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(Signature)

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Date April 28, 1973
ABSTRACT

Traditionally, assessment has been a difficult procedure among children with physical handicaps who are nonspeaking due to their limited response capacities. More accurate methods of assessment are needed. The use of computers in the assessment of children with physical and nonspeaking handicaps has considerable promise. This pilot study investigated the use of the computer as a viable tool during assessment of children with physical handicaps who are nonspeaking.

This study was exploratory. Methodological procedures changed as new discoveries were made. The study explored the possible advantages of using a Macintosh LC computer with adaptive peripherals (the Unicorn expanded keyboard and digitized speech) to assess the abilities of students with physical and speech impairments as measured by performance in an assessment protocol. It attempted to examine memory abilities. Children were given a series of photographs and/or letters to memorize under the following conditions:

a). standard stimulus exposure and response times (five and 20 seconds respectively).

b). prolonged stimulus exposure and response times (20 and 60 seconds respectively).

c). visual feedback only conditions

d). visual and auditory feedback conditions

The study addressed the following research questions:

1). Does lengthening the stimulus exposure and response times influence students' performance in an assessment protocol?

2). Does feedback; (visual and auditory combined or visual feedback only) influence students' performance on an assessment protocol?
Observations and measures were made of 1) the number of questions answered, 2) number of items remembered in sequence, 3) number of items remembered in a random order, and 4) response times.

General conclusions

The study found that computer based assessment has potential to help students demonstrate their potential because of its flexibility. The computer provides auditory/visual presentations enhancing students' perceptual access and response fluency and involving students actively. Student responses are more easily interpreted by the examiner as a result of auditory feedback. The assessor's powers are augmented because the computer presents questions and scores and tabulates results, thereby freeing the examiner to concentrate on and attend to the student.

However, there are cautions to be observed when using the computer during assessment of these children.

The usefulness of the computer is limited by its lack of ability to respond quickly and make adjustments to the assessment situation as perceived necessary by the assessor. The assessor must still be responsible for recognizing students' individuality and the human subtleties that arise during assessment which have not been anticipated in software programs. The benefits of the computer are not exploited unless an examiner is present to make sensitive adjustments to the assessment environment in order to meet the needs of students. The examiner must ensure that the computer's advantages do not hamper the powers of the "human" during assessment. The assessor must see the computer's role as one of augmentation. Assessment must take place over time and students must be familiar with the task and keyboard overlay before embarking on assessment. The study highlighted the heterogeneity and variability of children with severe disabilities. Software needs to be developed that is flexible enough to meet the needs of this population.
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Numerous individuals have contributed in important ways to the preparation of this thesis. I wish to pay special recognition to Dr. Sally Rogow, my senior supervisor, who has extended to me her knowledge, time and friendship throughout this year. She has served as my mentor - encouraging independence in my inquiry, and providing challenges to questions which I have ventured to ask. I also wish to thank the second member of my committee, Dr. Leroy Travis, for his conceptual feedback and valuable suggestions in this research. Lastly, I would like to thank Mr. Mike Bartlett, for offering to me his support in this study.

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The author is grateful to Special Education Technology - British Columbia for its encouragement and assistance in developing this pilot study.
CHAPTER ONE

INTRODUCTION

Background of the Problem

The integration of students with physical and communicative handicaps into the mainstream school environment has given the regular classroom teacher the responsibility of determining how best to provide appropriate educational programs for these students. Research studies demonstrate that the achievement of students with special needs increases when appropriate educational programs which meet the strengths and needs of the student are implemented (Salomon, 1972; Snow 1972). Assessment is a necessary component in the determination of the educational needs of these students (Zigmond, Vallecorsa & Silverman; 1983). The proper assessment of this population is difficult and is complicated by the range and severity of their physical and motor problems (Anastasi, 1988). This may influence the efficacy of assessment. These children have (or may have) severe speech problems as well as motor disabilities which may affect all four limbs. They may also experience a variety of learning difficulties which may be evidenced as a decrease in speed of information processing (Riedlinger-Ryan & Shewan, 1984; Koppitz, 1975, 1977; Weiner, 1969) and subsequent rates of responding.

Traditional assessment tools which have been standardized on non handicapped populations and which require verbal and/or writing skills do not reflect the strengths and abilities of those children who take longer to process and respond to information. Reavis, (1990), Taylor (1984) and Anastasi (1988) reported examiner difficulties in interpreting test results. Appropriate assessment procedures are needed for students with physical and speech impairments (Hasselbring, 1984). Assessment of students with severe physical and speech disabilities requires special assessment devices which allow students to show their true abilities (Baumgart et al. 1982).
There is research evidence that non speaking children may indeed have knowledge of language but cannot demonstrate their knowledge in the absence of a mode of communication (Thomas et al. 1985). New computer technology makes it possible to develop assessment tools which are designed to give these students the ability to respond. This thesis reports on a pilot project which employed computer technology to assist in the assessment of students with physical and speech impairments. The study was based on the belief that students with physical and communicative impairments have knowledge and can demonstrate it. There are many research studies which indicate that the abilities of these students are frequently underestimated (Anastasi, 1988). A computer based assessment and the peripherals designed for non speaking and physically handicapped individuals may permit an effective method of assessment and enrich educational programming.

