to reread portions of the writing and then verbally request the transcriber to make any needed revisions or read the transcribed text him or herself and then verbally request necessary changes (De La Paz & Graham, 1997;

Higgins & Raskind, 1995). Typically, when using a tape recorder to facilitate transcription, the person dictating the content does so without being given an opportunity to listen to their previously dictated text. If changes need to be made as the person dictates, they are immediately spoken into the tape recorder. All changes are made when the recording is later transcribed (Graham, 1990; MacArthur & Graham, 1987; Reece, 1992; Reece & Cummings, 1996).

In general, one of the main advantages of composing by dictation is that it uses the primary language system, oral expression, and, therefore, is a more natural and less demanding method of expression. As a result, dictation has the ability to increase the quantity of output, since it is a more efficient method to communicate. Dictation may also increase the quality of the output because it tends to encourage the writer to plan out what he or she wants to say in advance (Gardner, 1983). Finally, it has been noted that dictation allows individuals to increase the rate of output, or number of words in a specific time frame. This ability to compose closer to the speed of thought makes it easier to get ideas down on paper before they are forgotten (Haggblade, 1990).

Studies indicate that, once written language skills are acquired, the basic process of creating grammatically correct sentences and producing them in written language becomes relatively automatic for non-disabled writers. King and Rentel (1981) looked at stories of non-disabled primary-grade children and discovered that their dictated stories were far superior to their written stories. However, for non-disabled children, the mechanics of writing seem to no longer be a significantly limiting factor by the end of elementary school. Studies have indicated that by the end of fifth or sixth grade, dictated compositions of normally achieving children are longer but not qualitatively better than their handwritten compositions (Hidi & Hildyard, 1983; Scardamalia & Bereiter, 1986).

There is not a great deal of research on the effectiveness of dictation for individuals who have learning disabilities. However, the existing research does indicate that dictation may offer advantages for individuals with learning disabilities who have difficulties in the area of written expression by allowing them a more natural and less demanding way to express themselves, which, in turn, can increase the quantity and rate of output. In addition, dictation provides a method to circumvent the motor aspects and the mechanics component of writing, which has the potential to increase cognitive activities for attending to, organizing and reconstructing information and subsequently increase the quality of output.

MacArthur and Graham (1987) studied the writing of 11 fifth and sixth grade students with learning disabilities. In the study, the researchers compared three different modes of text production: dictation, word processing, and handwriting. The subjects were asked to compose stories using one of three color pictures provided. All of the subjects composed one story using each of the writing modes. While completing compositions using handwriting and keyboarding, the subjects were allowed to go back and revise their first draft. When dictating material, the subjects spoke into a tape recorder, and their words were later transcribed verbatim. If the students wished to make revisions while dictating, they were told to speak their changes into the microphone and they would be made as the transcriber typed them. In order to control for possible confounding effects of mechanical factors in the handwriting and keyboarding modes, errors in spelling, punctuation, and capitalization were corrected prior to scoring the essays for quality. Although there was no significant difference in the stories composed through handwriting and word processing, the stories that were dictated were completed nine times faster than those produced in handwriting and twice as fast as those created using a keyboard and word processor. The stories created through dictation also contained fewer grammatical errors and were of higher quality, as measured through a holistic evaluation involving eight story elements, than the other two modes of writing. The researches concluded that the slow rate of producing text through handwriting and keyboarding coupled with the additional cognitive and motor demands involved in these writing modes may interfere with the fluency and quality of written expression of individuals with learning disabilities. They also indicated that the quality of the dictated essays could have been even better had the subjects been able to see and read over what they had dictated instead of speaking directly into a tape recorder. This would have facilitated their ability to reread the text, to recall what they had said, to assess how it was organized, to consider what needed to be clarified, to stimulate further ideas, and to plan the remaining text.

Bereiter and Scardmalia (1987) examined handwriting and dictation of 48 fourth and sixth grade students with learning disabilities. In addition to comparing handwriting to dictation, the researchers also looked at the effects of slow dictation, where an experimenter transcribed the subject's dictated composition at the rate the subject was previously assessed to write. This was done in order to separate the effects of rate from the motor difficulties that may affect the writing of individuals with learning disabilities. The researchers found that the children produced 83% more words with slow dictation than with handwriting and 163% more words using normal dictation than with handwriting. The researchers concluded that the restraints placed on children's fluency using pen or keyboard may be overcome through dictation.

Graham (1990) conducted a follow-up to the original MacArthur and Graham (1987) study using the slow dictation procedure implemented by Bereiter and Scardmalia (1987) to isolate rate from the motor task of producing words in the subject's writing. The follow-up study included 12 fourth and 12 sixth grade students. Each student created three opinion essays, one each under normal dictation, slow dictation, and handwriting. In order to control for possible confounding effects of mechanical factors in the handwriting mode, the researchers corrected errors in spelling, punctuation, and capitalization prior to scoring the essays for quality. Results indicated that the subjects' normally dictated essays were of a higher quality (as measured holistically using analysis of word choice, grammar, sentence structure, organization, and ideation) than their handwritten essays and were created seven times faster for fourth graders and five times faster for sixth graders. The essays that were produced using slow dictation were also longer and of higher quality than the subjects' written compositions. There was no significant difference in the quality of essays produced during normal and slow dictation. In an unexpected result, the researchers found no significant difference between the length of the dictated and handwritten essays. This result was attributed to the difficulty with additional cognitive demands that the subjects may have encountered in developing the opinion essay. The researchers concluded that the motor demands of producing text in the handwriting mode proved to be very problematic for the subjects. They also indicated that an important benefit of dictation for individuals with learning disabilities is that it provides a method to circumvent the additional aspect of mechanics (e.g. spelling, punctuation, and capitalization) involved in written expression which, in turn, facilitates the ability to focus on higher-order cognitive activities such as planning and content generation.

Reece (1992, Experiment 3) compared dictation using a tape recorder with handwriting of fifth and sixth grade students who were identified as being poor writers. This group included students having learning disabilities, low general intelligence, and individuals with poor motor coordination. The students created three compositions (persuasive, personal narrative, and expository) using dictation and handwriting. Results revealed that there were no significant differences in the holistic scores of each writing mode, although the dictated essays did receive overall higher mean scores. However, the dictated essays were significantly longer than the handwritten essays and the students spent less time in producing the dictated essays. In a similar study, Reece (1992, Experiment 2) compared dictation into a tape recorder with handwriting using average achieving fifth and sixth grade writers. Results indicated no significant difference in the two production modes. The researcher concluded that the subjects' inability to see the text as it was produced outweighed any potential benefits of the dictation. Overall, Reece indicated that the constraining effects of mechanics were more problematic for poor writers than being unable to see one's text as it was composed.

Higgins and Raskind (1995) compared dictation to handwriting and keyboarding performance in 29 postsecondary students with learning disabilities. In the study, subjects created compositions based on one of six possible questions from a writing proficiency exam. The students wrote one essay using a pencil and paper or a keyboard and computer-based word processor and another by dictating to a human transcriber who then created a handwritten verbatim transcript of the oral essay. Results revealed that there were no significant differences in the holistic quality of the transcribed essays and the handwritten/word-processed essays. The study, however, may underestimate the usefulness of dictation since it did not assess rate and length of the essays.

In this study, Higgins and Raskind (1995) noted a few possible difficulties with dictation for postsecondary students with learning disabilities. They indicated that the nature of the social interaction that took place between the subject and the transcriber might have been a factor that contributed to the ineffectiveness of using the dictation mode. The researchers revealed that the students were hesitant to ask the transcribers to reread portions of their text, especially when a certain passage had to be read more than a few times. This difficulty could have caused the students not to plan or organize their ideas adequately before beginning because they did not want to keep the transcriber waiting. Finally, the researchers noted that some of the students had difficulty reading the transcriber's handwriting, and this fact may have contributed to an inability to benefit from reading previous portions of their papers.

Reece and Cummings (1996) conducted several studies similar to Reece's (1992) original study. These studies were also designed to look at the advantages and disadvantages of dictation. Two of the studies looked at normally achieving elementary school students and students with writing problems, many of whom were identified as having a learning disability. The students wrote papers using handwriting, dictation, and a "listening word processor." The listening word processor was a system that included a hidden typist and a computer monitor so that the writers could see their text as it was dictated. The students made revisions in the handwriting treatment simply by erasing and correcting their errors. Revisions were made in the other two treatments using verbal directions. Results indicated that dictated papers produced by normally achieving students did not differ in quality from the handwritten papers. However, poor writers did significantly better using the dictation mode of writing than they did using handwriting. Both groups wrote significantly better papers with the listening word processor than with either normal dictation or handwriting. The researchers indicated, once again, that for normally achieving elementary students, the inability to see the text during dictation outweighed the advantages of using the dictation mode of writing. They also concluded, as in Reece's original study, that for poor writers the constraints of mechanics were more problematic than the inability to see the dictated text. In this study, however, the researchers indicated that for both normally achieving elementary students and poor writers, the combination of dictation and the ability to see the text improved their ability to write when compared to handwriting and normal dictation.

De La Paz and Graham (1997) examined the effects of dictation and explicit instruction in planning on the composing skills of 42 students with learning disabilities in 5^{th}, 6^{th}, and 7^{th} grades. In the study, students were randomly assigned to four instructional conditions: (1) planning and dictation, (2) planning and handwriting, (3) essay structure and dictation, and (4) essay structure and handwriting. In the planning treatments, the researchers used the self-regulated strategy development model to teach a comprehensive planning strategy. Students assigned to the essay structure treatment learned about the characteristics of good essays, read and revised sample essays, and created and shared their essays with peers. In both treatments, half of the students dictated their essays and the other half wrote their essays by hand. Results indicated that students who received instruction in planning and used dictation outperformed students in the essay structure condition who wrote by hand. These students produced longer, more complete, more cohesive, and higher quality essays than the students in the essay structure/handwriting condition. The researchers noted, however, that instruction in planning did not benefit those who dictated more than those who wrote. In addition, neither dictation nor planning instruction in isolation resulted in the same level of improvement in the quality of the essays as the combination of planning and dictation. According to the researchers, this suggests that both factors were responsible for differences between the planning/dictation condition and the essay structure/handwriting condition. As a result, they conclude that it is important for writers to plan before composing when writing with dictation.

In conclusion, although there is evidence to support the effectiveness of dictation to produce longer and better quality essays for individuals with learning disabilities, this method has a number of shortcomings. The use of a tape recorder does not allow the individual producing the composition to easily review his or her work and to use that information to build ideas (Higgins & Raskind, 1995; MacArthur & Graham, 1987; Reece, 1992; Reece & Cummings, 1996). It has also been shown that social problems experienced by some individuals with learning disabilities may negatively affect their ability to work with a human transcriber (Higgins & Raskind, 1995). Dictation is also limited to the human resources available to do the transcribing, it is very costly, and of particular concern, especially to postsecondary students with learning disabilities, it promotes a loss of independence since the individual must rely on another person to be able to write (De La Paz, 1999; Higgins & Raskind, 1995).

Learning Disabilities and Social Skills

One of the issues that may adversely affect the ability of an individual with a learning disability to effectively use a human transcriber involves possible problems encountered in the social interaction with the transcriber. This assertion is supported by research indicating that the characteristics associated with individuals identified as having a learning disability may also manifest themselves through problems with specific social skills (Swanson & Malone, 1992; Hall et al., 1993; Tur-Kaspa & Bryan, 1994; Hartas and Dimitra, 1997; Brickerhoff, Shaw, and McGuire, 1993).

Due to the heterogeneous nature of learning disabilities, not all individuals with learning disabilities encounter difficulties with social skills. However, it is estimated that as many as one-third of individuals identified as having a learning disability also have problems with social skills (Voeller, 1994).

Social skills have been defined as “socially significant behaviors exhibited in specific situations which predict important social outcomes” (Gresham, 1992, p. 350). Socially significant behaviors are those that members of society consider important and desirable and that predict an individual’s success in regard to socially important outcomes. Socially important outcomes are those outcomes that make a difference in an individual’s functioning in society. Social skills deficits are typically understood to be acquisition deficits or performance deficits. Acquisition deficits describe socials skill deficits that are not part of an individual’s social skills repertoire. Performance deficits refer to the failure of an individual to perform a social skill in his or her repertoire (Gresham, 1992).

As reflected in the Interagency Committee on Learning Disabilities' definition, some experts regard social skills deficits as one of the primary areas of difficulty for individuals with learning disabilities. The Learning Disabilities Association of America (LDAA) definition also includes social skills deficits and indicates that the condition can affect self-esteem, education, and socialization (Gresham, 1992).

A number of experts assert that problems with social skills are due to the same neurological dysfunction that is believed to cause learning disabilities. It is argued that deficits in understanding and using social rules are closely related to deficits in information processing and attention, both of which are associated with learning disabilities (Bryan, 1982). It has also been noted that processing disorders such as word-retrieval difficulties, deficits in verbal fluency, or slow rates of processing verbal language or interpreting visual input such as facial expressions and body language can negatively affect social abilities by resulting in prolonged silences in a conversation, inappropriate behaviors, unrelated comments and subsequent embarrassment (Johnson & Blalock, 1987). Memory deficits have also been shown to cause problems with social interactions by causing individuals with learning disabilities to interrupt others or slow down their presentations with poorly timed questions (Hoffmann et al., 1987). Finally, the inability to simultaneously process auditory and visual input has been implicated in causing social problems. Individuals with such problems may try to limit the amount of visual information they have to process by avoiding eye contact while talking with others. This coping strategy often produces negative responses and social isolation (Vogel & Forness, 1992).

A number of researchers have examined the extent to which social skills represent a component of the deficits exhibited by individuals with learning disabilities. These studies have looked at the unique features of social skills that differentiate individuals with learning disabilities from the non-disabled population.

Swanson and Malone (1992) conducted a meta-analysis of the literature involving social skills and learning disabilities. The analysis included a review of 92 studies over a 16-year period (1974-90). In order to be considered for the review, the studies had to directly compare children with learning disabilities to average-achieving children on at least one social skills measure.

The results of the analysis were organized into a number of broad categories to address the question of whether children with learning disabilities differed from average-achieving children on social skills. The categories included social acceptance, social rejection, perceived status, aggression, inadequacy-immaturity, on-task behaviors, and social problem solving (Swanson & Malone, 1992).

The findings of the meta-analysis revealed that children with learning disabilities are less liked and more likely to be rejected by others. The effect sizes for measures of social acceptance were related to the types of measures used, with peer ratings producing a greater effect size. Grade level and ethnicity of the sample also were identified as factors that influence social acceptance effect sizes (Swanson & Malone, 1992).

Additional results indicated that children with learning disabilities had more significant difficulties with immaturity and personality problems than with aggressive behaviors. The results also suggest that children with learning disabilities have an accurate perception of their status within the context of the classroom environment (Swanson & Malone, 1992).

Finally, the review revealed that the majority of the studies focused on younger children. Three studies focusing on peer acceptance beyond the 6th grade resulted in moderate effect sizes. Four studies looking at other aspects of peer relationships produced much higher effect sizes than those focusing on just peer acceptance. The researchers indicate that these findings suggest that younger children may have low social skills as indicated by specific measures and, as they get older, their social skills become more complex and difficult to measure, but still remain problematic. The authors conclude that additional research is needed to further understand the changes in social skills in individuals with learning disabilities as they grow older (Swanson & Malone, 1992).

Hall et al. (1993) looked at whether students with learning disabilities differed from non-disabled students in terms of depression, causal attributions for success and failure, self-concept, and locus of control. The study involved eighty-two students in grades four, five, and six. The subjects were given the Intellectual Achievement Responsibility Scale, the Children's Depression Inventory, the Nowicki-Strickland Locus of Control Scale, the Self-Esteem Inventory, and the Children's Intervention Rating Scale. The results revealed that significant differences were found between the two groups in all cases.

Students with learning disabilities scored significantly lower than their non-disabled peers on the Children's Depression Inventory and, subsequently, were described as more at risk for depression. The researchers indicated that these scores could be a result of repeated failure in school, which in turn, results in poor motivation and attitude (Hall et al., 1993).

On the Intellectual Achievement Responsibility Scale students with learning disabilities perceived they had less intellectual-academic control than their non-disabled counterparts. The researchers indicated that students with learning disabilities were less likely than non-disabled students to accept responsibility for their successes and were more likely to accept responsibility for their failures (Hall et al., 1993).

In terms of self-esteem, students with learning disabilities scored significantly lower on the Self-Esteem Inventory and were more likely to express lower self-esteem than the non-disabled students. The researchers further broke down the self-esteem variable and discovered that there was a significant difference between the students with and without learning disabilities in the area of academic self-esteem but not in home-parent self-esteem. Again, this finding was attributed to school-related failures (Hall et al., 1993).

Students with learning disabilities also scored significantly higher on the Nowicki-Strickland Locus of Control Scale, which indicated that they were more likely to express an external locus of control than the non-disabled subjects. The researchers noted that this finding was consistent with previous research indicating successful children tend to attribute their success to internal factors such as ability and effort while unsuccessful children attribute their success to external factors such as luck (Hall et al., 1993).

Tur-Kaspa and Bryan (1994) evaluated the social information-processing skills of students with learning disabilities using Dodge's model of social competence as a theoretical framework. The researchers describe this model as one that asserts “a child comes to a particular situation or a task with a biologically determined set of response capabilities and a data base (i.e., his or her memory store of past experience and a set of goals), and he or she receives as input from the environment a set of social cues: The child’s response to those cues occurs as a function of the way he or she processes the social information” (Tur-Kaspa & Bryan, 1994, p. 13). The model assumes that the processing occurs in sequential steps. The information-processing steps that the researchers investigated included: (1) encoding social cues from the environment, (2) interpreting and integrating the environmental cues with prior knowledge, (3) searching for possible behavioral responses, (4) deciding the appropriate response, and (5) acting on that response decision.

The experimental group for the study consisted of 30 students with learning disabilities in third, fourth, seventh, and eighth grades. There were also two matched control groups consisting of 29 low-achieving students and 33 average-achieving students. All of the students were assessed on social information-processing skills, expressive and receptive vocabulary skills, and teachers’ ratings of social competence and school adjustment (Tur-Kaspa & Bryan, 1994).

Results from the study indicated that students with learning disabilities performed significantly less competently on the five information-processing steps than did average-achieving students. In addition, the students with learning disabilities demonstrated significantly more problems than low-achieving students in encoding information and in selecting solutions to social situations (Tur-Kaspa & Bryan, 1994).

Hartas and Dimitra (1997) looked at conversational and social problem-solving skills in adolescents with learning disabilities. One hundred sixteen junior high school children with and without learning disabilities were audiotaped as they played the role of advisor and caller in a simulated telephone conversation. The researchers divided the students into one of three types of groups: two adolescents with learning disabilities, one adolescent with a learning disability and one without, and two adolescents without learning disabilities. The study used a discourse analysis of transcribed calls to assess conversational and social problem solving strategies. The strategies evaluated included requesting, giving, and evaluating advice. The researchers found that adolescents with learning disabilities were just as skilled as those without learning disabilities in requesting advice. However, adolescents with learning disabilities had significant difficulties creating solutions to interpersonal problems as revealed in their inability to give advice to social problems in the role-playing scenario.

In a review of the literature concerning psychological and social skill issues of postsecondary students with learning disabilities, Brickerhoff et al. (1993) identified a number of primary problem areas. These areas include self-concept, ineffective socialization skills, dependency issues, stress and anxiety, and negative behaviors and feelings.

The authors noted that the most consistent social issue to emerge from the literature was a lack of a positive self-concept. Postsecondary students with learning disabilities are often depicted as viewing themselves negatively, despite successes they may have achieved throughout their lives. The authors cited numerous case studies describing these postsecondary students as angry, frustrated, and stressed because they have difficulty completing tasks easily and efficiently. However, the authors did mention that some case studies indicated that the difficulties serve to motivate students to try harder (Brickerhoff et al., 1993).

A second social skills deficit the authors identified involved inappropriate or ineffective socialization skills. The literature indicates that many adults with learning disabilities lack socialization skills such as the interpretation of social cues, the sensitivity to the subtleties of body language, the awareness of vocal tonality, the realization of time involved in social interactions, and the ability to interpret other people's moods. These deficits manifest themselves through inappropriate comments, difficulty anticipating behavior of others, difficulty in generalizing from experiences, inflexibility, and a tendency toward impulsive decisions (Brickerhoff et al., 1993).

Brickerhoff et al. (1993) also identified overdependence on others as a primary social skills problem for postsecondary students with learning disabilities. The literature describes a pattern where parents may be overprotective or totally detached from children who have learning disabilities. These responses can inhibit the child's movement toward independence. As an adolescent, the individual with a learning disability will often transfer these dependent feelings to their environment, including teachers and friends. This shift of locus of control causes the student to be unable to make decisions affecting his or her life.

The authors also indicated that stress and anxiety was an important issue related to social skills behavior. They cited a few studies where all of the college students with learning disabilities exhibited both overt and covert symptoms of stress. Other studies identified stress signs including physical mannerisms such as tics, general physical health problems, and conversations that often focus on stress (Brickerhoff et al., 1993).

Another area affecting social skills behavior involves what the authors loosely categorized as overt negative behaviors or feelings. They noted that the literature indicates a variety of negative behaviors in different situations. These negative behaviors include frustration, anger, depression, insecurity, and isolation. The literature seems to argue that in childhood, people with learning disabilities may see society as hostile, demanding, and threatening. This may result in negative behaviors during adulthood (Brickerhoff et al., 1993).

In conclusion, there does not appear to be sufficient research, at this time, to support the assertion that social skills deficits have a neurological origin. However, the existing research does indicate that children, adolescents, and adults with learning disabilities do seem to have more problems with various aspects of social functioning when compared to their non-disabled counterparts. As a result, it seems reasonable to assert that the identified social skills deficits could be a factor in the social interactions involved with postsecondary students who use a human transcriber to produce written composition. In particular, deficits in socialization could manifest themselves in the inability to pick up on social cues, which, in turn, might cause the person dictating, and editing to feel they are imposing on the transcriber's time, especially when they must continually have work read and re-read. Persons with disabilities might also feel anxious, nervous or embarrassed when required to interact with the transcriber, which may cause them to spend less time dictating or editing than they would otherwise spend.

The process of transcribing an individual's dictation through the use of a tape recorder can serve as a method to circumvent many of the social issues surrounding the use of a human transcriber. However, some researchers have indicated that actually seeing the dictated text helps in composition (MacArthur & Graham, 1987; Reece, 1992; Reece & Cummings, 1996). Using a tape recorder does not allow the person who dictates the material to review his or her composition. Furthermore, this technique does little to overcome the issue of loss of independence, since someone else still must transcribe the tape-recorded material. Speech recognition technology, however, may provide the advantages of using oral expression through dictation to circumvent the difficulties in text production, preserve the ability to reread the dictated composition, overcome the social difficulties of using a human transcriber, and also prevent the loss of independence inherent in relying on a human to transcribe the dictation.

Speech Recognition Technology

Speech recognition is the ability of a computer and program to recognize and carry out voice commands or take dictation. Using speech recognition software, users can tell computers to execute commands, and they can dictate text directly into a word processor on a computer.

In general, speech recognition software used for dictation involves the process of the user speaking into a microphone, the computer processing the captured words through a sound card, the software analyzing the sounds and matching the voice pattern against a provided or acquired vocabulary, and the matched words appearing as text in a word processor (Raskind, 1993). Most modern speech recognition systems can be used immediately, but learn the characteristics of each person's voice over time, and, as a result, the more a person uses the system, the better able it is to understand what the user is saying. These systems also allow the user to edit the dictated text using voice or keyboard commands.

A Brief History

In the early 1990's, speech recognition software emerged on the scene as an alternative to word processing. Unfortunately, at that time, the computers available to run the systems were inadequate and the software itself was unreliable. Since the hardware was not capable of running the software, the result was a barely functional system that did not consistently recognize even the simplest one-word utterances. Even when the hardware improved to the point where the software worked moderately well, end users could never get the same results that they witnessed when salespersons would demonstrate the product. This was primarily due to the fact that the salesperson was using a well-rehearsed script that the software had "learned" through hours of training. These factors caused many people to have a negative impression of the speech recognition technology (Fishman, 1996).

In 1994, with the development of the Pentium Processor and the lowered cost of memory, the hardware was sufficient to run speech recognition software. The cost of speech systems was dropping as well. In 1993, a typical system cost $35,000, and in 1994, $15,000. At that price, the systems could even pay for themselves by costing less than the annual salary of a typical transcriptionist. The ease of installing the necessary equipment, such as a sound card, was also improving. The sophistication of the speech recognition databases, the speed and quality of the recognition and the lowered cost of hardware all began to slowly change the attitude of users toward the technology. Speech recognition was becoming a viable option for certain applications (Fishman, 1996).

During the early to mid 1990s, all marketed speech recognition systems relied on discrete speech technology. Using this technology, users were required to pause between words during dictation. These systems were classified as speaker-dependent, which means that each user had to train the system to recognize his or her dictated speech. The systems relied on a 1,000- to 10,000-word template created in a training session to interpret speech sounds (Williams, 1998). The training consisted of users reading selected text passages and took anywhere from one to three hours to complete. During the training, the users needed to speak clearly and distinctly and were required to carefully isolate each word. The computer would then match the sounds dictated in training to the text passages it heard (Lange, 1993).

Discrete speech speaker-independent systems, which operated by matching sounds but did not require the creation of user-specific templates, did exist. However, these systems were generally less accurate unless the vocabulary was extremely restricted (Lange, 1993).

The discrete speech systems would continually adapt to the user’s speech, word by word. As a result, when a recognition error would occur, the user was required to make the correction at that time. These systems would generally provide users with a list of several words in order to locate the target word. When a correction was made, the template word was then matched to the user’s speech pattern (De La Paz, 1999).

The accuracy rates for discrete speech systems were rather low, with rates for various systems ranging anywhere from 50 to 90% (Fishman, 1996). Leonard (1991) noted that even at 90% accuracy, these speech systems were likely to incorrectly interpret a 10-digit telephone number over half of the time.

Although the capabilities of discrete speech recognition technology were increasing and more and more people began to show interest in the product, there was much room for improvement. The systems seemed to work reasonably well for issuing commands to the computer such as “open” or “select,” but, for many, they proved to be an unnatural and very difficult method to dictate text into a computer.

In April 1997, Dragon Systems, Inc. marketed the first continuous speech recognition system, *Dragon NaturallySpeaking*. This system allowed users to dictate text into the computer using natural conversational speech (Dragon Systems, 2001). The *NaturallySpeaking* system used a more complex foundation than previous discrete speech systems. It was based on the acoustic features of language and used statistical modeling techniques and learning algorithms that allowed it to analyze dictated speech in the context of how it is typically used. The statistical model used examples of written language where the number of times a word appears in conjunction with other words was recorded. Those texts were analyzed and used to calculate the probability of one word following another, or appearing at the beginning or end of a sentence. As an individual began to speak, the software analyzed what was said and built a tree of probabilities representing all the possible combinations of phonemes and the words they could form. At any point, each branch of the tree contained a probability level, and the branch with the highest probability was the one that was chosen (Williams, 1998).

The use of a probability tree was a breakthrough technique for interpreting dictation, but it came at a price. The continuous speech system required much more memory than previous speech software and even the fastest computers still could only access the memory at the speed of the system bus (i.e., the set of wires on the system board that connects the various components of the computer), which, at the time, did not exceed 75 MHz. Memory and memory access speeds were important because each node of each branch of the probability tree had to be held in memory until the sentence was finished. With continuous speech, the number of possibilities is huge, and to start discarding branches of the tree prematurely would significantly decrease accuracy since the software cannot recognize a word it does not have in memory (Williams, 1998).

NaturallySpeaking came standard with a 30,000-word general vocabulary file, which also contained the language model. Like the speaker-dependent discrete systems, the user would then customize the vocabulary and language model by reading from a set of text passages, which allowed the model to more closely match his or her dictation style. The more consistently the user dictated the text passages, the better the system's recognition rate (De La Paz, 1999).

A number of companies, Dragon, IBM, Lernout & Hauspie, and Phillips, have since dedicated tremendous resources to improve the quality of continuous speech recognition (Essex, 1999). These companies have come out with a number of speech products over the last few years. The new continuous speech systems provide a more natural and accurate method to dictate text into a computer's word processor than previous discrete speech systems.

Current continuous speech recognition systems allow the user to dictate text into the computer more naturally, but still aren't completely natural because accuracy is dependent on the user having consistent patterns of pronunciation. In addition, although most systems capitalize the first word of each sentence, the user must learn and use commands for capitalization, punctuation, and modification of dictated text. Most systems allow the user to format dictated text using either the keyboard or voice commands (De La Paz, 1999).

Typical continuous speech recognition systems come standard with a general vocabulary file containing the available words and a language model. The vocabularies of these systems range from 20,000 to 55,000 immediately recognizable words, with less common words being retrieved from a larger back-up dictionary (De La Paz, 1999).

Unlike the older discrete speech systems, continuous speech technology does not continually adapt to the user's speech. As a result, these systems allow users to make corrections at any time. Continuous speech systems also offer a few methods to make corrections to the dictated content. The user can select and use voice to repeat an incorrectly interpreted word or spell the word using either voice or the keyboard. Once an unknown word is repeated or spelled, the system automatically adds it to the user's active vocabulary (De La Paz, 1999).

Although the manufacturers make claims that accuracy rates of the continuous speech systems can reach 95-99% (Essex, 1999), the reality is that many factors may affect the actual accuracy of these systems. These factors include what content is being dictated and how similar the words or phrases are to one another and the variability in the user's speech that may occur due to fatigue, a cold, or mispronunciations. Another factor that can influence accuracy involves the environment in which the system is used, such as placement of the microphone and the surrounding noise level (De La Paz, 1999). The quality of the equipment used with the system can also affect accuracy. A slower computer with a small amount of memory can cause words or phrases to be lost or a poor quality microphone can reduce the voice input quality and increase recognition errors (Essex, 1999).

One of the primary strengths of continuous speech technology is the ability to enter text quickly. Once the user becomes accustomed to using speech input and the software has been trained to recognize his or her voice, it is possible achieve input rates of up to 130 words per minute. In addition, most modern products provide support for commonly used packages like *Microsoft Word*®. These systems also include their own word processors, so it is not necessary to learn how to use a new set of word processing features in addition to becoming familiar with speech input commands (Williams, 1998).

Many of the new speech systems have a variety of language packages that include English, French, and Spanish. Some of these systems require the user to briefly train the computer to adapt to his or her voice, while others use a speaker-independent language model and are usable right out of the box. However, even the speaker-independent systems improve with use.

Good continuous speech recognition systems continue to increase in effectiveness and efficiency, as well as decrease in cost, and are now available for as little as $55. All of these systems will work on Pentium-based computers (which now have system bus speeds of 100 MHz or more) and require between 64 and 128 megabytes of random access memory. Many packages are also available for the Power Macintosh. With the relatively cheap cost of computers and memory, a good system is well within the reach of the average consumer.

Applications

The range of potential applications of speech recognition technology is quite large. Researchers have begun to explore the possibilities, and the technology has been considered for and implemented in a variety of settings. The most popular applications include medical, industrial, and educational.

In one area of educational applications, speech recognition technology has the potential to make the greatest difference as a solution for individuals with disabilities. With current speech recognition systems being relatively easy to use, cost efficient, and capable of running on a standard computer system, more researchers, therapists, and teachers are becoming optimistic about the use of this technology to assist individuals with disabilities in school, at home, and in the workplace. Examples of research in this area include the use of speech recognition systems to control the environment for individuals who have physical and/or cognitive disabilities and the use of the technology to help improve the speech accuracy of individuals with communication disorders and hearing impairments (Noyes & Frankish, 1992; Cavalier & Ferretti, 1996; Cavalier and Brown, 1998).

Recently, a few researchers have begun investigating the use of speech technology as an alternative for students with learning disabilities to get their thoughts down on paper (De La Paz, 1999; Higgins & Raskind, 1995; Wetzel, 1997). Speech recognition technology has the potential to provide a method to write that capitalizes on oral expressive strengths much like normal dictation while preserving the ability to easily reread the dictated composition. These systems may also help individuals with learning disabilities to circumvent the social issues that can come into play while using a human transcriber. Furthermore, the technology may provide a more independent accommodation for postsecondary students with learning disabilities in the writing process. The new continuous speech systems may also provide a more natural and quicker way to get text into the computer than the older discrete speech systems. In addition, a benefit for universities providing accommodations is that these systems are much cheaper than the annual salary of typical transcriptionists. Despite these advantages, however, the additional cognitive demands of learning and executing commands for capitalization, punctuation, and editing required by the continuous speech writing mode could offset any potential benefits of oral expression for individuals with learning disabilities. At this point, however, there is little research to substantiate whether or not this technology may serve as a useful accommodation for individuals with learning disabilities.

Learning Disabilities and Speech Recognition: The Research

There have been a number of articles and studies that have investigated the potential advantages of using speech recognition technology to assist individuals with disabilities. However, there are considerably fewer studies that have looked at the effectiveness of speech recognition technology in helping students with learning disabilities compensate for written language difficulties, only one of which involved postsecondary students. This review did not locate any studies that looked at the compensatory effectiveness of continuous speech recognition technology to support the written expression of postsecondary students with learning disabilities.

Raskind (1993) provided an overview of a variety of technologies to assist individuals with learning disabilities. At the time of his writing, the researcher noted that his overview was important because a review of the leading refereed journals in the area of learning disabilities revealed no articles dealing with assistive technologies.