Purpose of the Study

The purpose of the study was to develop an assessment protocol which presented students with access to a response mode. The study examined the effects of providing extended viewing and response time. The assessment protocol presented students with two types of feedback: visual and auditory combined and visual feedback only. The study considered the effects of two feedback conditions; auditory and visual; and the effects of varying stimulus exposure and response time conditions.

The project made use of a computer with adaptive peripherals. A Macintosh computer with an adapted peripheral called the Unicorn expanded keyboard was employed. The Macintosh computer is widely used in classrooms because of the variety of educational software available for use with special populations. The Unicorn expanded keyboard is widely used to bypass motor limitations in the physically handicapped. The assessment program called the Computer Based Assessment for Memory software and The Computer Based Cognitive Measure Observation Form was developed for the pilot project. The software was designed by Motionworks Interactive
Questions to be Investigated

This study explored the possible advantages of using a computer with adaptive peripherals (the Unicorn expanded keyboard and digitized speech) to assess the abilities of students with physical and speech impairments as measured by performance in an assessment protocol.

Research Questions

The study focused on the following questions:

1). Does lengthening the stimulus exposure and response time influence students' performance in the assessment protocol?

2). Does enhanced feedback; (visual and auditory combined or visual feedback only) influence students' performance on the assessment protocol?

Organization of the Thesis

Chapter 1 will introduce the pilot project, described its purpose and contains a review of the literature regarding educational assessment of students with physical disabilities, computer applications to assessment, and the application of technology to students with multiple handicaps.

Chapter 2 will describe the subjects, the procedures employed and the measures used in the study.

Chapter 3 reports the results of the study and offers a discussion of the findings and limitations of the study.

Definition of Terms

Adaptive technology: The technology which allows access to the microcomputer through an alternate interface (or input) method other than the regular keyboard.
Unicorn Expanded Keyboard (Unicorn Engineering Inc.): This is one type of alternate interface system. The Unicorn expanded keyboard is an alternate keyboard and is approximately 54 centimetres wide by 36 centimetres in height and consists of 128 programmable keys or cells. An overlay fits on top of the board. Letters, words, phrases, pictures or other symbols may be placed on the overlay. One large cell can represent one function or 128 cells can represent 128 different functions. The device allows the user to select items from a display of symbols with a fist, finger, hand or other body part.

Ke:nx Interface Box: This is an interface device which connects the Unicorn expanded keyboard to the Macintosh computer.

Voice output systems: These systems supply synthetic speech to the visual display of the screen. Although most often used as a prosthesis for the visually impaired, it can be of benefit to the physically disabled/non speaking population. Laddaga, Levine and Suppes (1977) found that a high quality speech synthesizer or digitized speech is necessary for auditory feedback to be of benefit to children.

Macintosh LC computer: This computer contains the Hypercard programming language, colour monitor (25 centimetres by 19 centimetres) and digitized speech.
Assessment of Children with Physical Handicaps

Assessment of children who cannot speak is made complicated by limited motor and communicative abilities. Few instruments have been designed to assess the skill levels of these children while allowing for their motor limitations (Anastasi, 1988; Dykes, 1985; Sigafoos, 1987). Most assessment measures use adaptations of standardized formal and informal test protocols to determine the specific strengths and weaknesses of these children. These tests have been normed on the nonhandicapped population (Sattler, 1982; Anastasi, 1988). This has not produced a satisfactory solution and dissatisfaction has been expressed with the results (Russel, 1984; Sattler, 1982; Anastasi, 1988).

The child who is physically disabled and nonspeaking almost always experiences severe restriction of movement, skeletal deformities, sensory disorders, seizure disorders or other medical problems (Orelove & Sobsey, 1991). The single largest identifiable cause of multiple disabilities is cerebral palsy (Orelove & Sobsey, 1991). Cerebral palsy is a chronic non-progressive condition caused by damage to a developing brain. The term cerebral palsy includes a variety of conditions which result in movement disorders. The three major types are spasticity, athetosis and ataxia (Bobath, 1975; Finnie, 1975).

Children with cerebral palsy have a wide range of mobility and motor problems. Some may experience little difficulty while others are severely affected.

Motor disorders adversely affect the ability to write, hold books, turn pages, etc., (Luebben, 1990). Some children may be able to write slowly for short periods of time while others lack the required finger and hand control. Accuracy, speed, range of motion, grasp, strength and endurance are all affected to different degrees (Haley, Hallenborg & Gans, 1989). Some children are non ambulatory while others may walk
with assistance (Orelove & Sobsey, 1991). Many have additional disabilities such as sensory, visual or hearing impairments. There are also physical disabilities that develop as a consequence of immobility (Campbell, 1989; Robinson & Hupp, 1986). Typical problems include curvature of the spine, permanent shortening of muscles and tendons, partial or total dislocation of the hips and disorders of the hips and ankles which further interfere with movement and cause extreme discomfort. Almost one third of children with cerebral palsy experience seizure disorders (Spooner & Dykes, 1982). Although seizures are most frequently controlled with medication, medications themselves can cause adverse side effects which interfere with learning. These children are also prone to respiratory infection (Thompson & Guess, 1989). Frequent health problems, adverse reactions to medications and hospitalizations for surgeries further restrict their activity and limit their life experiences.

The inability of motor impaired individuals to physically act upon their environments limits the variety of first hand learning experiences (Goldenberg, 1979; Reidlinger - Ryan & Shewan, 1984; Miller, 1986; Dunn, 1991).

Cognitive development is not an independent feature of development. It grows out of experience. If the quality of that experience is impaired, then cognition will be correspondingly involved. Ayres cited by Miller.(p.183)

Thomas et al. (1985) reported a high incidence of language disorders in young adults with physical difficulties. This higher rate may be attributed to the higher incidence of language disorders associated with some neurological conditions. Physical disability also has a direct or indirect effect on the development and use of language. Inability to speak severely limits the development of the pragmatic and communicative functions of language. However, there may also be gross speech deficits which do not impair language. There is a further component to the limitations imposed by the
physical disability. Miller, Yoder & Schiefelbusch (1983), Orelove & Sobsey (1991) and Meyen (1978), report that some children demonstrate immaturity and low self esteem due to their limited opportunities for social interactions.

Despite expressive language problems, many individuals have higher order thinking and receptive language abilities (Webster and McConnell, 1987). Lenneburg (1967) cited several examples of children who demonstrated delayed language as young children but when speech developed, language was used age appropriately. One 14 month old who had been tracheotimized for six months began to babble at an age appropriate level one day after the tube was removed. No practice or experience at hearing his own vocalizations was required. Comparable observations were observed in children who were severely neglected by their parents and who appeared to be grossly mentally, physically and socially handicapped. According to Lenneburg (1967), although practice is not the same as learning, it is false to assume that these children have not undergone years of learning; they simply could not respond. He further stated that there appears to be no general deficiency in the fundamental cognitive skills of language delayed children as compared to normally speaking children. Students' knowledge of language cannot be judged from their ability to produce language as speech or written communication (Hawkridge et al., 1985; Halliday, 1989). It is crucial for assessment to be based on the current knowledge and skill level rather than depend on their limited motor repertoire in order for these children to demonstrate their potential (Halliday, 1989).

Dykes (1985), stated that attitudes have contributed to diminished expectations for the student with disabilities. According to Dykes, attitudes of nurturing and protection are often maintained for school aged students. Limitations are imposed by attitudes and expectancies of speaking interactors with nonspeaking students (Miller, Yoder & Schiefelbusch, 1983). Often, vocal speakers' level of communication is considerably lower than the capabilities of the nonspeaker and responses are not required or expected at all. Low expectations lead to treating the student as if he or she
has little knowledge because he can demonstrate so little (Dykes, 1985). For these reasons, these children have often gone without assessment or have been assessed improperly. This has resulted in inappropriate placement in educational programs.

Assessment of Students with Physical Disabilities who are Non-speaking

Children with physical or verbal impairments cannot manipulate formboards or other performance materials. Tools which require object assembly tasks, object sequencing, block design and reproduction and puzzle solving require a variety of sensorimotor systems such as hand-eye motor coordination to negotiate a motoric response. Most traditional assessment tools operate under the assumption that students can move about unimpaired (Bailey & Simeonson, 1988; Boyd et al., 1989). This is appropriate when assessing motor movement, but it is unfair to ask for fatiguing and sometimes impossible motor movement performance during assessment of intelligence and achievement etc. All too often all that is assessed is the student's endurance and tolerance.

Susceptibility to fatigue makes short testing sessions a necessity (Anastasi, 1976). Working against a time limit or in strange surroundings often increases anxiety, which, in turn, intensifies the motor disturbance of children with motor impairments (Anastasi, 1976; Taylor, 1980). Timed assessments are legitimate if the skill being assessed is that of speed Reavis (1990). However, in the assessment of attention span, intelligence or achievement, timed assessments are not appropriate with students who have physical disabilities or who cannot speak. Forer et al (1991) stated that it is important to provide extra testing time so that disabled examinees can both process information and negotiate motoric responses. A study by Ragosta and Wendler (in progress), found that disabled students require between half again to double time to take the Scholastic Aptitude Test.
Neisworth and Bagnato (1986) point out that standardized tests may serve to compound the problems because they involve procedures which do not permit ample response time.