The researcher included speech recognition as one of the technologies he investigated. He indicated that the discrete speech systems available at the time could be particularly useful to individuals with learning disabilities whose oral language exceeds their written language. He noted that the technology could allow individuals with learning disabilities to dictate into a word processor at speeds of 40 to 70 words per minute and could also provide a method to edit the dictated text using voice commands (Raskind, 1993).

In two separate reviews that investigated methods in which computers can support individuals who have difficulty with the writing process, MacArthur (1999) and De La Paz (1999) included speech recognition technology. Both researchers indicated that dictation has an advantage over traditional modes of writing because it circumvents the problem of producing words and eliminates the demands of spelling, capitalization, and punctuation from negatively affecting the quality of the composition. They also indicated that speech software opens up the possibility of composing by dictation without the direct assistance of another person. In her review, though, De La Paz (1999) mentioned that there could be some difficulties with using speech recognition for individuals who have learning disabilities. The author revealed that although speech recognition, like dictation, frees users from worrying about spelling and handwriting, it imposes new burdens that include careful speech and explicit punctuation, error correction, and editing procedures. In addition, she noted that students might need guidance as they initially learn to use these procedures. Nevertheless, both researchers argued that the time has come to begin assessing the use of technology to support individuals who have difficulties with the production process of writing.

Wetzel (1996) conducted an exploratory study on using a discrete speech recognition program to improve writing with one sixth-grade student with a learning disability. He followed the progress of the student through 14 sessions over a 10 week period and used videotape and writing products to evaluate the student's mastery of the speech system, the adequacy of the system as a writing tool, and the potential for improvement of the student's writing.

The researcher indicated that the student did learn to speak clearly and pause between words during the 10-week period. However, he noted that the top recognition rate of the discrete speech system only reached 74% despite claims by the manufacturer of 90% accuracy. He also noted that the primary difficulty for the student involved correcting dictation errors. When the speech recognition system did not recognize a word, the student would type in the correct word using the keyboard. The student, however, had trouble spelling some of the words the software did not recognize. The problem was magnified when, in his attempt to spell the word, he would sound it out while the microphone was on, which resulted in other unwanted words appearing on the screen. This caused the student to be frustrated and he would breathe deeply or cough, causing more unwanted words to appear (Wetzel, 1996).

Overall, the researcher concluded that it is possible for an elementary school student to learn to use a discrete speech system, but the software accuracy was too low to effectively improve the quality of written expression. He also indicated that the student dictated more writing than was typical, but because of limitations of the software, it was not possible to draw any conclusions about the quality of his written work. The researcher noted that if the speech system was a little easier to use and the performance of the system was improved, the student's written communication would be expected to improve (Wetzel, 1996).

The author made several suggestions for further research. These suggestions included research with different speech software products and the assessment of whether they could prove useful to students with learning disabilities, especially with regard to accuracy rate and correction procedures. Other recommendations dealt with the need to assess the differences between writing by pen or keyboard and writing using speech recognition. Additionally, the author indicated that speech technology may be more useful to some students with disabilities than others, and research is needed to determine how to select those who would most likely benefit from it (Wetzel, 1996).

Higgins and Raskind (1995) conducted the first experimental study to assess the effectiveness of discrete speech recognition technology as a compensatory tool for the written composition of individuals with learning disabilities. The study involved 29 postsecondary students. The researchers used the Upper Division Written Proficiency Exam to do a holistic analysis of the subjects' written composition. Each subject wrote three essays in three different treatments: (1) writing with a pencil and paper or a keyboard without assistance, (2) writing using a human transcriber, and (3) writing using a discrete speech recognition system. The subjects were randomly assigned to one of two groups: one group received training first and used the speech program to write the first essay and then wrote the other two essays, the other group took the two written language tests without using the speech recognition program, received the training, and then wrote the final essay with the speech recognition program. This was done in order to control for the training effect that might occur due to the 5-10 hours the users spent in order for the system to learn their voices. Two readers scored all of the written compositions. The raters were instructed to give the writing a holistic score using a number of criteria with regard to rhetorical and syntactical adequacy of the paper. Criteria included ability to address the topic, organization and development, use of language, and appropriate word choice (Higgins & Raskind, 1995).

Results of the study revealed that writing using the discrete speech recognition program did not differ significantly from the transcribing treatment, but was superior to writing without assistance using a pencil and paper or keyboard. The results also indicated that there was no significant difference between the transcribing treatment and the writing without assistance treatment. Although not significant, the speech treatment did receive a higher mean score than the transcription treatment (Higgins & Raskind, 1995).

The researchers also did an exploratory analysis of the written compositions using some measures they found in the literature to assess written expression. The researchers included measures of vocabulary involving number of unique words, words of seven or more letters, number of adjectives, and number of adverbs. Results from these analyses indicated that the single most important predictor of the holistic score was words of seven or more letters. The speech technology when compared to the no assistance condition showed a significantly greater use of words of seven letters or more (Higgins & Raskind, 1995).

The researchers noted the study showed that discrete speech recognition promotes use of the more developed oral vocabularies of the subjects as indicated by the use of larger words. In an effort to explain the surprising result of the transcription treatment, where dictation using transcription was not significantly different from writing without assistance and had a lower mean score than the speech recognition treatment, the researchers pointed out the possible difficulties individuals with learning disabilities have with social interactions. They revealed that the participants often apologized when asking the transcribers to reread parts of the text and, therefore, may not have edited the final output as thoroughly as they did with the speech program. As a result, the difficulty the students had with social skills may have offset any potential advantages of oral communication in the human transcriber treatment, causing it to exceed the unassisted writing treatment less than expected and to fail to match the results achieved by using oral communication through the speech recognition system. In summary, the researchers asserted that the findings indicate that discrete speech recognition is beneficial to postsecondary students with learning disabilities in the area of written composition (Higgins & Raskind, 1995).

Raskind and Higgins (1998) followed their 1995 study with a three-year longitudinal study that investigated the changes in academic outcomes, behaviors, and attitudes as a result of using speech recognition technology during that time. The data was collected using interviews, questionnaires and self-reports. The authors acknowledge, however, that many of the reported changes may have been due to other factors than the use of speech technology.

Over the three-year period, participants significantly increased their GPAs for courses with heavy reading and writing requirements when compared to a matched control group. University attrition rate for the participants was only 1.4% compared to 34% for a matched control group of students with learning disabilities who did not participate in the study. Results also indicated that an examination of the computer log-on procedures revealed an increase in the hours of use for the speech recognition technology. Furthermore, an examination of databases documenting use of services and data from several questionnaire responses indicated that students who participated in the study increased their overall independence by relying less on family members, friends, and classmates to help them compensate for their disabilities (Raskind & Higgins, 1998).

In another study that extended their original 1995 study, Raskind and Higgins (1999) looked at speech recognition technology as a remedial tool. In introducing the study, the researchers indicated that many of the students who participated in the original study (Higgins & Raskind, 1995) continued to use the discrete speech recognition system over the next three years and reported improved reading abilities including word recognition and comprehension. These findings prompted the researchers to consider speech recognition as not only a compensatory tool, but also a remedial one.

In generating hypotheses concerning how discrete speech recognition technology might be used as a remedial tool, the researchers indicated that the process of generating accurate text through voice requires the user to read and check the text on the screen to verify that the right word is displayed. If it is incorrect, the user must choose the word from a list of correctly spelled words. By selecting the correct word, the user is required to attend to specific phonemic, graphemic, and morphemic characteristics of similar sounding and looking words. The researchers hypothesized, then, that the speech technology could improve reading by simply providing more opportunity to read. The researchers also hypothesized that the bimodal (auditory and visual) presentation of dictated words on the screen may enhance the ability of the user to process and store the information. They also indicated that a proprioceptive/kinesthetic component is present since the individual has to use the necessary oral mechanisms to speak the words. Both the bimodal and proprioceptive/kinesthetic approaches have literature to support their effectiveness for students with learning disabilities. The researchers also noted that the auditory/visual presentation of individual words using discrete speech technology might enhance grapheme-phoneme correspondence. Finally, the technology may also provide a motivational venue in which to learn (Raskind & Higgins, 1999).

Higgins and Raskind's (1999) study was designed to determine whether elementary and secondary students with learning disabilities who use discrete speech technology to write self-selected compositions would demonstrate improvements in reading and spelling. The study consisted of 39 students with learning disabilities between the ages of 9 and 18. All students met the criteria agreed on by the National Joint Committee on Learning Disabilities and also showed deficits of two years or more in reading comprehension, phonological analysis, and/or spelling. Nineteen of the students used speech recognition 50 minutes a week for sixteen weeks to perform writing exercises, and twenty students in the control group performed the same exercises using a standard keyboard.

Results of the study revealed that the speech recognition group showed significantly more improvement than the control group in word recognition, spelling, reading comprehension, and phonological awareness. Further analysis indicated that the significant gains made by the speech recognition group in the areas of word recognition, spelling, and reading comprehension could be attributed solely to the improvement in phonological awareness. Overall, they indicated the results reveal that the use of discrete speech recognition to create written text can have a remedial effect (Raskind & Higgins, 1999).

In their most recent study, Higgins and Raskind (2000) added to their previous research by looking at continuous speech recognition software as a remedial tool for reading and spelling of children with learning disabilities. In doing so, they introduced a few distinct differences between continuous and discrete speech technologies that may have an impact on the effectiveness of the technologies as both compensatory and remedial tools.

The authors mentioned that the primary difference between the discrete and continuous speech systems is that the continuous systems do not require a pause between words. As a result, they noted that it was no longer necessary for the users to recognize word boundaries while dictating. The researchers also noted that the entire utterance appears on the screen at once. This, in turn, may make it harder for users with learning disabilities to gain phonological awareness of particular words as they dictate or correct their writing. Correcting individual words may also be more difficult since these words may be harder to identify and isolate within phrases or sentences. Also, the continuous speech systems often incorrectly interpret entire phrases or sentences as single words or vice versa, which may be more difficult to correct since it is harder to isolate, select the incorrect word and then substitute the correct one. Additionally, since the continuous speech systems display longer utterances, there is a longer lag time between the dictated text and its appearance on the screen. Consequently, the simultaneous multi-sensory experience offered by discrete systems may be lost. Finally, the researchers mentioned that proofreading using continuous speech is no longer done word-by-word as with discrete speech systems. As a result, proofreading is very similar to the type done with pencil and paper or word processing, which involves a complex process of correcting words, usage errors, grammatical errors, spelling, and punctuation. The authors noted that the literature indicates students with learning disabilities have great difficulty with this type of proofreading (Higgins & Raskind, 2000).

The study added an additional experimental group to the previously published study (Raskind & Higgins, 1999). The new experimental group consisted of 13 students with learning disabilities who wrote using a continuous speech system. The participants worked at the computer for 50 minutes a day for 16 weeks in the semester following the 1999 study. This group was then compared to the previous control and experimental groups (Higgins & Raskind, 2000).

Results of the study revealed that both discrete and continuous speech groups showed significant improvement in word recognition and reading comprehension when compared to the control group. The discrete speech group also showed significant improvement in spelling when compared to the control group. Additional analysis indicated that phonological processing improved for the discrete speech group when compared to the control group, while sentence span tasks increased for the continuous speech group (Higgins & Raskind, 2000).

In their discussion, the researchers mentioned that their findings are consistent with research revealing remedial effects on reading using various types of computer instructional programs. They attributed the remedial advantages of speech technology to working with text in a variety of ways in a motivational environment. In an attempt to explain why only the discrete speech system provided a remedial effect in spelling, the authors compared and contrasted the editing environment of the two systems. They revealed that using the discrete system, users accessed a choice box containing words that could be compared to the dictated word, which provided practice reading and discriminating similar sounding and looking words. The continuous speech system, on the other hand, used a separate correction screen making the dictated text temporarily unavailable. This did not provide the same opportunity to read and compare text alternatives. In addition, the separate correction screen produced succeedingly more accurate guesses on the word list as the desired letters were typed. Rarely did the user have to type out the entire word before the correct choice was made, which also did not allow as much practice in spelling out the correct words. However, the researchers noted that although this method of correcting words did not produce a remedial effect, it could provide a compensatory effect in that it allowed students to make corrections at a more rapid rate, which could, subsequently, improve the rate of dictation. The study, though, did not measure compensatory advantages of continuous speech (Higgins & Raskind, 2000).

In other differences between the two types of speech systems, the researchers explained that the discrete speech technology promoted phoneme/grapheme word awareness as measured by increased ability to delete the first sound of a word and then say the remaining segment, while the continuous speech system improved the users' ability in sentence span tasks, or the ability to recall the last word of a set of sentences read aloud by the experimenter. The authors indicated that the discrete speech system promoted focus on individual words, while the continuous speech system may have provided practice at holding phrases and sentences in working memory (Higgins & Raskind, 2000).

The researchers indicated that both discrete and continuous speech systems could have positive, though different, remedial effects for individuals with learning disabilities. The authors also indicated that their work has shown that speech technology can be usable by individuals across a broad age range (Higgins & Raskind, 2000).

In summary, there is little formal research dealing with the use of speech recognition technology for postsecondary students with learning disabilities as a method to compensate for deficits in the area of written expression. The existing research, however, does indicate that discrete speech technology promotes the use of the more developed oral vocabularies of these students when compared to writing through visual-motor methods such as a keyboard or pencil and paper (Higgins & Raskind, 1995). The research also seems to indicate that discrete speech recognition technology improves academic outcomes, behaviors and attitudes of postsecondary students with learning disabilities (Raskind & Higgins, 1998). In related studies, discrete speech recognition technology also appears to have remedial advantages in both reading and spelling by promoting phonological awareness of individual words (Higgins & Raskind, 2000; Raskind & Higgins, 1999). The most recent study also indicates that there are specific differences in discrete and continuous speech recognition systems that may impact both remedial and compensatory uses of the technology. Using the new continuous speech systems, the users no longer have to recognize word boundaries, which may make it harder to gain phonological awareness of particular words during dictation. It may also be harder to proofread and to edit work using the continuous speech technologies since the user must deal with longer pieces of text at a time. Continuous speech technology, however, may offer other remedial advantages that involve working with larger chunks of text (Higgins & Raskind, 2000).

Higgins and Raskind (1995), in the only formal study to date investigating the compensatory effects of speech recognition technology on the written composition of postsecondary students with learning disabilities, based their findings on one particular method for oral expression, the discrete speech system *Dragon Dictate*. Further research is needed to explore the compensatory advantages of speech using continuous speech recognition technology due to the differences in both dictation and editing inherent in these systems. The results of this study were also based on scoring criteria from one particular instrument. Since the evaluation of written composition will undoubtedly vary with different scoring scales, research is needed with other instruments to look at the efficacy of using this technology to compensate for poor writing as evaluated by diverse criteria.

Assessment of Written Expression

The most widely used method to assess a person's written expression is through direct assessment. This method generally requires the individual to create an essay from an assigned topic under timed circumstances. The topic for the written composition is usually announced at the time of the assessment, and the person being tested is typically not allowed to use any outside resources or confer with anyone regarding the writing task. Once the task is completed, a scorer assesses the writing based on some set of predetermined criteria (Ballator, Farnum, & Kaplan, 1999).

The writing task may vary, depending on the topic or the age of the examinees. Typically, the writing task for a direct assessment is narrative, descriptive, persuasive, or expository. In a direct assessment of writing, elementary students might be required to describe something they have seen, while postsecondary students might be asked to develop a convincing argument to support a position. Narrative and descriptive tasks are more closely aligned with the writing taught at the elementary level, whereas persuasive and expository tasks more closely match the type of writing done at secondary and postsecondary levels (Ballator et al., 1999).

The use of writing samples to assess written expression has been adopted by a number of states to determine the writing competence of secondary and college students. They have also been included in the General Education Development (GED) test for high school equivalency diplomas, and have been adopted by some universities as placement tools (Wolcott & Legg, 1998).

The process of having students interpret the intent of a topic, write a response, and do at least some revising and proofreading reveals numerous components of an individual's writing skills. Typically, the direct assessment of writing indicates how well an individual thinks through a particular topic, develops his or her ideas, and expresses those ideas. It can also be an indicator of how well a person can control the sentence structure and mechanics of writing (Wolcott & Legg, 1998).

In terms of measurement, writing samples offer a number of clear advantages. Since individuals are asked to do the same type of writing under specific time constraints, writing samples provide relatively controlled testing conditions. Furthermore, such variables as the testing context, availability of resources, and scoring methods are kept constant. This allows comparisons to be made among the students who were assessed. Other advantages include the time and effort required to score the essays. Timed essays are usually shorter and easier to score then longer compositions such as those found in portfolios (Gorrell, 1988).

The direct assessment of writing is usually scored using one of three methods: analytical, holistic, or primary trait. Each method has its own assumptions and techniques for analyzing the compositions.