Reavis (1990), noted that most students with severe disabilities do not perform in a consistent manner. Russel (1984), also observed that a thorough evaluation of the intelligence of nonspeaking children is a difficult procedure. Neisworth and Bagnato (1986) stated that children with special needs have uneven developmental profiles, are difficult to assess and change rapidly. Motor, cognitive and communicative impairments are not mutually exclusive of each other; they interact continually, compounding problems of assessment. According to Kraat (1984), nonverbal cues are easily misinterpreted or ignored.

The difficulty in assessment of nonspeaking children is confirmed by Taylor (1984) and Anastasi (1988) who also stated that students' nonverbal behavior is often misread or misinterpreted. They reported that it is important to ensure that the assessment be administered so as not to bias and penalize children with impaired speaking ability. The results of assessment should not reflect the child's impaired ability to speak yet many tests assume the child can speak.

Appropriate assessment instruments do not exist and assessment personnel have not been trained to assess these children (Hupp & Donofrio, 1983; Mulliken & Buckley, 1983; Sigafoos, Cole & McQuarter, 1987). Few recently developed tools are appropriate for this population.

The items employed by assessment tools may not reflect the life events and experiences of students with disabilities (Debuskey, 1970; Reavis, 1990; Meyen, 1978; Bennet, 1983; Forer et al., 1991). Taylor (1984) noted that certain types of assessment tools contain items foreign to many children such as bicycle, keys, etc.. If a student has never seen a kitchen stove, or does not know how meals are prepared, common kitchen items may not be recognized. While some students may recognize a line drawing of a bed; others have had too limited life experiences to recognize outline drawings of
"beds". Others may require actual photographs rather than pictures. According to Reavis (1990), many assessment tools use only line drawings or the printed word. Little attention has been paid to the bias against students who cannot explore their environment independently or who live in institutional settings (Reavis, 1990).

The Application of the Computer to the Assessment Process

Hasselbring (1984), found that the computer can be used to overcome some of the problems inherent to the assessment process.

Computers have been described as flexible, motivating, patient, consistent and capable of delivering instruction that can be customized to meet the needs of individual students (Baumgart & VanWallegam, 1987; Behrmann, 1984). Computers are motivating to children who usually respond well to sound and graphics (Iacono & Miller, 1989). Students will work longer (Hagen & Behrmann, 1984) and for those students who are fearful of failure or taking risks due to a long history of failure, the computer provides a nonconfrontational environment in which to work.

Children with physical handicaps may have difficulties attending to the relevant dimensions of tasks, or have memory and perceptual problems (Iacono & Miller, 1989). The computer has been found to help students attend to relevant stimuli in tasks (Iacono & Miller, 1989).

A report of the U.S. Department of Education (1983) (cited by Hasselbring) stated that computers and computer diagnosticians have the potential to make teachers more aware of

"the ways in which procedural skill and conceptual knowledge combine to produce good performance..... and which components are deficient in a particular student and help them become aware of areas in which their students need further work" (p. 20)
Computer-based assessment instruments generally fall into two categories; interactive and noninteractive. Noninteractive programs are used by examiners for scoring, analyzing, and sometimes writing reports (based on commonly used standardized tests). This type of assessment does not permit the student to interact with the computer. Interactive programs use software which enables the student to use the computer, often without the need for examiner intervention.

Some of the generally accepted advantages to using the computer in noninteractive assessment include improved levels of standardization in the procedures used during test administration, scoring and interpretation; the collection of response data in real time; and the development and use of assessment models that were previously too complex for human presentation (Fifield, 1989; Repp et al, 1989). Test administration is the least developed application of computer technology in psychoeducational assessment to date (Fifield, 1989). Krug (1984) listed only a small portion of tests (less than 20%) as appropriate for special education settings.

Fifield (1989) observed that the computer has helped to alleviate problems of standardization by consistent and precise presentation of problems, reliable interpretation and accurate scoring. Fifield noted that variations in test administration are sometimes required for students who are unable to work within the constraints of standardized procedures. Use of the computer during assessment can free the examiner from scoring, increase the opportunity for observation and, thus, provide a more thorough examination of student skills and deficits. Beyond these benefits to the student, current research also indicates that educators' attitudes and performance can improve with the use of computers (Walton, 1985; Gardner, 1985). Hasselbring (1984), cited advantages that include huge savings in examiner time and reduced administration and errors in scoring. Invalid interpretations of responses can be controlled more tightly and often eliminated.

Overton and Scott (1972), reported no significant differences between administering the Peabody Picture Vocabulary Test in automated style or manually.
Space (1981), Elwood & Griffin (1972) asserted that scores obtained from computer adapted versions of existing paper and pencil tests were essentially the same as each other. They reported high correlations between computer-administered and face-to-face administrations of the Weschler Intelligence Scale. Fifield (1989), found that in spite of high correlations obtained by computer and paper versions of a scale of social competence, the scores were statistically different. Brinker (1982), stated the computer provides the educator with opportunities to observe the child during the assessment process (teachers did not have to count responses when computers were used. Instead they were able to look at other things which the students were doing while they were using the computer). Brinker goes on to state that it is clear that the function of the microcomputer is to provide teachers with a more detailed picture of the learner.

Other researchers (Gardner & Breuer, 1985; Stoddard, 1982; Hasselbring, 1984), report the computer as having been a useful tool in the assessment of the developmentally disabled. They found the computer to produce results which indicated reliability and validity at a level which was judged superior to traditional procedures. Becker and Schur (1986) state that computer technology can improve the assessment process for developmentally disabled by providing instruments which are more accurate, less time consuming and more flexible than conventional assessment tools.

Fitch et al. (1984), reported the computer as useful in the screening of communication disorders. It assisted by printing directions on the screen item by item (reducing the chances of errors in administration by presenting items in sequence and not changing the item on the screen until a response had been given). The computer eliminated arithmetic errors by storing responses signaled to it and computing scores.

Fay, Okamoto, Brebner and Winter (1982), reported on the use of computer-assisted assessment with individuals who were severely physically handicapped. Their subjects had a limited response repertoire (e.g. eye blink). These authors reported reliability and stated that technology provides a tool for obtaining precise measures of subtle responses.
Lillie, Hannum and Stuck (1989) noted that interactive assessment or "on line testing" must be approached with caution. They say that most studies citing the advantages of using the computer assume that students are equally able to use the computer keyboard. A student who knows the correct response but has difficulty using the keyboard may make mistakes for reasons other than not knowing the correct response called for on the test. Lillie, Hannum and Stuck (1989) point out that students who can use standard modes such as writing, are able to use test taking strategies such as skipping questions which they feel unsure of, continue with the assessment items they do know, and return later to answer the more difficult questions.

Adaptive Computer Technology


"Computer technology has great potential benefits for children and adults with disabilities. Its power rests in the application of the technology as a tool for manipulation of ideas and objects, and as a tool for compensation, to take the physical or cognitive handicap out of a disability. (p. xii).

The Unicorn expanded keyboard can bypass motor problems (Treischmann & Lerner, 1990; Hagen, 1984; Behrmann, 1988). Treischmann (1990) stated the Unicorn board has provided children with physical impairments the opportunity of working independently. Shell, Horn & Severs, 1989; Kinney & Blackhurst, 1987) state that the Unicorn board can be effectively used to augment written or verbal communication. Spoken output from the computer may also augment students' ability to understand.

In a study done on the benefits of spoken output versus spoken output plus text, (McGregor, Drossner & Axelrod, 1990), students made fewer errors in the voice plus
text condition than in the text condition alone. Hinchley et al. (1977), noted that speech output can involve students more actively in the instructional process.

Intelligibility of voice synthesis is important (Helsel - Dewart & Van Den Meiracker, 1987; Mitchell & Atkins, 1989) and will only be beneficial to students who understand it (Mirenda and Beukelman, 1987; Horn, Shell & Severs, 1986).

A Model for the Computer Based Assessment of Students with Physical Handicaps who are Nonspeaking

Miller and Sprong (1986), recommended that assessment tools elicit optimal performance and be well constructed. This study attempts to elicit optimal performance among students.

The present study is a pilot study of the use of a computer and peripherals including software to assess nonspeaking students. A model which includes the use of the computer with adaptive peripherals to meet the response capacities of these children and includes the development of software designed to be adaptable to varying processing modes and processing rates of this population may begin to supply an answer to the problem of equalizing the assessment process for students with physical and communicative handicaps. This model will include the development of such software. The Unicorn board with digitized speech will be used to provide auditory feedback and bypass physical deficits.

This study explored the possible advantages of using a computer with adaptive peripherals (the Unicorn expanded keyboard and digitized speech) to assess the abilities of students with physical and speech impairments as measured by performance in an assessment protocol.

Research Questions

The study focused on the following questions:

1). Does lengthening the stimulus exposure and response time influence students' performance in the assessment protocol?
2). Does enhanced feedback; (visual and auditory combined or visual feedback only) influence students' performance on the assessment protocol?
CHAPTER TWO
METHODOLOGY

This chapter describes the subjects, methodology and procedures of the study. It also describes the alterations which were made to the original procedure as a result of new discoveries which were unveiled as the study progressed. Specific justifications for procedural alterations are offered in the Discussion section of this thesis.

Statement of the Problem

The use of computers in the assessment of children with severe motor limitations has considerable promise. To develop appropriate educational programming for students who are nonspeaking and physically handicapped, more accurate methods of assessment are needed. By offering a response mode that may circumvent these students' motor limitations and by extending stimulus exposure and response time and allowing flexible presentation modes (such as paired auditory and visual feedback or visual feedback alone), it may be possible to create an environment more conducive to allowing students to demonstrate their powers.