An analytical assessment of writing assumes that mastery of the components that make up writing leads to a successful composition. As a result, this assessment focuses on the necessary components that are needed to produce effective writing. Each of the components, which vary depending on the rating scale but may include elements such as essay organization and coherence, grammar, and mechanics, are independently evaluated by two raters and assigned an individual score (Burry & Quellmalz, 1983). Analytical assessments are often used for diagnostic purposes and are sometimes used to complement holistic writing assessments (Witt, 1995).

In direct writing assessments, holistic scoring is the most widely used scoring procedure. Holistic scoring is based on the premise that the whole of a composition is greater than the sum of the parts. As a result, a composition is not evaluated based on individual components such as sentence structure and mechanics, but is evaluated in terms of the overall impact of the composition's components working together. The general impact of a paper is based on the scorer's overall understanding of a holistic rating scale and his or her ability to apply those criteria to the writing (Wolcott & Legg, 1998). There are two primary methods for holistically rating papers. They involve matching papers with another representative sample in a previously graded series or scoring the sample for the prominence of certain features inherent in a specific writing task based on a predefined scale (Jones-Loheyde, Jambeck, & Esquilin, 1983).

In a typical holistic assessment, two scorers independently rank order the essays using previously scored sample papers or score the essays using a six- to ten-point rating scale. Holistic scales vary, usually due to the author's perspective and/or the writing task it is designed to assess, but often include criteria such as clear main idea, logical organization, and relevant detailed support. The scores of the two raters are then averaged to obtain the overall score for the paper. If there is a discrepancy between the scores of the two readers, usually two points or more on a six- to ten-point scale, a third reader scores the essay. Depending on the procedure, the third score either replaces the most discrepant score or the three scores are averaged to obtain the overall score (Burry & Quellmalz, 1983).

Primary trait assessment is a specialized form of holistic scoring. The assessment assumes that it is possible to identify specific qualities of writing that are important for success on a given task. It focuses on the primary tasks of writing (i.e., narrative, descriptive, persuasive, and explanatory) along with the purpose and audience involved with each task. The assessment identifies a primary trait to be analyzed in terms of a specific purpose and audience and includes a rating scale to assign scores. Raters use the guide to analyze the compositions in terms of the identified trait (Saunders, 1999). As an example, the National Assessment of Educational Progress (NAEP) has developed a scoring guide that includes a picture of a boat in which children are playing. The primary trait is described as “Elaborated expression of a point of view through entry into an imaginative situation” (Ballator et al., 1999, p. 44). The guide includes a rating scale assessing the degree to which the writer immerses him or herself into an imaginative situation based on the picture.

The studies in this review involving transcription and speech recognition investigated written expression of individuals with learning disabilities through direct assessment using narrative, persuasive, or expository writing tasks. MacArthur and Graham (1987) assessed the writing of elementary students using a narrative task. Reece (1992) and Reece and Cummings (1996) investigated compositions of elementary students using each of the three tasks. De La Paz and Graham (1997) and Graham (1990) investigated the writing of elementary students using a persuasive task, while Higgins and Raskind (1995) assessed the writing of postsecondary students using an expository task.

When comparing the oral (auditory-motor) methods of expression (i.e., dictation and speech recognition) to common visual-motor methods of expression such as handwriting or keyboarding, the prevailing theory and research asserts that oral expression may improve the quality, rate, and/or length of compositions for individuals with learning disabilities because handwriting and keyboarding is a slower and more demanding mode of writing (Bernstein & Tiegerman, 1993; Gardner, 1983; Haggblade, 1990; Vogel & Moran, 1982). As a result, most of the transcription and speech recognition studies in this review evaluated the quality of written expression and also the length and rate of production of each essay. Every transcription or speech recognition study that assessed the quality of writing did so using a holistic method. Several of the studies also included additional analytical measures of written competence.

In the MacArthur and Graham (1987) study, where the researchers compared three modes of writing (e.g., handwriting, keyboarding, and dictation), essay quality was evaluated with a holistic method using an eight-point scale focusing on story structure, grammar, and organization. Two raters scored each essay and the scores were averaged to obtain the overall essay score. The study reported an interrater reliability index of .82. The study also assessed length and rate of production for each essay. In addition, the researchers included a few analytical analyses of the essays that looked at language complexity (i.e., word length and ratio of different words used).

Graham (1990), in assessing handwriting, normal, and slow dictation modes of producing compositions, evaluated the quality of the essays using an eight-point holistic rating scale focusing on word choice, grammar, sentence structure, organization, and ideation. The raters were also provided with a representative sample of low-, medium-, and high-scoring essays to use as a guide. Two scorers rated all essays and these scores were averaged to obtain the overall rating. The interrater reliability of the essay scores was .86. The researcher also evaluated essay length.

Reece (1992) and Reece and Cummings (1996) in a series of studies assessing the compensatory effects of dictation on written composition, used a six-point holistic rating scale to evaluate essay quality. Once again, two raters scored each essay and the scores were averaged to obtain the overall score.

De La Paz and Graham (1997), in looking at the effects of dictation and explicit instruction on written composition performance, analyzed the quality of the essays using a holistic rating scale geared to assess persuasive writing. The raters scored the essays based on whether the writers adequately developed and supported their arguments. The raters also used a representative sample of low-, medium-, and high-scoring essays as a guide. Differences between essays were resolved through discussion. The interrater reliability was reported as .80. The researchers also used an analytical scale to evaluate essay coherence through proportion and severity of grammar and mechanical errors in the composition. Additionally, the researchers assessed length and rate of production for each essay.

Higgins and Raskind (1995) conducted their study using one particular holistic assessment instrument, the Upper Division Proficiency Exam. The instrument uses a six-point scale focusing on rhetorical and syntactical adequacy of the essays. Two raters familiar with scoring the exam evaluated all essays. In the case of a discrepancy, a third reader evaluated the essay and all three scores were averaged to obtain the overall score. The interrater reliability of the scores was reported to be .93. In addition, this study looked at essay length and did additional analytical analyses of vocabulary use and syntactic complexity, which included number of words with seven or more letters and the number of different morphemes, adverbs and adjectives. The study also assessed the length of each essay. The study, however, did not assess rate of production of the essays and, consequently, may have underestimated the advantages of oral expression in producing written compositions for individuals with learning disabilities.

In terms of transcription and speech recognition research, the consensus method for assessing quality of written expression is through the use of holistic measures. This is likely due, in part, to the ease of scoring and relatively high interrater reliability that can be achieved using this method (Wolcott & Legg, 1998). Furthermore, the primary purpose of these studies is to assess the impact of writing mode on the overall written expressive abilities of individuals with learning disabilities. As a result, it is not necessary or appropriate to assess analytical components such as spelling, capitalization, and punctuation since they are not factors in every mode. Holistic measures are the most appropriate means to assess the overall quality of compositions produced by various writing modes, such as handwriting, keyboarding, dictation, or speech recognition.

Since different holistic measures of essay quality focus on varying criteria depending on the perspective of the creator and the writing task to be assessed, one measure is not sufficient to warrant extensive generalizations of effectiveness of writing modes. As a result, follow-up studies assessing the compensatory effects of oral expression through the use of continuous speech recognition need to focus on the use of other holistic scales to evaluate quality and, at minimum, need to include the additional measures of length and rate of production.

Summary

In the early 1960s professionals began to identify and define a new term, learning disability, to describe individuals with specific learning deficits. In 1969, this term was defined by the National Advisory Committee and offered to Congress. The definition, which included the recognition of deficits in basic psychological processes and excluded other causes, was subsequently enacted into law and served as the basis for a number of legislative pieces including the Education for All Handicapped Children Act, Public Law 94-142 (Smith, 1991) and the Individuals with Disabilities Education Act (IDEA), Public Law 101-476 (Lerner, 1997).

The operational component of the federal definition indicates that an individual has a specific learning disability if that person does not achieve at appropriate academic levels despite adequate learning experiences and if that person has a discrepancy between achievement and intellectual ability in one or more of seven academic areas, one of which involves written expression (Kavale & Forness, 2000; Lerner, 1997). The federal guidelines stipulate that states may write their own definitions, but they can be no more exclusive than the federal criteria (Smith & Strick, 1997; Smith, 1991).

Several other definitions of learning disabilities have been created over the years. Among the most popular is the definition put forth by the National Joint Committee on Learning Disabilities (NJCLD) in 1981. The NJCLD revised the federal definition to demonstrate that learning disabilities occur across the lifespan and to emphasize that underachievement is due to a neurological dysfunction within the individual (Kavale & Forness, 2000; Smith, 1991). The NJCLD definition has been accepted by a number of organizations that serve individuals with learning disabilities (Lerner, 1997).

While the process of defining the term "learning disability" has been difficult and controversial, many of the our current definitions are in fundamental agreement on most issues. These definitions typically make reference to a central nervous system dysfunction, psychological processing difficulties, difficulty in academic learning tasks, a discrepancy between achievement and potential, and the exclusion of other causes (Hammil, 1993).

The eligibility requirements in most states are usually based on either the federal government's or National Joint Committee on Learning Disabilities' definition (Smith & Luckasson, 1992). Because the federal definition of learning disabilities makes reference to a severe discrepancy between expected and actual achievement as an indicator of a learning disability, many states and school districts have developed discrepancy formulas to help in the identification process (Forness et al., 1983; Frankenberger & Harper, 1987; Kavale & Nye, 1981).

Typically, at the postsecondary level, programs require similar documentation for students with a previous learning disability diagnosis in order to deem them eligible for services. This documentation includes a psychoeducational assessment and/or an Individualized Education Program (IEP) from the student's previous school completed within the past 3 years (Carlton & Walkenshaw, 1991).

As reflected in the numerous operational definitions used by states and school systems to identify students with learning disabilities, there is currently no agreement on a nationally consistent and measurable operational definition (Kavale & Forness, 1995; Smith & Luckasson, 1992). This lack of consistency had made the generalizability of research findings problematic (Kavale & Forness, 1995; Reid et al., 1996). It is still possible, however, to conduct research, but until a common definition is developed, researchers must thoroughly describe and control variability in their population selections (Hammil, 1993).

Since there is no universal operational definition of learning disabilities, the number of individuals identified at the elementary, secondary, and postsecondary level as having a learning disability depends, for the most part, on the criteria each state uses to determine eligibility for services. Despite this fact, 1996 figures revealed that the average prevalence of individuals identified as having a learning disability among states was 4.36% of the school age population (ages 6-21) and all states consistently identified between 2.35% and 7.23% of the school age population. Learning disabilities now account for 51.2% of all students with disabilities ages 6-21 who are enrolled in school (U.S. Department of Education, 1997).

As indicated in the federal definition, individuals with learning disabilities exhibit specific deficits. The information-processing theory, which looks at cognitive processes that underlie observable performances, is the primary model used to characterize these deficits (Bernstein & Tiegerman, 1993; Reid et al., 1996; Swanson, 1989).

The information-processing theory, as applied to individuals with learning disabilities, assumes that these individuals have an intellectual ability that exceeds their information-processing systems. In the individual who is learning disabled, some information-processing components, which include both processing skills and system structure, are not operating effectively for certain tasks (Reid et al., 1996; Stanovich, 1986).

Although individuals with learning disabilities are generally considered to be a heterogeneous group, the common set of information-processing problems that these individuals experience is reflected in the recognition of several general characteristics. They include hyperactivity, attention deficits, motor deficits, perceptual motor deficits, language deficits, impulsivity, and cognitive deficits (Bernstein & Tiegerman, 1993)

The characteristics associated with individuals who have learning disabilities often manifest themselves through academic deficits. The majority of individuals with learning disabilities have deficits that affect both language comprehension and production. These language deficits are generally classified into two broad categories: oral language and written language (Bernstein & Tiegerman, 1993; Lerner, 1997; Reid et al., 1996).

In the integrated language system, oral language (e.g., listening, speaking) is acquired first and provides a foundation for written language (e.g., reading and writing) (Smith & Strick, 1997). Written language is generally considered the secondary language system since it is acquired last, while the expressive mode of writing is viewed as the most sophisticated and difficult to acquire component of the language system (Bernstein & Tiegerman, 1993; Lerner, 1997). Individuals with learning disabilities encounter difficulties with both oral expressive and written expressive language.

The oral expressive language problems encountered by individuals with learning disabilities often result from auditory processing deficits. These problems include deficiencies in vocabulary acquisition, disorders of grammar or syntax, and delayed speech (Lerner, 1997). Successful remediation of oral expressive difficulties does not necessarily preclude problems with written expressive language (Lerner, 1997).

Approximately 80 to 95% of adults with learning disabilities report significant problems with writing (Blalock, 1981; Mangrum & Strichart, 1984; Stanovich, 1986; Vogel & Moran, 1982).

Individuals with learning disabilities often have difficulty with many of the component skills (e.g., formulation or organization of ideas, vocabulary, syntax, spelling, punctuation, and capitalization) of written expression (Lerner, 1997; Smith & Luckasson, 1992; Reid et al., 1996). Individuals with learning disabilities also often have difficulty with the production process of writing, including both handwriting and keyboarding, due to problems in using and integrating cognitive and motor processes.

The motor requirements of written language may interfere with composing by forcing the individual to attend to the production process and, subsequently, negatively affect other cognitive activities such as attending to, organizing and reconstructing information. Because the slower rate of writing or typing may not be able to keep up with the writer's thoughts, content generation and planning may be negatively affected (Bernstein & Tiegerman, 1993; Vogel & Moran, 1982). The production difficulties in writing may also negatively affect motivation and persistence during composition (Bernstein & Tiegerman, 1993).

Because individuals with learning disabilities have difficulty with written expression, oral language may provide a less demanding method of communicating ideas. As a result, researchers have explored dictation as a means to circumvent some of the problems individuals with learning disabilities have with written expression.

One advantage of dictation is its ability to increase the quantity of output, or number of words produced in a given time frame. Since dictation seems to encourage planning, it may also increase the quality of output (Gardner, 1983). Additionally, it has been noted that dictation allows individuals to compose closer to the speed of thought, making it easier to get ideas down on paper before they are forgotten (Haggblade, 1990).

Existing research supports the effectiveness of dictation for individuals with learning disabilities to produce longer (Reece, 1992; Reece & Cummings, 1996) and better quality essays (Graham, 1990; MacArthur & Graham, 1987; Reece & Cummings, 1996) at a faster rate (Bereiter & Scardmalia, 1987; Graham, 1990; MacArthur & Graham, 1987), especially when combined with planning (De La Paz & Graham, 1997), when compared to other visual-motor writing modes such as handwriting and keyboarding. However, dictation has a number of shortcomings. The use of a tape recorder does not allow the person producing the composition to easily review his or her work and use that information to build on ideas (MacArthur & Graham, 1987; Reece, 1992; Reece & Cummings, 1996). In addition, social problems experienced by individuals with learning disabilities may negatively affect their ability to work with a human transcriber (Higgins & Raskind, 1995). Dictation is also limited to the human resources available to do the transcribing, it is very costly, and promotes a loss of independence (De La Paz, 1999; Higgins & Raskind, 1995).

Although not all individuals with learning disabilities have difficulties with social interactions, it is estimated that as many as one-third of them do have problems with social skills (Voeller, 1994; Swanson & Malone, 1992). There is a large amount of research that has examined the extent to which social skills represent a component of the deficits exhibited by individuals with learning disabilities. Most of the studies have focused on the extent to which social skills differentiate individuals with learning disabilities from the non-disabled population.

The research indicates that children with learning disabilities are less liked and more likely to be rejected by others. Children with learning disabilities also have more difficulties with immaturity and personality problems (Swanson & Malone, 1992). The literature also suggests that children with learning disabilities are at more risk for depression, tend to have an external locus of control, and have low self-esteem (Hall et al., 1993). Both children and adolescents with learning disabilities demonstrate problems in developing solutions to social problems (Hartas & Donahue, 1997; Tur-Kaspa & Bryan, 1994). In addition, the literature indicates that adults with learning disabilities have social skills problems that include low self-concept, ineffective socialization skills, over-dependence on others, high levels of stress and anxiety, and negative behaviors and feelings (Brickerhoff et al., 1993).

Since children, adolescents, and adults with learning disabilities seem to have more problems with various aspects of social functioning when compared to their non-disabled counterparts, it seems reasonable to assert that the identified social skills deficits could have a negative effect on the written composition produced by individuals with learning disabilities who use a human transcriber. In particular, deficits in socialization could manifest themselves in the inability to pick up on social cues which, in turn, may cause the person dictating and editing to feel they are imposing on the transcriber's time, especially when they must continually have work read and re-read. Persons with disabilities might also feel anxious, nervous or embarrassed when required to interact with the transcriber, which may cause them to spend less time dictating or editing than they would otherwise spend.