Research Questions

This study explored the possible advantages of using a computer with adaptive peripherals (the Unicorn expanded keyboard and digitized speech) to assess the abilities of students with physical and speech impairments as measured by performance in an assessment protocol (described below). It examined memory abilities by requesting children to memorize photographs and/or letters under the following conditions:

a). prolonged stimulus exposure and response time (20 second exposure time/60 second response time).

b). standard stimulus exposure and response time (five second exposure time/20 second response time).
c). visual and auditory feedback conditions

d). visual feedback only conditions

More specifically, the study focused on the following questions:

1). Does lengthening the stimulus exposure and response times influence students' performance in the assessment protocol?

2). Does enhanced feedback; (visual and auditory combined or visual feedback only) influence students' performance on the assessment protocol?

The Subjects

The subjects of this study all had severe physical and speech impairments. The term "severe" is used here to describe subjects whose movements were characterized by unusual limitations in motor fluidity, range of motion, speed and accuracy. The term "severe", when referring to speech impairments, refers to children who are nonverbal but may communicate through some vocalizations or gestures. Their ages ranged from six years to thirteen years. There were six boys and two girls in the study. (The "Special Education Technology - British Columbia" database was used to locate students who used Unicorn expanded keyboards). All subjects had experience with either the Unicorn expanded keyboard, similar adaptive keyboards or a communication device requiring activation by a finger or fist. Subjects did not have hearing or visual impairments. Ten subjects were selected, but two left the study, one due to illness and another for unscheduled surgery. The remaining eight subjects were integrated into regular classrooms with support from an itinerant special education teacher. Subjects' physical disabilities ranged from Cerebral Palsy, Apert's syndrome, Cornelia DeLangue syndrome, or other forms of brain damage resulting from meningitis and hydrocephalus. Table 2.0 shows the ages and backgrounds of the subjects.

Information was available on all subjects concerning visual and hearing acuity, handedness, and medication. Information on the subjects' mode of communication and method of responding "yes" and "no" enabled the examiner to make appropriate
adaptations during assessment. Specific adaptations are described at the end of this chapter.

Table 2.0

Summary of Subject Characteristics and Backgrounds

<table>
<thead>
<tr>
<th>Subject</th>
<th>Age</th>
<th>Grade Placement</th>
<th>Diagnosis</th>
<th>Prior Computer Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>7 yrs.</td>
<td>1</td>
<td>Apert's syndrome (digit disfigurement) non speaking</td>
<td>modified keyboard, Unicorn expanded keyboard</td>
</tr>
<tr>
<td>B</td>
<td>8 yrs.</td>
<td>Kindergarten</td>
<td>Cerebral Palsy (spastic) non speaking</td>
<td>Mini Unicorn keyboard, Touch window screen</td>
</tr>
<tr>
<td>C</td>
<td>13 yrs.</td>
<td>7</td>
<td>Cerebral Palsy (spastic) non speaking</td>
<td>Unicorn expanded keyboard</td>
</tr>
<tr>
<td>D</td>
<td>10 yrs.</td>
<td>4</td>
<td>Hydrocephalus, Epilepsy non speaking</td>
<td>Unicorn expanded keyboard</td>
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<tr>
<td>E</td>
<td>8 yrs.</td>
<td>Kindergarten/1</td>
<td>Cornelia De Lange syndrome (limb deficiency) non speaking</td>
<td>Unicorn expanded keyboard, Introtalker (communication device)</td>
</tr>
<tr>
<td>F</td>
<td>6 yrs.</td>
<td>Kindergarten</td>
<td>Cerebral Palsy (spastic) non speaking</td>
<td>Unicorn expanded keyboard</td>
</tr>
<tr>
<td>G</td>
<td>13 yrs.</td>
<td>7</td>
<td>Cerebral Palsy (spastic) non speaking</td>
<td>Switch, Unicorn expanded keyboard</td>
</tr>
<tr>
<td>H</td>
<td>9 yrs.</td>
<td>Resource room</td>
<td>Cerebral Palsy (athetoid) non speaking</td>
<td>Unicorn expanded keyboard</td>
</tr>
</tbody>
</table>

Procedure

Hardware

The hardware included a desktop computer and a specially adapted keyboard. The desktop computer was a Macintosh LC computer with four megabytes of memory, the Hypercard programming language installed, a colour monitor and digitized speech. Programming was done with the use of the Hypercard programming language which is found on all Macintosh computers.
The assessment procedure also involved the use of the Unicorn expanded keyboard connected to a Macintosh LC computer using a Ke:nx interface box (Don Johnston). The expanded keyboard was used to allow maximum access to the computer. The Ke:nx interface box was used to connect the Unicorn to the computer and allow input from the device to the computer.

For the purpose of the study, eight squares were programmed with a one inch space around each square. The one inch space around each square was designed to reduce the chances of error by giving the subjects a bigger area in which to maneuver. This was designed to make visual scanning of items easier. The overlays placed over the squares had either photographs or letters. (Appendix A contains sample overlay). Two different representational levels were programmed into the software to allow for subjects who worked at lower and more advanced representational levels to participate in the study. (Representational level refers to a level of symbols used to depict meaning. Symbols used may range from photographs, line drawings, stylized drawings, to the more advanced levels - letters, and the printed word. All of these symbols stand for a real object or represent concepts).

The Software

The Computer Based Assessment for Memory (C.B.A.M.) software was designed as a multimeasure device (using two different types of assessment tools; the computer and an observation form). The assessment tool used adjustable features which allowed for comparison between four different computer assessment conditions; 1) prolonged stimulus exposure time 2) prolonged response time, 3) auditory plus visual feedback and 4) visual feedback only. The software was designed as follows.

The tasks were presented in two phases; the practice phase and the assessment phase. During the practice phase, subjects were shown one demonstration item and the examiner demonstrated the responses expected from the subject. The subject then received an opportunity to practice on two sample items. Following this practice, the
student was presented with the actual assessment items. The questions for the practice phase followed this format for both auditory/visual and visual feedback only sections.

Practice Phase

The practice sequence consisted of presenting the demonstration screen showing one photograph or letter. The practice phase was augmented by examiner instructions and proceeded as follows. The subject was instructed to watch the examiner demonstrate how the program worked. The researcher demonstrated the procedure to the subject. For example, the researcher modeled the task by saying "Now I am looking at the picture of the dog on the screen. Can you touch the dog? I am thinking of it in my head. Try and look at the dog and think of it in you head. Now I am going to try to keep the picture of the dog in my mind until I can press the picture of the dog on the Unicorn board...Do you see the picture of the dog on your Unicorn board? When the picture disappears, I can press the picture on the board to give my answer. See? Watch." (The examiner entered a response on the expanded keyboard to show the first sample item - one photograph. The computer timed the response rate (i.e. the time between the end of the stimulus presentation and the subject's first response).

Subjects were given an opportunity to practice by answering the same question that was given to the examiner. The examiner said "Now you try it. Watch the screen.....Do you see the picture?" (Examiner points to the screen). Try to keep the picture in your mind until you can press the same picture on your Unicorn board......Wait until the picture on the screen goes away before you press the picture on the board......Good!"

The subject entered the response to the next practice question. The computer timed the response rate. If the subject did not begin to respond within the designated time (20 seconds under standard conditions and 60 seconds under prolonged conditions), to the first sample question, the program branched back to repeat the first sample question. Only one opportunity to repeat the first sample question was allowed. If the subject again did not respond, the program then moved to the second sample
question. If the subject still did not respond within the designated amount of time to the second sample question, the program repeated the second sample question once again. The assessment procedure was to be terminated if subjects did not respond during the practice session. The practice phase allowed the examiner to track the subject's accuracy and make a decision as to whether to continue the assessment program. The assessment was administered if subjects were able to correctly answer one sample question. The volume of the digitized speech was adjusted prior to the assessment phase to ensure subjects could hear the auditory feedback. Subjects' ability to hear the feedback was confirmed through monitoring orientation of body and eye gaze toward the screen in response to auditory stimuli throughout the practice phase.

When subjects had completed the practice phase, the assessment phase began. The assessment procedure required subjects to scan the Unicorn board overlay, locate the item and press the appropriate cell on the expanded keyboard. The Unicorn expanded keyboard "beeped" to show that a response had been registered. Assessment tasks required subjects to memorize the items as well as the sequence of presentation. As the assessment program progressed, the number of items increased from two items to four and the representational level became more abstract.

Assessment Sequence

A question was presented for a predesignated amount of time. After presentation of the item(s), the screen went blank. The computer then started timing the time taken to respond (i.e. between presentation time and response). Subjects responded by depressing the correct square(s) on the Unicorn expanded keyboard. If the subject did not respond in the predesignated amount of time (20 second under standard conditions and 60 seconds under prolonged conditions) or made an error, the program continued to the next question. If subjects made two consecutive incorrect responses, (incorrect being a response that is not started in time or is not in the correct order), the program
moved to the next set of questions. Both response time and accuracy were recorded for each question.

After the assessment had finished and when time permitted, subjects were asked to identify the conditions under which they would like to complete further tasks; 1) slow or fast stimulus exposure time; 2) slow or fast response time, 3) auditory/visual feedback or 4) visual only feedback. They were also asked to identify the representational level they preferred to work with. For example, subjects' attention was drawn to the overlay and they were asked "Which did you like the best - photographs or letters? Would you like to work with the (photographs/letters) again? Would you like to be able to see the (photographs/letters) for a long time or a short time? Would you like a lot of time to touch the (photographs/letters) or just a little bit of time? Do you want to hear the computer talk?" Questions were repeated more than once for those subjects appeared to have trouble understanding. The examiner made the appropriate adjustments to the computer and then asked the subject if the adjustments which had been made were correct. Subject response were confirmed by monitoring eye gaze, facial gestures and body orientation.