The process of transcribing an individual's dictation through the use of a tape recorder can serve as a method to circumvent many of the social issues surrounding the use of a human transcriber. However, some researchers have indicated that actually seeing the dictated text helps in composition (MacArthur & Graham, 1987; Reece, 1992; Reece & Cummings, 1996). Using a tape recorder does not allow the person who dictates the material to review his or her composition. Furthermore, this technique does little to overcome the issue of loss of independence, since someone else still must transcribe the tape-recorded material. Speech recognition technology, however, may provide the advantages of using oral expression through dictation to circumvent the difficulties in text production, preserve the ability to reread the dictated composition, overcome the social difficulties of using a human transcriber, and also prevent the loss of independence inherent in relying on a human to transcribe the dictation.

Speech recognition incorporates software and hardware to enable a personal computer to recognize and carry out voice commands or take dictation. Speech recognition software used for dictation involves the process of the user speaking into a microphone, the computer processing the captured words through a sound card, the software analyzing the sounds and matching the voice pattern against a vocabulary template, and the matched words appearing as text in a word processor (Raskind, 1993). Although most modern speech recognition systems can be used immediately, they still learn the characteristics of a person's voice and, over time, become better able to interpret what the user is saying. Most systems also allow the user to edit the dictated text using voice or keyboard commands.

During the early to mid 1990s, all marketed speech recognition systems relied on discrete speech technology (Williams, 1998). In 1997, Dragon Systems, Inc. produced the first continuous speech recognition system, *Dragon NaturallySpeaking*. This system allowed users to dictate text into the computer using natural conversational speech (Dragon Systems, 2001).

Current continuous speech recognition systems require the user to have consistent patterns of pronunciation. Additionally, although most systems capitalize the first word of each sentence, the systems require the user to learn and use commands for capitalization, punctuation, and modification of dictated text (De La Paz, 1999).

Good continuous speech recognition systems and are now available for as little as $55. All of these systems will work on Pentium-based or Power Macintosh computers and require relatively small amounts of memory. The combination of cheaper computers, memory, and speech recognition software puts a good system well within the reach of the average consumer.

The range of potential applications of speech recognition technology is quite large. Researchers have begun to explore the possibilities, and the technology has been implemented in a variety of settings, including medical, industrial, and academic or educational areas.

One particular educational application involves the use of speech recognition systems as an accommodation for individuals with disabilities. Recently, a few researchers have begun investigating the use of speech technology as an alternative for students with learning disabilities to get their thoughts down on paper (Higgins & Raskind, 1995; Wetzel, 1997; De La Paz, 1999). Speech recognition technology has the potential to provide a method to write that capitalizes on oral expressive strengths much like normal dictation while circumventing the social problems of using a human transcriber and preserving the ability to easily reread the dictated composition. The technology may also provide a more independent accommodation for postsecondary students with learning disabilities in the writing process. Additionally, the new continuous speech systems are cheap solutions that may provide a more natural and quicker way to get text into the computer than older discrete systems. Certain characteristics of the speech recognition writing mode, such as the additional cognitive demands of learning and executing commands for capitalization, punctuation, and editing, however, may offset any potential benefits of using the technology. Despite these questions, there is little research that has investigated whether or not this technology may serve as a useful solution for individuals with learning disabilities.

The first experimental study to assess the effectiveness of speech recognition technology as a compensatory tool for the written composition of individuals with learning disabilities, Higgins and Raskind (1995), involved 29 postsecondary students. The researchers used the Upper Division Written Proficiency Exam to do a holistic analysis of the subjects' written composition. Each subject wrote three essays in three different treatments: 1.) writing with a pencil and paper or a keyboard without assistance; 2.) writing using a human transcriber; and 3.) writing using a discrete speech recognition system. Results of the study revealed that writing using the discrete speech recognition program did not differ significantly from the transcribing treatment, but was superior to writing without assistance using a pencil and paper or keyboard.

The researchers indicated that the study showed speech recognition promotes use of the more developed oral vocabularies of the subjects. The researchers also revealed that, although not significant, the speech technology outperformed the human transcribers, which they attributed to contextual and social influences. Overall, the researchers assert the findings indicate that speech recognition is beneficial to postsecondary students with learning disabilities in the area of written composition (Higgins & Raskind, 1995).

Raskind and Higgins (1998) followed their 1995 study with a three-year longitudinal investigation that looked at the changes in academic outcomes, behaviors, and attitudes as a result of using speech recognition technology during that time. The data was collected using interviews, questionnaires and self-reports. Over the three-year period, participants significantly increased their GPAs for courses with heavy reading and writing requirements and had smaller attrition rates when compared to a matched control group of students with learning disabilities who did not participate in the study. Furthermore, data indicated that students who participated in the study increased their overall independence by relying less on family members, friends, and classmates to help them compensate for their disabilities.

In related studies, Raskind and Higgins (Raskind & Higgins, 1999; Higgins & Raskind, 2000) investigated speech recognition technology as a remedial tool. Results of these studies indicated that discrete speech technology provides significant remedial advantages in word recognition, reading comprehension, and spelling, while continuous speech recognition promotes the ability to hold longer chunks of text in working memory.

In their latest study on the remedial effects of speech recognition, Higgins and Raskind (2000) noted specific differences between discrete and continuous speech systems that may impact both remedial and compensatory effects of the technologies. Specifically, with continuous speech systems, it may be harder to proofread and to edit work than with discrete systems since the user must deal with longer pieces of text at a time.

The only formal study to date investigating the compensatory effects of speech recognition technology on the written composition of postsecondary students with learning disabilities, Higgins and Raskind (1995), based its findings on one particular method for oral expression, the discrete speech system *Dragon Dictate*. Further research is needed to explore the compensatory advantages of oral expression using continuous speech recognition technology due to the differences in both dictation and editing inherent in these systems. The results of this study were also based on scoring criteria from one particular instrument. Since the evaluation of written composition will undoubtedly vary with different scoring scales, research is needed with other instruments to look at the efficacy of using this technology to compensate for poor writing.

When comparing the oral (auditory-motor) methods of expression (i.e., dictation and speech recognition) to common visual-motor methods of expression such as handwriting or keyboarding, the prevailing theory and research asserts that oral expression may improve the quality, rate, and/or length of compositions for individuals with learning disabilities because handwriting and keyboarding are a slower and more demanding mode of writing (Bernstein & Tiegerman, 1993; Gardner, 1983; Haggblade, 1990; Vogel & Moran, 1982). As a result, most of the transcription and speech recognition studies in this review evaluated the quality of written expression and also the length and rate of production of each essay.

The quality of written expression is most commonly evaluated through direct assessment. The direct assessment of writing uses one of three scoring methods: analytical, holistic, or primary trait.

The consensus method for assessing the quality of written expression in the transcription and speech recognition studies is through the use of holistic measures (De La Paz & Graham, 1997; Graham, 1990; Higgins & Raskind, 1995; MacArthur & Graham, 1987; Reece, 1992; Reece & Cummings, 1996). This is likely due, in part, to the ease of scoring and relatively high interrater reliability that can be achieved using the holistic method (Wolcott & Legg, 1998). The choice of the holistic method may also be popular since the primary purpose of these studies is to assess the impact of writing mode on the overall written expressive abilities of individuals with learning disabilities. As a result, it is not necessary or appropriate to assess analytical components such as spelling, capitalization, and punctuation since they are not required in every mode.

Due to the fact that different holistic measures of essay quality focus on varying criteria depending on the perspective of the creator and the writing task to be assessed, one measure is not sufficient to warrant extensive generalizations of effectiveness of writing modes. As a result, follow-up studies assessing the compensatory effects of oral expression through the use of continuous speech recognition need to focus on the use of other holistic scales to evaluate quality and, at minimum, need to include the additional measures of length and rate of production.

In summary, a large number of individuals who are identified as having learning disabilities have deficits in written expression. Existing theory and research indicate that for those individuals oral expression (auditory-motor) not only precedes, but also exceeds their written expression (visual-motor) capabilities. As a result, dictation has been investigated as an accommodation for these individuals. Research in this area indicates that dictation does tend to increase quality, length, and rate of production of written expression. This mode, however, has a number of shortcomings, including difficulties caused by social skills deficits and a loss of independence. In addition, for universities providing this accommodation, the annual cost of providing a transcription service is high. Speech recognition has the potential to overcome these shortcomings, but presently little research has been conducted to investigate the advantages and disadvantages of this mode of writing, especially with the new continuous speech systems. Further research is needed to examine the compensatory effectiveness of continuous speech recognition on the written expression of postsecondary students with learning disabilities using holistic measures to assess the quality of students' compositions. These studies also need to look at the length of essays and the rate of production in order to adequately assess the usefulness of oral expression through the use of speech recognition technology.

Research Questions and Hypotheses

Based on the review of literature, this study intended to answer the following research questions concerning the written composition performance of postsecondary students with learning disabilities:

1. Will the written composition performance of postsecondary students with learning disabilities in the area of written expression when using oral expression through the use of continuous speech recognition technology differ from their written composition performance when using oral expression through the use of a human transcriber?

2: Will the written composition performance of postsecondary students with learning disabilities in the area of written expression when using oral expression through the use of continuous speech recognition technology differ from their written composition performance when using a visual-motor method of writing (a keyboard without assistance)?

3: Will the written composition performance of postsecondary students with learning disabilities in the area of written expression when using oral expression through the use of a human transcriber differ from their written composition performance when using a visual-motor method of writing (a keyboard without assistance)?

Since the oral language performance of students with learning disabilities exceeds their visual-motor performance, there should be a noticeable difference in the written composition quality, rate of production, and length using speech recognition and transcription (auditory-motor) writing modes as compared to the written composition quality, rate of production, and length using the keyboarding (visual-motor) writing mode. Furthermore, due to the possibility of social skills deficits negatively affecting the use of a human transcriber to produce a written composition, there should be a noticeable difference between the quality, rate of production, and length of the composition using this writing mode when compared to the speech recognition (oral expression) writing mode. Test scores should support the following hypotheses:

H_1: Postsecondary students with learning disabilities in the area of written expression will receive higher written composition scores and produce longer essays at a faster rate when using oral expression through the use of continuous speech recognition to write than when using oral expression through the use of a human transcriber;

H_2: Postsecondary students with learning disabilities in the area of written expression will receive higher written composition scores and produce longer essays at a faster rate when using oral expression through the use of continuous speech recognition to write than when using a visual-motor method of writing through a keyboard without assistance;

H_3: Postsecondary students with learning disabilities in the area of written expression will receive higher written composition scores and produce longer essays at a faster rate when using oral expression through the use of a human transcriber to write than when using a visual-motor method of writing through a keyboard without assistance.

II. METHODOLOGY

The research questions and hypotheses for this study were evaluated through an experimental research design. These questions and hypotheses necessitated an experimental approach for two primary reasons. First, the research questions and hypotheses indicated a need to manipulate a categorical variable, writing mode, in order to investigate its causal relationship with another factor, written composition performance. It is widely accepted that experimental designs are particularly suited to investigate causal relationships between categorical or continuous variables and dependent measures (Howell, 1997; McMillan, 1992; Pedhazur & Schmelkin, 1991). Second, the hypotheses concerning the effects of the mode of writing on the written composition scores of students with learning disabilities required controlled experimental comparisons among the treatment conditions. The controlled comparisons are important in order to eliminate extraneous variables from explaining any cause and effect relationship. Once again, an experimental approach is the most effective research design to implement such controls (Howell, 1997; Pedhazur & Schmelkin, 1991).

A within-subjects design where all participants wrote essays for each of the three treatments was used for this study. This particular design is consistent with the majority (5 of 7) of studies conducted on transcription (Reece, 1992; Reece & Cummings, 1996; MacArthur & Graham, 1987; Graham, 1990) and speech recognition (Higgins & Raskind, 1995). This approach was chosen, as is likely the case with previous studies, due to the limited population of individuals with learning disabilities in the area of written expression. The study was approved, as necessary, by the institutional review board at Virginia Tech (see Appendix A).

Setting and Participants

The study took place in the Assistive Technology Laboratory at Virginia Polytechnic Institute and State University (Virginia Tech). Virginia Tech is a research university of 25,000 students located in Southwest Virginia. Virginia Tech offers over 60 bachelor degree programs and about 110 masters and doctoral programs. The university population consists of about 85 percent undergraduate and 15 percent graduate students. About 59 percent of the students are male and 41 percent female (Virginia Tech University Relations/Publications, 2001).

According to data from the Dean of Students Office, as of Fall, 2001, there were 473 self-identified students with disabilities attending Virginia Tech. Of this total, 140 students had documented learning disabilities. This total consisted of 89 males and 51 females (Dean of Students Office, 2001a). The Dean of Students Office does not track overall figures based on the specific deficits of students with learning disabilities, but has guidelines that must be met before students are eligible to receive services.

To be eligible for disability-related services at Virginia Tech, students must have a documented disability condition as defined by Section 504 of the Rehabilitation Act of 1973 or by the Americans with Disabilities Act of 1990 (ADA). Students with disabilities interested in receiving accommodations at Virginia Tech must present acceptable professional documentation of their disability to the Dean of Students Office. Students with learning disabilities are required to submit a comprehensive psychological and educational evaluation to request accommodations. Documentation for learning disabilities must include current measures of aptitude (e.g., intelligence quotient), achievement (e.g., levels of functions in reading, mathematics, and written language), and information processing (e.g., short- and long-term memory, sequential memory, processing speed, and motor ability) (Dean of Students Office, 2001b). The Dean of Students Office at Virginia Tech has a set of guidelines for acceptable testing instruments to assess these three areas (see Appendix B). Norm-referenced intelligence tests such as the *Wechsler Adult Intelligence Scale* or the *Stanford-Binet Intelligence Scale* are generally considered acceptable to determine aptitude scores, while norm-referenced tests such as the *Stanford Test of Academic Skills* or the *Woodcock-Johnson Pyschoeducational Battery-Revised: Tests of Achievement* are adequate to determine the academic achievement of individuals with learning disabilities. Information-processing skills are typically assessed using instruments such as the *Detroit Tests of Learning Aptitude-3*. Results from the aptitude and achievement instruments were used as the basis for identifying individuals who have learning disabilities in the area of written expression. Results from the information-processing tests were used to characterize the deficits of the participants selected for the study.

Due to confidentiality issues pertaining to students with disabilities, it was not possible to obtain a list of all the individuals with learning disabilities at Virginia Tech; therefore, the Dean of Students Office contacted the students, and they, in turn, contacted the researcher. The researcher, through The Dean of Students Office, solicited students who had self-identified as having a learning disability. Once the students contacted the researcher, they filled out a release form allowing access to their records in order to determine their eligibility by verifying a learning disability in the area of written expression (see Appendix C). All students who were found eligible to participate in the study signed an informed consent form (see Appendix D). These students were also asked to fill out an additional demographic/contact information form (see Appendix E).

Thirty-three students enrolled at Virginia Tech originally contacted the researcher to express interest in participating in the study. After a review of their records, sixteen of the thirty-three students were found to be eligible and subsequently agreed to participate. All of the participants were identified as having a learning disability in the area of written expression prior to entering the University. Eleven of the students were male and five of the students were female. All sixteen of the students identified themselves as Caucasian. Five of students were freshmen (31%), five were sophomores (31%), two were juniors (13%), and four were seniors (25%). The mean age for the group was 20.5 years.

Thirteen of the students had I.Q. scores on file from the *Wechsler Intelligence Scale for Children* (WISC-III) and three had I.Q. scores from the *Wechsler Adult Intelligence Scale – Revised* (WAIS-R). The mean I.Q. for the group, using the scores from these instruments, was 121.2.

Twelve of the thirteen students having I.Q. scores from the WISC-III also had achievement scores from the *Woodcock-Johnson Psycho-Educational Battery- Revised* (WJ-R). All of these students showed a discrepancy of at least 15 standard score points between written language achievement as measured by the Written Expressive subtest of the WJ-R and intelligence as measured by the WISC-III. Two of the three students having I.Q. scores from the WAIS-R also had achievement scores from the WJ-R. These two students also showed a discrepancy of at least 15 standard score points between written language achievement (as measured by the Written Expressive subtest of the WJ-R) and intelligence. The remaining two students had a documented 25-point discrepancy between verbal and performance I.Q on the WISC-III and WAIS-R aptitude tests, respectively. These two students also had professional documentation (e.g., a psychological evaluation) and other achievement scores (e.g., the *Test of Written Language –3* and the *Wide Range Achievement Test*) indicating deficits in the area of written expression. In addition, based on results from several information-processing measures that included the *Detroit Tests of Learning Aptitude –3* and subtests from the *WAIS-R* and *Woodcock-Johnson Psychoeducational Battery – Revised: Tests of Cognitive Ability*, all sixteen of the students demonstrated visual-processing problems and perceptual-motor deficits.

Instrument

The College-Level Academic Skills Test (CLAST), developed by the Florida Department of Education, is an achievement test that measures college-level communication and mathematics skills. The CLAST includes a holistically scored essay subtest designed to assess the overall quality of writing samples of postsecondary students (Florida Department of Education, 1994).

In the CLAST, two raters, working together, use previously scored papers or samples from the existing pool of papers to be scored to choose range finders that are representative of the established standards defined in a six-point scale to rank order the writing samples (see Appendix F). The raters then independently read through each essay once and assign a score from 1 to 6 to the paper. After all essays have been scored, the papers are reviewed and if the two scores for any one essay differ by more than one point, a third rater, an essay referee, reads the paper and assigns a score. The third score will replace the most discrepant score. The two scores for each essay are added for a total score ranging from 2 to 12 (Florida Department of Education, 1994).

The English Department at Virginia Tech has several faculty members who have training in the use of holistic instruments and have used a number of these instruments, including the essay subtest of the CLAST, to score compositions written by postsecondary students. The researcher contacted the chair of the English Department and he, in turn, identified three faculty members as experienced scorers. The researcher then contacted these individuals and all three (two scorers and a referee), agreed to serve as raters and use the holistic rating scale in the CLAST to score all of the essays.

The technical manual for the CLAST indicates that the reliability of the essay ratings are increased when the raters are trained in the use of the instrument and adhere to the established criteria for scoring essays. The reliability for the refereed scores of the essay tests using several prompts over three different administrations, as determined from the 1993-94 statewide Florida data set, indicated a .86 alpha coefficient (Florida Department of Education, 1994).

Content validity of the essay subtest of the CLAST was ensured through the use of university faculty with expertise in English language skills and testing to develop the instrument. All test items were also field tested in community colleges and state universities and only those items meeting preset criteria from the Florida Department of Education (1994) were included. In addition, using trained English faculty from Virginia Tech further ensures that the criteria used in the rating scale are properly implemented.

Equipment

Eight 733 MHz IBM computers with Intel Pentium® III processors with MMX and 256 megabytes of RAM were used in the study. The computers were running the *Windows® 2000* operating system. All written compositions were created using the *Microsoft Word ® 2000* word processor. The continuous speech recognition system, *IBM ViaVoice*™ *Pro Edition*, was installed on each computer and a high quality USB microphone was used for voice input. Each participant completed the treatment in a soundproof room located in the Assistive Technology Laboratory.

Procedure

The procedures and instructions for this study were piloted with several students prior to beginning the formal research. This was done to ensure that the procedures were logical and that the instructions were understandable. No changes were made as a result of this pilot.

All participants went through an initial training session (see Appendix G). This session familiarized the participants with the speech recognition program and taught them the basics of punctuating, formatting and correcting text with the speech recognition program using voice commands listed on a command reference sheet (see Appendix H). A follow-up session allowed the participants to train their personal voice model and practice dictating and correcting text. The participants worked with the system until they felt comfortable dictating and correcting errors using the reference guide. Once the participants went through the training, each wrote three timed (50-minute) expository essays in one of three randomly sequenced treatment conditions: (1) Writing on a computer using a speech recognition system, (2) Writing using a transcriber entering text into a computer, and (3) Writing on a computer using a standard keyboard without assistance.

In the speech recognition writing treatment, the subjects dictated their compositions into a word processor and edited all work using voice commands. In the human transcriber treatment, the transcriber typed all dictation verbatim into a word processor. Subjects in this treatment were able to read the dictated text from the computer screen and then verbally request necessary changes. All transcriptions were done by a single transcriber. In the keyboard without assistance treatment, the subjects typed and edited their text directly into a word processor, but were not allowed to use spelling or grammar tools. In addition, no spelling or grammar tools were used in the speech recognition or transcription treatments. The process of eliminating the use of spelling and grammar tools for writing is consistent with the previous research conducted on speech recognition (Higgins & Raskind, 1995).

All participants in each treatment were given instructions specific to each of the treatments as well as identical general instructions from the CLAST (See Appendix I). The researcher provided a written version to each student and read the instructions and the test question aloud as he or she followed along. One of three possible writing prompts was randomly assigned to each treatment for each subject (see Appendix J).

Due to the lab constraints and in order to minimize distractions, each participant completed the treatments individually. In addition, each participant completed only one treatment per day. Participants in all three treatments used IBM computers and the

Microsoft 2000® word processor located in the lab to produce their writing. The researcher did all of the transcriptions. A proctor observed each writing session.

Scoring

The length of the essays were calculated by the *Microsoft 2000*® word processor. The rate of production of the essays was assessed by dividing essay length (number of words) by the time it took to produce the essay.

In order to control for possible confounding effects of mechanics, errors in spelling, punctuation, and capitalization were corrected prior to scoring the essays for quality. The holistic instrument does not assess such errors and the process of correcting these errors is consistent with previous transcription research (Graham, 1990; MacArthur & Graham, 1987).

As noted earlier, two faculty members at the University trained in the use of the CLAST holistic scoring instrument, using a previously scored set of essays as anchors, rated each composition, without knowing under which treatment the essays were administered. The two essay scores were added together to obtain an overall writing quality score. The two sets of scores generated by each rater were used to calculate an interrater reliability index. The interrater reliability index was .90.

Materials

In order to ensure proper implementation of the procedure and organization of the data, several additional materials were used. The researcher randomly assigned each subject a number corresponding to a computer identification number, treatment sequence, prompt sequence, and essay identifier detailed in a matrix (see Appendix K). This matrix included the identification of the computer the participant used in the study and every possible combination of treatment sequences and prompts while ensuring that no participant received the same prompt more than once. By recording the computer identification, the table ensured that participant trained and wrote their essays using the same computer and microphone. By randomly assigning each participant to a slot in the matrix, without replacement, the treatments, prompts and order in which each participant progressed through the study was chosen at random. This information was then used to fill out an essay check sheet prior to beginning the treatments (see Appendix L). The check sheet was used to track the progress of each participant as they moved through the study. During each treatment, the proctors recorded observations for each writing session on a separate observation sheet (see Appendix M). The information from the observation sheet was useful in the interpretation of the analyzed data. Each essay was written using a document template with locations to enter the subject number and essay number at the top of the page. The proctor printed out each essay at the end of the treatment and transferred the subject and essay numbers from the check sheet to the essay. All essay variables (e.g., length, rate of production, and quality) were recorded on an essay score form (see Appendix N). This form was used to facilitate entry of the data into a software program for analysis.

Analysis of Data

Organization

The assessment of each dependent measure (i.e., essay quality, rate of production, and length) resulted in a number. These numbers were used to calculate the mean score and standard deviation for each of the three measures. The data were organized and summarized as shown in Table 1.

Table 1
Data Organization Table

	Speech Rec. Treatment. (n=20)		**Human Trans. Treatment (n=20)**		**Keyboarding Treatment (n=20)**	
Measures	M	SD	M	SD	M	SD
Essay Quality						
Rate of Production						
Length of Essay						

Statistical Procedures

Once the mean and standard deviation for each group was calculated, a one-way analysis of variance (ANOVA) was performed on each of the dependent measures using the *SPSS*® statistics program in order to determine if there was a significant difference (alpha=.05) in the three groups. All significant differences were followed-up by post-hoc analyses to determine the nature of those differences.

III. RESULTS

The purpose of this study was to answer the following research questions concerning the written composition performance of postsecondary students with learning disabilities:

1. Will the written composition performance of postsecondary students with learning disabilities in the area of written expression when using oral expression through the use of continuous speech recognition technology differ from their written composition performance when using oral expression through the use of a human transcriber?
2. Will the written composition performance of postsecondary students with learning disabilities in the area of written expression when using oral expression through the use of continuous speech recognition technology differ from their written composition performance when using a visual-motor method of writing (a keyboard without assistance)?
3. Will the written composition performance of postsecondary students with learning disabilities in the area of written expression when using oral expression through the use of a human transcriber differ from their written composition performance when using a visual-motor method of writing (a keyboard without assistance)?

The research questions for this study were evaluated by analyzing scores from three separate measures: (1) the quality of the written compositions, (2) the rate of production of the written compositions, and (3) the length of the written compositions.

All assumptions of homogeneity of variance between groups were tested and met using Levene's (1960) statistic. The results of the homogeneity of variance test can be seen in Appendix O.

Written Composition Quality

The descriptive statistics (means and standard deviations) for the written composition quality across the three treatments are presented in Table 2. The ANOVA tables for the written composition quality across the three treatments can be found in Appendix P.

Table 2
Descriptives for Essay Quality

	N	Mean	Std. Deviation
keyboarding	16	5.1875	2.4824
transcription	16	7.6250	2.9637
speech recognition	16	7.5000	2.1909
Total	48	6.7708	2.5456

Since the ANOVA indicated differences existed between the means for written composition quality, additional post hoc analyses were run (see Appendix Q). The Tukey HSD analysis was used due to its moderate algorithm.

The results from the ANOVA for essay quality indicated a significant difference between the essay scores across the three treatment groups, F (2, 45) = 4.580, $p < .05$. The post hoc analysis indicated that students with learning disabilities received higher written composition scores when writing with transcription (M = 7.6250) than when writing using a keyboard without assistance (M = 5.1875). The analysis also indicated that students with learning disabilities receive higher written composition scores when writing with speech recognition (M = 7.5000) than when writing using a keyboard without assistance (M = 5.1875). There was no significant difference in the quality of essays between the transcription and speech recognition writing modes.

Written Composition Length

The descriptive statistics (means and standard deviations) for the written composition length across the three treatments are presented in Table 3. The ANOVA table for the written composition length across the three treatments can be found in Appendix R. Results indicated no significant difference existed among the written composition length across the three treatments, F (2, 45) = .180, $p > .05$; consequently, no post hoc analyses were performed.

Table 3
Descriptives for Essay Length

	N	Mean	Std. Deviation
keyboarding	16	410.0000	109.3667
transcription	16	381.1875	131.1723
speech recognition	16	393.8125	162.7117
Total	48	395.0000	133.7917

Written Composition Rate of Production

The descriptive statistics (means and standard deviations) for the written composition rate of production across the three treatments are presented in Table 4. The ANOVA tables for the written composition rate of production across the three treatments can be found in Appendix S.

Table 4
Descriptives for Essay Rate of Production

	N	Mean	Std. Deviation
keyboarding	16	10.6825	2.4657
transcription	16	14.7981	2.9556
speech recognition	16	14.2394	2.7738
Total	48	13.2400	2.7317

Since the ANOVA indicated differences existed between the means for written composition rate of production, additional post hoc analyses were run (see Appendix T). The Tukey HSD analysis was used.

The results from the ANOVA for essay rate indicated significant differences among the essay scores across the three treatment groups, $F(2, 45) = 10.627$, $p < .05$. The post hoc analysis indicated that students with learning disabilities write compositions at a faster rate when writing with transcription ($M = 14.7981$ wpm) than when writing using a keyboard without assistance ($M = 10.6825$ wpm). The analysis also indicated that students with learning disabilities write compositions at a faster rate when writing with speech recognition ($M = 14.2394$ wpm) than when writing using a keyboard without assistance (M = 10.6825 wpm). There was no significant difference in the rate of production between the transcription and speech recognition writing modes.

Analysis

As hypothesized, postsecondary students with learning disabilities in the area of written expression produced better quality essays at a faster rate using the transcription and speech recognition writing modes when compared to the keyboard without assistance writing mode. This finding is consistent with the literature indicating individuals with learning disabilities in the area of written expression encounter more difficulty with the secondary and more complex visual-motor language system of writing than they do with the primary system of oral language (Blalock, 1981; Lerner, 1997; Mangrum & Strichart, 1984; Mykleburst, 1973; Stanovich, 1986; Shepard & Smith, 1983; Vogel & Moran, 1982; Wetzel, 1997). It is also consistent with previous research indicating individuals with learning disabilities in the area of written expression write better quality essays (Graham, 1990; MacArthur & Graham, 1987; Reece & Cummings, 1996) at a faster rate (Bereiter & Scardmalia, 1987; Graham, 1990; MacArthur & Graham, 1987) using dictation when compared to handwriting and keyboarding.

In this study, observations indicated that the participants were able to effectively train the speech system to work for them. The speech technology worked very well with the minor exception of some difficulties encountered with correcting text. Additional observations indicated that the only limitation for the participants in the transcribing treatment was the rate at which the transcriber typed. Participants in the keyboarding treatment produced text visibly slower than in the transcription and speech recognition treatments.

The participants all did very well with the training process for the speech recognition software. Most of them were able to read the required text and then immediately began dictating with few or no errors. A few of the participants, however, had to adjust to the style of dictation required by the speech system. Specifically, several of the males in the study initially mumbled when they began dictating and experienced a high error rate. After being informed that they must slow down their speech a little and enunciate their words clearly, the errors dramatically decreased. Overall, the participants were able to get their thoughts down very well during the treatment with little need to make corrections. When corrections were necessary, though, some of the participants experienced difficulty replacing the incorrect word or phrase with the correct one.

During the transcription treatment, the transcriber was easily able to type the thoughts of the majority of the participants without any difficulty. Three of the students, however, got excited as they dictated their ideas and spoke much faster than the transcriber could type. When the transcriber got too far behind to keep up, he would read the last few words that had been transcribed and ask the participant to start again at that point. These three students quickly adjusted their dictation speed to the rate that the transcriber was typing. When changes were required, the students would indicate what needed to be changed and then told the transcriber how to modify the text. Neither the transcriber nor the participant had any difficulty with the editing process.

Although all of the participants were touch typists, it was evident during the observations that many of the students experienced difficulty getting their thoughts down using the keyboard. They took longer to write and tended to take more time making corrections than in the other two treatments. None of them demonstrated any physical difficulties using the keyboard or mouse, but the process of using these tools did have a noticeable affect on their rate of production, which may have contributed to the decreased quality of their work.

The previous study (Higgins & Raskind, 1995) conducted on the use of discrete speech recognition as a compensatory tool for postsecondary students with learning disabilities found that essays written using the discrete speech recognition technology did not differ significantly from the essays written during the transcribing treatment, but allowed students to write qualitatively better essays when compared to those written with a keyboard, much like the continuous speech recognition system in this study. Higgins and Raskind (1995), however, found no significant difference between the transcription treatment and the keyboarding treatment, a result the researchers attributed to social difficulties the students exhibited when interacting with the transcriber. In contrast, the current study found both the continuous speech recognition treatment and the transcription treatment produced qualitatively better essays when compared to the keyboard without assistance treatment. Observations conducted during the current study revealed that, although two of the students seemed a bit uncomfortable when working with the transcriber and did occasionally apologize when requesting changes to be made to their essays, the majority of the students seemed quite comfortable and even tried to engage the transcriber in conversation before and after the treatment. The two students who seemed uncomfortable did noticeably relax after several minutes of dictation.

Although the speech recognition treatment did not differ significantly from the transcription treatment, unlike the Higgins and Raskind (1995) study both the essay scores and rate of production for the speech recognition group was slightly lower than the transcription group. Based on observations of each treatment during the study, several possible reasons were determined to contribute to this result. The first included the fact that, even with training and time to work with the technology, the students did not have ample time to fully familiarize themselves with the technology and the nuances of correcting their work. Although most of the students were able to get their thoughts down via the technology with few errors, there were several instances when correction of a word or phrase did slow down the production of the essay. In more than one instance, the student ended up changing an initial phrase the computer did not recognize to another phrase. On the other hand, the only limiting factor for the students using the transcriber was the rate at which the transcriber typed. This limitation, however, was only a factor for three of the sixteen students. In the Higgins and Raskind (1995) study, however, the transcription treatment did not score as well as the speech treatment due to the identified social skill difficulties encountered by the students. Another factor that could have negatively affected the quality and/or rate of production of the speech recognition essays was the way the features of the technology interacted with some of the participants' writing style. When using the speech recognition program and the human transcriber, the participants would think about what they wanted to say for a moment and then begin dictating. During the transcription treatment, the transcriber was able to type effectively regardless of the way that the participant dictated, but the performance of the speech recognition technology was affected by the way the students dictated their essays.

Although all students were trained to dictate in larger chunks of text, preferably a minimum of a sentence at a time, their ability to clearly organize their thoughts before dictating varied. When the students collected their thoughts and dictated one sentence or even one paragraph at a time, the speech system performed very well. The technology, however, was not as accurate when the student would begin a sentence, pause to think, and then complete the sentence. The technology also had some difficulty when the student would begin a thought and then try to modify it in the course of the dictation, resulting in two different phrases that the software tried to interpret as one sentence. This observation is consistent with the literature that indicates when the continuous speech recognition algorithm evaluates and selects words in context of other words, the smaller or less sensible the sentence structure, the lower the accuracy because there are less context clues available to choose the appropriate word (Williams, 1998; De La Paz, 1999).

In another unexpected result, there was no significant difference in the lengths of the essays across the three treatments. This outcome is similar to Graham's (1990) results of composition lengths between handwritten and dictated essays. Graham (1990) asserted the increased cognitive demands of the opinion essay used for dictation when compared to the descriptive essay used for handwriting was the reason for the result. The current study, however, randomly matched the same three prompts across the treatment groups. Observations, though, suggest that the way the participants structured their essays may have contributed to the results. Every participant in the study across all three treatment groups began their essays by developing an opening paragraph introducing the main topic and two or three supporting ideas. Additional paragraphs were then written to develop each of the supporting ideas. The participants also created a closing paragraph to summarize their essays. The limit of two to three supporting ideas for the essay was likely a result of the imposed time constraints. In the transcription and speech recognition treatments, the participants were able to get their ideas down at a faster rate and, on many occasions, finished prior to the 50-minute time limit. During the keyboarding treatment, however, the participants were more likely to write for the entire time and several of the participants were unable to complete the essays before the session concluded. Since all of the essays used the same framework, the participants wrote essentially the same length essays during the session, but at much different rates of production.

Conclusions and Future Research

This study suggests that current continuous speech recognition technology can offer postsecondary students with learning disabilities in the area of written expression a method to write that is superior to keyboarding as indicated by measures of quality and rate of production. Since the speech recognition technology does not have the limitations of the transcription process (i.e., loss of independence and high cost), it may be the best alternative for postsecondary students with learning disabilities in the area of written expression to maximize their oral language strengths to more efficiently produce better quality writing.

As a result of their success with the technology, many of the students chose to continue using the speech recognition technology. At the conclusion of the study, six of the participants contacted the researcher to inquire about coming to the Assistive

Technology Lab to use the continuous speech technology to assist them with their written work. Several other students mentioned that they would purchase the software to use in subsequent semesters.

As students make use of the technology on a long-term basis, this could affect the performance of the system. Additional investigation is needed to look at the effectiveness of continuous speech recognition over time. Since the technology continually adapts to the user's voice, the system may improve with more hours of use. Improved accuracy and familiarity with the commands used for correcting text may further enhance the usefulness of speech recognition technology when compared to transcription and keyboarding modes of writing. It would be useful to determine at what point the speech recognition technology is at its optimum accuracy rate by tracking improved accuracy over time and monitoring when it levels off.

Further research is also needed to investigate the usefulness of speech recognition technology for individuals with more severe writing and accompanying reading disabilities. Although the postsecondary students in this study had little or no difficulty with reading the essays required to train the speech recognition system, individuals with more severe writing and reading disabilities or younger students with learning disabilities in the area of written expression may have difficulty reading the passages needed for training. This research could lead to recommendations that would include an option for speech recognition systems to incorporate voice synthesis to read the text. The student could then listen to the passage and repeat it back to the computer to complete the training process.

Additional research that compares various speech recognition software products may also be useful to help determine whether or not all continuous speech products offer the same benefits to students with learning disabilities in the area of written expression. Differences in the way the speech algorithms work among the products and the unique methods that each product uses to allow users to train, dictate, and edit text may impact the usefulness of the software.

Further research may also be needed to look at the usefulness of speech recognition technology for individuals as evaluated by other instruments for assessing the quality of writing. This study looked at the quality of writing without regard to particular components such as mechanical skills. This holistic approach was chosen due to its wide acceptance. In addition, the previous study on speech recognition (Higgins & Raskind, 1995) also used holistic measures to assess writing. Researchers, however, may wish to look at other scoring instruments based on different philosophical approaches that use analytical methods to assess writing to determine if there is any impact on the overall assessment of the quality of a student's writing when using speech recognition technology.

Finally, this particular study only investigated the compensatory use of speech recognition technology as a means of inputting text. Additional research with continuous speech recognition technology and individuals with learning disabilities in the area of written expression needs to extend the current study by looking at the compensatory effectiveness of using voice synthesis and highlighting technologies to create auditory and enhanced visual environments for reading and editing text once it has been input into the computer. These additional technologies may further maximize the oral language abilities of individuals with learning disabilities and provide additional visual cues during editing when compared to typical editing processes in the transcription and keyboarding modes. Many of the current continuous speech recognition systems on the market incorporate voice synthesis and there are other programs available that incorporate both voice synthesis and text highlighting features. Typical transcription and keyboarding modes of writing do not incorporate these technologies.

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APPENDIX A

Institutional Review Board Approval

Virginia Tech
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Institutional Review Board

Dr. David M. Moore
IRB (Human Subjects) Chair
Assistant Vice Provost for Research Compliance
CVM Phase II - Duckpond Dr., Blacksburg, VA 24061-0442
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5 November 2001

MEMORANDUM

TO: Richard Snider Educational Leadership & Policy St. 0254

FROM: David M. Moore

SUBJECT: IRB EXEMPTION APPROVAL – "Recognition on the Written Composition of Postsecondary Students with Learning Disabilities" – IRB #01-482

I have reviewed your request to the IRB for exemption for the above referenced project. I concur that the research falls within the exempt status.

cc:File
Department Reviewer: Jan Nespor

APPENDIX B

Tests for Assessing Adolescents and Adults

When selecting a battery of tests, it is critical to consider the technical adequacy of instruments including their reliability, validity, and standardization on an appropriate norm group. The professional judgment of an evaluator in choosing tests is important.

The following list is provided as a helpful resource, but it is not intended to be definitive or exhaustive.

Aptitude

- *Wechsler Adult Intelligence Scale – Revised (*WAIS-R)
- *Woodcock-Johnson Psychoeducational Battery – Revised: Tests of Cognitive Ability*
- *Kaufman Adolescent and Adult Intelligence Test*
- *Standford-Binet Intelligence Scale* (4th ed.)

The *Slosson Intelligence Test –Revised* and the *Kaufman Brief Intelligence Test* are primarily screening devices, which are not comprehensive enough to provide the kinds of information necessary to make accommodation decisions.

Academic Achievement

- *Scholastic Abilities Test for Adults* (SATA)
- *Stanford Test of Academic Skills*
- *Woodcock-Johnson Pyschoeducational Battery –Revised: Tests of Achievement*
- *Wechsler Individual Achievement Test* (WIAT)

or specific achievement tests such as:

- *Nelson-Denny Reading Skills Test*
- *Stanford Diagnostic Mathematics Test*
- *Test of Written Language – 3* (TOWL-3)
- *Woodcock Reading Mastery Tests - Revised*

Specific achievement tests are useful instruments when administered under standardized conditions and interpreted within the context of other diagnostic information. *The Wide Range Achievement Test – 3* (WRAT-3) is not a comprehensive measure of achievement and therefore is not useful as the sole measure of achievement.

Information Processing

Acceptable instruments include the *Detroit Tests of Learning Aptitude –3* (DTLA-3), the *Detroit Tests of Learning Aptitude – Adult* DTLA-A), information from subtests on *WAIS-R, Woodcock-Johnson Psychoeducational Battery – Revised: Tests of Cognitive Ability*, as well as other relevant instruments.

APPENDIX C

Release Form

I, ____________________________________, give Richard Snider, a doctoral student in
(Print your name)
Instructional Technology at Virginia Tech, permission to access my comprehensive psychological and educational evaluation, including measures of aptitude, achievement, and information processing, on file at the Dean of Students Office.

I understand that my name will not be used or associated in any way with the information in my personal files.

______________________________________ __________________________

Signature of Student Date

*** This consent form is only valid through December 2002.

APPENDIX D

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
Informed Consent for Participants
of Investigative Projects

Title of Project: The Compensatory Effectiveness of Oral Expression through the use of Continuous Speech Recognition on the Written Composition of Postsecondary Students with Learning Disabilities

Investigators: Richard Snider, M.Ed.

I. The Purpose of the Research/Project
The purpose of this research project is to look at three different methods of writing (speech recognition, transcription, and keyboarding) and to explore how each writing mode affects the overall quality, length, and rate of production of your compositions.

II. Procedures
It is assumed that you already know how to use a keyboard to write and that you can dictate your thoughts to a transcriber without additional training. There are, however, characteristics and procedures that are important with regard to speech recognition that you may need to know. As a result, you will go through an initial training session on using speech recognition technology that consists of two parts. First, you will listen to a presentation on how to use speech recognition technology to be given in Torgersen 1180. This presentation should not last longer than a half an hour. Second, you will train the speech recognition system to recognize your voice and practice dictating some text into the computer. This part should also last no longer than half an hour. You will listen to the first part of the initial training, the presentation on speech recognition, in small groups. You will each train the system and write the essays individually. Overall, the initial training (including both parts) will take approximately 1 hour.

After you have worked with the speech recognition program, you will be required to plan, write, and proofread three separate essays (each within 50 minutes). One will be with the speech recognition program, one with a keyboard, and one by dictating text to a transcriber who will type it into a computer. You will only write one essay per day. You don't have to do the essays on three consecutive days, but I would like you to complete all three essays within two weeks of your training session. In each of the three essays, you will use an IBM computer and the Microsoft 2000® word processor to produce your writing. An A.T. Lab staff member will do all of the transcriptions.

Before you write each essay, I will provide written instructions to you and read them aloud as you follow along. Each essay will consist of a topic that you must respond in some way. You will be asked to explain and illustrate your answer from your own experience, your observations of others, or your reading. You will use a different writing topic in each of the three essays. Overall, you will be spending no more than 2 hours and 15 minutes over three days to write all three essays.

The length of your essays will be calculated by the *Microsoft Word*® word processor. The rate of production of the essays will be assessed by dividing essay length by the time it took you to produce the essay. Two individuals trained in the use of the College Level Academic Skills Test (CLAST) holistic scoring instrument will use this scale to score the overall quality of your composition.

Your total commitment to this research study, including both the training and the writing components, will be no more than 3 hours and 30 minutes.

III. Risks
There are no known risks to you as a participant in this research project.

IV. Benefits of this Project
The study will serve to build on previous research and to further the knowledge of the effectiveness of using computer-based continuous speech recognition as a compensatory tool for written composition of students with learning disabilities. It may also promote further research on the educational applications of speech recognition systems for individuals with learning disabilities.

Results of the study will be reported to the Equal Opportunity and Affirmative Action (EOAA) Office at Virginia Tech. You may also contact the researcher at any time for a summary of the results.

V. Extent of Anonymity and Confidentiality
As a participant in this research project, you will be anonymous. The Dean of Students Office and Assistive Technology Lab and its employees are, under policy, required not to reveal any information about identified postsecondary students with disabilities without written consent. In this research project, your name will not be recorded or used in any way. Your written compositions will be identified by a number in the upper right hand corner of the score sheet. Only the researcher will have access to the collected data.

VI. Compensation
You will receive, at the conclusion of the study (after training has been completed and all three compositions have been written), a payment of $100. If you withdraw from the study prior to completing all components, you will be compensated for the sessions that you completed. If you complete the initial training, you will be compensated with $25. You will be paid an additional $25 dollars for each essay you complete.
Funding for the study was provided through the EOAA Office at Virginia Tech.

VII. Freedom to Withdraw
You are free to withdraw from this study at any time.

VIII. Approval of Research
This research project has been approved, as required, by the Institutional Review Board for Research Involving Human Subjects at Virginia Polytechnic Institute and State University, by the Department of Teaching and Learning (T&L).

IX. Subject's Responsibilities
I voluntarily agree to participate in this study. I have the following responsibilities:

- I will not discuss the study with any other persons before they participate in the project.
- I will attend the initial training on the speech recognition system
- I will write three separate essays on three different days

X. Subject's Permission

I have read and understand the Informed Consent and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent:

____ Date__________
Subject signature
____ Date __________
Witness (Optional except for certain classes of subjects)

Should I have any pertinent questions about this research or its conduct, and research subjects' rights, and whom to contact in the event of a research-related injury to the subject, I may contact:

Richard Snider — 231-6690 / rsnider@vt.edu
Investigator(s) — Telephone/e-mail

Mike Moore — 231-8341 / moorem@vt.edu
Faculty Advisor — Telephone/e-mail

Jan Nespor — 231-5642 / nespor@vt.edu
Departmental Reviewer/Department Head — Telephone/e-mail

David M. Moore — 540-231-4991/moored@vt.edu
Chair, IRB — Telephone/e-mail
Office of Research Compliance
Research & Graduate Studies

This Informed Consent is valid from 11/6/01 to 11/6/02.

[NOTE: Subjects must be given a complete copy (or duplicate original) of the signed Informed Consent.]

APPENDIX E

Demographic/Contact Information Sheet

Name: ______________________________ Date of Birth: _________

SSN#: ______________________________

Permanent address: ____

____

Local address: ____

____

Email address: ______________________

Phone number: ______________________

Gender: (circle one) Male Female

Race: (place an “X” in the appropriate blank) ___African-American ___Asian
___Hispanic ___Pacific Islander ___White ___Other

Major: ______________________________

Year in School: ___Freshman ___Sophomore ___Junior ___Senior ___Other

I understand that my name will not be used or associated in any way with the information on this sheet.

APPENDIX F

CLAST Holistic Scoring Rubric

Score of 6 Implied or stated thesis that is developed with noticeable coherence. Ideas are substantive, sophisticated, and carefully elaborated. Choice of language and structure is precise and purposeful. Control of sentence structure and usage, despite an occasional flaw, contributes to the writer's ability to communicate the purpose.

Score of 5 Presents an implied thesis and provides convincing, specific support. Ideas are usually fresh, mature, and extensively developed. Command of language and use of a variety of structures are demonstrated. Control of sentence structure and usage, despite an occasional flaw, contributes to the writer's ability to communicate the purpose

Score of 4 Presents a thesis and often suggests a plan of development, which is usually carried out. Enough supporting detail to accomplish the purpose of the paper is provided. Makes competent use of language and sometimes varies sentence structure. Occasional errors in sentence structure and usage do not interfere with the writer's ability to communicate the purpose

Score of 3 Presents a thesis and often suggests a plan of development, which is usually carried out. Support that tends toward generalized statements or a listing. In general support is neither sufficient nor clear enough to be convincing. Sentence structure tends to be pedestrian and often repetitious. Errors in sentence structure and usage sometimes interfere with the writer's ability to communicate the purpose

Score of 2 Paper usually presents a thesis. The writer provides support that tends to be sketchy and/or illogical. Sentence structure may be simplistic and disjointed. Errors in sentence structure and usage interfere with the writer's ability to communicate the purpose.

Score of 1 Paper generally presents a thesis that is vaguely worded or weakly asserted. Support, if any, tends to be rambling and/or superficial. The writer uses language that often becomes tangled, incoherent, and thus confusing. Errors in sentence structure and usage frequently occur.

APPENDIX G

Outline for the Initial Training Session on Speech Recognition Technology

I. Administrative
   a. Completion of Informed Consent form
   b. Completion of Demographic/Contact Information form
   c. Assignment of Subject Number and Treatment/Prompt sequence
   d. Scheduling of essay time slots

II. Introduction to speech recognition technology

III. Setting up the System
   a. Adjusting the microphone
   b. Turning the microphone on and off
   c. Creating a voice model

IV. Dictating with ViaVoice
   a. Overview of dictation process
   b. Dictating Punctuation
   c. Dictating numbers
   d. Spelling words in spell mode
   e. Saying commands while dictating
   f. Correcting errors

V. Hands-on Guided Practice with the Speech Recognition Program
   a. Create the voice model
   b. Practice dictating and correcting text

APPENDIX H

The IBM *ViaVoice*™ *for Windows*® *Pro Edition* Command Reference

DICTATION

What You Say	What You Get
New paragraph	Creates a new paragraph from the cursor position
Scratch that	Deletes the last dictated text
Select <text>	Selects the specified text
Select this	Selects the text on or in front of the cursor

CORRECTING DICTATION

What You Say	What You Get
Correct this	Opens or gives focus to the Correction Window for the text on or at the cursor
Undo this	Undoes the last typed text
Delete this	Deletes the selected text
Delete to end of line	Deletes the entire line of text from the cursor position
Correct <text>	Opens the Correction Window for the specified text
Try Again	Selects next occurrence of text specified in previous correction command
Pick <n>	Replaces selected text with correct alternate <n> in the Correction Window
Return to text	Gives focus to the dictated text
Show Correction Window	Displays window for correcting misrecognized text
Hide Correction Window	Closes the correction window

TEXT EDITING/FORMATTING

What You Say	What You Get
Capitalize this	Capitalizes the dictated text on or at the cursor
Uppercase this	Uppercases the dictated text on or at the cursor
Lowercase this	Lowercases the dictated text on or at the cursor
Bold this	Bolds the dictated text on or at the cursor
Underline this	Underlines the dictated text on or at the cursor
Italicize this	Italicizes the dictated text on or at the cursor
Select line	Selects the entire line of text
Select document	Selects all text in the current document
Select to beginning of document	Selects all text from the cursor to the beginning of the document
Select to the end of document	Selects all text from the cursor to the end of document

APPENDIX I

Essay Instructions

Keyboarding Instructions:
In this writing task, you will use a standard keyboard to type your essay into the computer. In order to proofread your essay, you will read over it and use the keyboard and mouse to make any needed corrections.

Transcription Instructions:
In this writing task, you will dictate all of your work to a human transcriber who will then enter it into the computer. In order to proofread your essay, you will read over it and request that the transcriber make any needed corrections.

Speech Recognition Instructions:
In this writing task, you will dictate all of your work into the speech recognition microphone, which will place the text into the computer. In order to proofread your essay, you will read over it and speak the necessary commands into the microphone to make changes. You may use your reference guide to assist you in remembering the commands for making changes.

General Instructions (to all three treatments):
You will have 50 minutes to plan, write, and proofread an essay on the given topic. This should be plenty of time to briefly think about the topic and get some ideas down. To help you pace yourself, the proctor will tell you when you have 10, 5, and 1 minute remaining. THE FOLLOWING TOPIC IS THE ONE YOU WILL WRITE ABOUT:

(Place either prompt A, B, or C here. Read the prompt.)

(For Prompts A & C) Do you agree or disagree? Explain and illustrate your answer from your own experience, your observations of others, or your reading

(For Prompt B) Write an essay completing this statement. Be sure to explain reasons for your choice.

At least two evaluators will read your essay and assign it a score. They will pay special attention to whether you have

- addressed the topic as it is written
- established a clear thesis or main idea
- developed your thesis logically and in sufficient detail
- used well-formed sentences and paragraphs, and
- used language appropriately and effectively

Take a few minutes to think about what you want to say before you start writing. Leave yourself some time at the end of the period to proofread and make corrections.

APPENDIX J

Writing Prompts

A. Nothing requires more discipline than freedom

B. I have experienced various things that have made me feel worthwhile, but I have never felt better than when _______________.

C. Any advance involves some loss.

APPENDIX K

Treatment/Prompt/Essay Matrix

Comp. ID.	No.	Name	Essay	Treatment	Prompt	Essay	Treatment	Prompt	Essay	Treatment	Prompt
	I		1	K	A	2	T	B	3	S	C
	II		4	K	A	5	T	C	6	S	B
	III		7	K	B	8	T	A	9	S	C
	IV		10	K	B	11	T	C	12	S	A
	V		13	K	C	14	T	A	15	S	B
	VI		16	K	C	17	T	B	18	S	A
	VII		19	K	A	20	S	B	21	T	C
	VIII		22	K	A	23	S	C	24	T	B
	IX		25	K	B	26	S	A	27	T	C
	X		28	K	B	29	S	C	30	T	A
	XI		31	K	C	32	S	A	33	T	B
	XII		34	K	C	35	S	B	36	T	A
	XIII		37	T	A	38	K	B	39	S	C
	XIV		40	T	A	41	K	C	42	S	B
	XV		43	T	B	44	K	A	45	S	C
	XVI		46	T	B	47	K	C	48	S	A
	XVII		49	T	C	50	K	A	51	S	B
	XVIII		52	T	C	53	K	B	54	S	A
	XIX		55	T	A	56	S	B	57	K	C
	XX		58	T	A	59	S	C	60	K	B
	XXI		61	T	B	62	S	A	63	K	C
	XXII		64	T	B	65	S	C	66	K	A
	XIII		67	T	C	68	S	A	69	K	B
	XXIV		70	T	C	71	S	B	72	K	A
	XXV		73	S	A	74	K	B	75	T	C
	XXVI		76	S	A	77	K	C	78	T	B
	XXVII		79	S	B	80	K	A	81	T	C
	XXVIII		82	S	B	83	K	C	84	T	A
	XXIX		85	S	C	86	K	A	87	T	B
	XXX		88	S	C	89	K	B	90	T	A
	XXXI		91	S	A	92	T	B	93	K	C
	XXXII		94	S	A	95	T	C	96	K	B
	XXXIII		97	S	B	98	T	A	99	K	C
	XXXIV		100	S	B	101	T	C	102	K	A
	XXXV		103	S	C	104	T	A	105	K	B
	XXXVI		106	S	C	107	T	B	108	K	A

APPENDIX L

Essay Check Sheet

Name: ______________________________

Subject number (roman numeral): ________

Date completed initial training: ___________

Essay No: ____ Date completed: ________

Treatment: (circle one) K T S

Prompt: (circle one) A B C

Essay No: ____ Date completed: ________

Treatment: (circle one) K T S

Prompt: (circle one) A B C

Essay No: ____ Date completed: ________

Treatment: (circle one) K T S

Prompt: (circle one) A B C

APPENDIX M

Observation Sheet

Subject number (roman numeral): ____

Essay number: ____

Essay Starting time (hh:mm): ________

Essay Ending time (hh:mm): ________

Please note anything, in your view, that could have POSITIVELY or NEGATIVELY affected the ability of the participant to produce the composition. Please include any questions that may have been asked, any interruptions or distractions that occurred during the treatment, or any behaviors with planning or using the writing tool.

APPENDIX N

Essay Score Sheet

Subject number (roman numeral): ____

I.

Essay number: _______
Essay score 1:_______, 2. _______ I.R.:_______ 3. (if needed)_______ Total:_______
Essay length (no. of words): ________
Essay rate of production (length divided by time): __________

II.

Essay number: _______
Essay score 1:_______, 2. _______ I.R.:_______ 3. (if needed)_______ Total:_______
Essay length (no. of words): ________
Essay rate of production (length divided by time): __________

III.

Essay number: _______
Essay score 1:_______, 2. _______ I.R.:_______ 3. (if needed)_______ Total:_______
Essay length (no. of words): ________
Essay rate of production (length divided by time): __________

APPENDIX O

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
Essay Score	1.135	2	45	.331
Essay Length	1.322	2	45	.277
Essay Rate	.711	2	45	.496

APPENDIX P

ANOVA for Essay Quality

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	60.292	2	30.146	4.580	.015
Within Groups	296.188	45	6.582		
Total	356.479	47			

APPENDIX Q

Multiple Comparisons on Dependent Variable: Essay Quality

Tukey HSD

(I) Writing Mode	(J) Writing Mode	Mean Difference (I-J)	Std. Error	Sig.
keyboarding	transcription	-2.4375*	.9071	.027
	speech recognition	-2.3125*	.9071	.037
transcription	keyboarding	-2.4375*	.9071	.027
	speech recognition	-.1250	.9071	.990
speech recognition	keyboarding	2.3125*	.9071	.037
	transcription	-.1250	.9071	.990

* The mean difference is significant at the .05 level.

APPENDIX R

ANOVA for Essay Length

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6675.125	2	3337.563	.180	.836
Within Groups	834634.875	45	18547.442		
Total	841310.000	47			

APPENDIX S

ANOVA for Essay Rate of Production

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	159.477	2	79.738	10.627	.000
Within Groups	337.637	45	7.503		
Total	497.114	47			

APPENDIX T

Multiple Comparisons on Dependent Variable: Essay Rate of Production

Tukey HSD

(I) Writing Mode	(J) Writing Mode	Mean Difference (I-J)	Std. Error	Sig.
keyboarding	transcription	-4.1156*	.9684	.000
	speech recognition	-3.5569*	.9684	.002
transcription	keyboarding	4.1156*	.9684	.000
	speech recognition	.5587	.9684	.833
speech recognition	keyboarding	3.5569*	.9684	.002
	transcription	-.5587	.9684	.833

* The mean difference is significant at the .05 level.

Richard Conrad Snider

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Blacksburg, VA 24061
(540) 231-5167
rsnider@mail.vt.edu

718 McBryde Drive
Blacksburg, VA 24060
(540) 953-3362

EDUCATION

Ph.D. **Curriculum and Instruction (Instructional Technology),** April 2002
Virginia Polytechnic Institute & State University, Blacksburg, VA
Dissertation: *The Compensatory Effectiveness of Oral Expression through the use of Continuous Speech Recognition Technology in Supporting the Written Composition Performance of Postsecondary Students with Learning Disabilities*. Dissertation Advisor: Dr. D. Mike Moore

M.Ed. **Curriculum and Instruction (Learning Disabilities)**, December 1994
Virginia Polytechnic Institute & State University, Blacksburg, VA

B.A. **Philosophy & Religion**, *magna cum laude,* May 1991
Emory and Henry College, Abingdon, VA

AFFILIATIONS/HONORS

Association for Educational Communications and Technology (AECT)
International Society for Technology in Education (ISTE)
Virginia Society for Technology in Education (VSTE)
Southwest Virginia Technology Consortium
Virginia Assistive Technology Systems (VATS) Southwest Region Consortium
Virginia Assistive Technology Taskforce
Virginia Tech Database Knowledge Group Fellow
Toshiba Computers, Inc. 2000-1 ADA Advisory Panel
Phi Kappa Phi Honor Society
E&HC Sigma Mu Scholarship Society
E&HC Departmental Award in Philosophy

GRANTS

Affirmative Action Incentive Grant, 2001
The Compensatory Effectiveness of Oral Expression through the use of Continuous Speech Recognition on the Written Composition of Postsecondary Students with Learning Disabilities. An experimental study comparing speech recognition to transcription and keyboarding on the written composition of postsecondary students with learning disabilities ($2500).

A Support Program for Innovative Research Strategies (ASPIRES), 1995

Research, Design and Development of an Accessible Computer Laboratory at Virginia Polytechnic Institute & State University ($5000). Co-investigator: Virginia Reilly, Ph.D.

CERTIFICATION

Virginia Teaching License, grades K-12, Learning Disabilities

RESEARCH INTERESTS

Assistive Technologies	Universal Design
Databases in Education	Distance Education

TEACHING INTERESTS

Instructional Design
Educational Applications of Microcomputers
Educational Applications of Databases
Computer Applications for Special Populations
Instructional Design for Special Populations
Research in Instructional Technology
Multimedia Presentation Development
Distance Learning in Education
Design and Development of Web-Based Instruction

TEACHING EXPERIENCE

Instructional Technology Department, Spring 2002

Instructor. Virginia Polytechnic Institute & State University
Shared responsibility for instruction and evaluation of student achievement for one section of the graduate level course "Educational Applications of Databases." Maintained office hours to work with students.

Instructional Technology Department, Summer 2001

Instructor. Virginia Polytechnic Institute & State University
Shared responsibility for instruction and evaluation of student achievement for one section of the graduate level course "Multimedia Presentation Development." Maintained office hours to work with students.

Instructional Technology Department, Summer 2000

Instructor. Virginia Polytechnic Institute & State University
Shared responsibility for instruction and evaluation of student achievement for one section of the graduate level course "Multimedia Presentation Development." Maintained office hours to work with students.

Instructional Technology Department, Spring 2000

Instructor. Virginia Polytechnic Institute & State University
Shared responsibility for redesigning & redeveloping course content and responsibility for instruction and evaluation of student achievement for one section of the graduate level course "Educational Applications of the Microcomputer." Maintained office hours to work with students.

Instructional Technology Department, Fall 1999

Instructor. Virginia Polytechnic Institute & State University.
Shared responsibility for instruction and evaluation of student achievement for one section of the graduate level course "Educational Applications of the Microcomputer."

Training and Technical Assistance Center, October 28, 1999

Guest Lecturer. Roanoke College, Roanoke, VA
Lectured to an instructional technology class on the topic of "Assistive Technology in Higher Education."

Training and Technical Assistance Center, March 9, 1999

Guest Lecturer. Roanoke College, Roanoke, VA
Lectured to an instructional technology class on the topic of "Assistive Technology in Higher Education."

Training and Technical Assistance Center, April 6, 1999

Guest Lecturer. Southwest Virginia Community College, Richlands, VA
Lectured to a technology education class on the topic of "Assistive Technology for Children, Adolescents, and Adults."

PROFESSIONAL EXPERIENCE

Training and Technical Assistance Center, 1995-Present

Technology Coordinator. Virginia Polytechnic Institute & State University. Supervise faculty, staff, and students in the development and delivery of technology support services; support administrators, educators and staff engaged in the delivery of technology services to students with disabilities; teach courses in educational uses of technology; design and develop presentations on the integration of technology in education for delivery at conferences and workshops; develop a program to loan surplus University equipment to area schools; train area school teachers to use computer loan equipment; establish and maintain a World Wide Web server; design and develop the Center's web site; design and develop an online interactive video streaming workshop series; design and develop online modules to assist educators in meeting the requirements put forth by the Virginia Technology Standards for Teachers; design and develop a database system for statewide data reporting; write grants to fund assistive technology research projects; chair and participate on search committees to hire new employees; participate on statewide assistive technology taskforces and University assistive technology steering committees; participate on advisory panels for research in assistive technology.

Computer Science Department/Dean of Students Office, 1994-1995

Senior Lab Specialist . Virginia Polytechnic Institute and State University. Planned, researched, acquired funding through grant writing, and implemented a project to create a fully accessible computer laboratory for students with disabilities at Virginia Polytechnic Institute and State University.

Kipps Elementary School and Blacksburg Middle School, 1994

Student Teacher. Montgomery County Public Schools, Montgomery Co., VA
Performed assessments, developed instructional procedures, taught students with learning disabilities, and provided technology services to special education administrators, teachers, and students.

Training and Technical Assistance Center for Disabilities, 1993-1994

*Technology Assistant***.** Virginia Polytechnic Institute and State University. Supported staff in delivery of services, assisted with presentations and workshops, and maintained and upgraded computer equipment and software.

Riner Elementary School and Auburn High School, 1993

Intern. Montgomery County Public Schools, Montgomery Co., VA
Performed assessments, developed instructional procedures, and taught students with learning disabilities.

INSTRUCTIONAL DESIGN PROJECTS

Pulaski County Social Services, 2001
Consultant. Worked on a team to develop a database driven online system for data entry and reporting.

John Wiley and Son's, Inc., 2001
Consultant. Designed and developed a web site to accompany a textbook on thermodynamics.

History Department, Virginia Polytechnic Institute and State University, 2001
Consultant. Designed and developed a database system for making inferences from historical source material in order to promote collaboration and critical thinking skills.

John Wiley and Son's, Inc., 2001
Consultant. Designed and developed a banner image for a CD accompanying a textbook on spreadsheets.

John Wiley and Son's, Inc., 2001
Consultant. Developed a CD to accompany a Microsoft Excel statistics tutorial textbook. Project included design and development of a banner image.

John Wiley and Son's, Inc., 2000
Consultant. Redesigned a web site for a business textbook. Project included design and development a virtual company logo and image-based site map.

John Wiley and Son's, Inc., 2000
Consultant. Developed a web site and CD to accompany an electrical engineering textbook.

RDAISA , 2000
Consultant. Worked on a team to develop a dynamic, database driven help system for a military website.

CONFERENCE AND WORKSHOP PRESENTATIONS

2002

Hicks, D., Snider, R., Potter, K., & Holmes, G.(2002). *'Getting it out there and getting it used:' Database applications, collaboration and technology integration in teacher education.* Roundtable discussion at the Society for Information Technology and Teacher Education (SITE) International Conference, Nashville, TN.

Potts, A., Holmes, G., Potter, K., & Snider, R. (2002). *Beyond Electronic Portfolios: Developing Images of Possibilities Through Database Portfolios*. Roundtable discussion at the Society for Information Technology and Teacher Education (SITE) International Conference, Nashville, TN.

2001

Hicks, D., Snider, R., Potter, K., Holmes, G., & Craig, C. (2001). *In search of a more perfect union: Using databases to teach the doing of history*. Presentation at the annual meeting of the NCSS. Washington, D.C.

Perkins, R., Snider, R., & Lockee, B. (2001). *Strategies for scaling up a distance education program.*. A paper presented at the Association for Educational Communications and Technology (AECT) Convention. Atlanta, GA

Macedo, P., Snider, R., Penney, S., & Laboone, E. (2001). *The development of a model for using e-portfolios in instructional technology programs*. A paper presented at the Association for Educational Communications and Technology (AECT) Convention. Atlanta, GA

Snider, R., Perkins, R., Holmes, G., & Lockee, B. (2001). *A systematic model for scaling up a distance education program.*. A presentation at EDUCAUSE 2001: An EDU odyssey. Indianapolis, IN.

Snider, R. (2001). *The use of speech recognition to support the written expression of individuals with learning disabilities*. A presentation at the T/TAC Technology Statewide Conference, Roanoke, VA.

Snider, R. (2001). *Prototype of a digital video captioning program*. A presentation at the Web Applications Research and Design (WARD) Developers Conference, Blacksburg, VA.

Snider, R. & Potter, K. (2001). *The use of databases as a collaborative tool to promote technology integration and critical thinking*. Paper presented at the annual meeting of the Eastern American Research Association (EERA), Hilton Head, SC.

1999

Snider, R. (1999). *Exploring Computer-based Communication Devices.* A presentation at the T/TAC Communication Compendium Workshop, Abingdon, VA.

Snider, R. (1999). *Alternative Methods for Accessing the Computer.* A presentation at the Virginia Association for Early Childhood Education Conference, Roanoke, VA.

1998

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