Pilot Assessment Items

The software consisted of Photographs, Line drawings and Letters. Photographs and Letters were used for the purposes of this study. Incorporating all three sections into the assessment would make the session lengthy, tiring subjects and not allowing them to exhibit their best performance. Items selected were considered to be items familiar to the subjects. (Both visual and auditory/visual feedback conditions were given on both Photographs and Letters tasks). The items below were used in the assessment and presented in the order which appears in Figure I. Alterations to this order of presentation were determined by the subject's physical, emotional and cognitive ability to perform the task and are listed at the end of this chapter. Justifications for the specific alterations which were made are offered in Chapter Four. Figure I shows the sequence of presentation of the assessment levels.
Figure 1
Sequence of Presentation of Assessment Items

1). PHOTOGRAPH MEMORY (Visual/Auditory Items)
2). PHOTOGRAPH MEMORY (Visual Items)
3). LETTER MEMORY (Visual/Auditory Items)
4). LETTER MEMORY (Visual Items)

The items in each section were as follows:

1). PHOTOGRAPH MEMORY (VISUAL/AUDITORY ITEMS)
   two photographs with auditory labels: pencil, book
   two photographs with auditory labels: fork, money
   three photographs with auditory labels: apple, pencil, fork
   three photographs with auditory labels: money, book, sweater
   four photographs with auditory labels: car, money, watch, sweater
   four photographs with auditory labels: watch, fork, money, book

2). PHOTOGRAPH MEMORY (VISUAL ITEMS)
   two photographs: cup, crayon
   two photographs: spoon, hand
   three photographs: socks, cup, spoon
   three photographs: hand, crayon, dog
   four photographs: shoes, hand, glasses, dog
   four photographs: glasses, spoon, hand, crayon

3). LETTER MEMORY (VISUAL/AUDITORY ITEMS)
   two letter memory with auditory labels: g, t
   two letter memory with auditory labels: r, k
   three letter memory with auditory labels: q, g, r
   three letter memory with auditory labels: k, t, l
   four letter memory with auditory labels: u, k, j, l
four letter memory with auditory labels: j, r, k, t

4). LETTER MEMORY (VISUAL ITEMS)

  two letters: a, b
  two letters: p, o
  three letters: c, a, p
  three letters: o, b, n
  four letters: f, o, s, n
  four letters: s, p, o, b

Measures

Measures were made of subjects' responses with regard to:

  1). length of presentation and response time allowed
  2). visual combined with auditory feedback

The assessment software was applied under the following four conditions:

1). Standard and Prolonged Stimulus Exposure and Response Time Conditions
  a). In the "standard" condition, subjects were given five seconds to view a stimulus question and twenty seconds to respond to it.
  b). In the "prolonged" condition, stimulus exposure time and response time were extended. Subjects were exposed to the stimulus task for 20 seconds and were given 60 seconds to respond.

Five second and twenty second viewing times were chosen because more similar exposure times may not have been sufficient enough to yield results indicative of the potential benefits or disadvantages of using the computer during assessment. This was also the case with response times (20 seconds versus 60 seconds). Both conditions were applied across Photograph Memory and Letter Memory levels of the assessment software.
2). Auditory/Visual Feedback Combined and Visual Feedback only Conditions

c). Subjects were exposed to auditory combined with visual feedback and their responses recorded.

d). Subjects were also exposed to visual feedback alone. Responses were recorded.

Both of these conditions were applied across Photograph Memory and Letter Memory levels of the assessment software.

The **Computer Based Cognitive Measure Observation Form**

Descriptive particulars for each person who was a subject were provided through the use of an observation form. See Appendix B. The heterogeneity of subjects with physical and speech impairments made it important to note the behaviors which occurred during the assessment to give a richer picture of the assessment situation and consider the impact various conditions might have on the use of technology. The knowledge of those familiar to the subject was considered important in order to structure the assessment to facilitate optimal performance. Data regarding uses of the expanded keyboard in the classroom, position and angle of the keyboard and monitor that allowed subjects to best perceive visual output (left, right or in midline) and target squares on the expanded keyboard. were gathered through the Observation form from school personnel.

Subjects' behaviors in the following categories were noted:

1. motor
2. motivation/boredom
3. ability to keep place between screen and keyboard
4. ability to shift gaze among items on the screen
5. attention to the screen/keyboard
6. attention to auditory feedback
7. familiarity with technology
8. self checking

The study was conducted during regularly scheduled school hours. Assessments were carried out in a quiet room in the school (usually the learning assistance centre or medical room). The assessments were scheduled to take approximately 60 minutes. The researcher and an assistant or child care aide familiar with the student were present during the assessment session. The Regional Coordinator from Special Education Technology - B.C. also attended. The researcher conducted the assessment while others present observed from chairs situated approximately two feet behind the subject.

Prior to the assessment session, each subject was briefed by the classroom teacher. The subject was told that two people would be coming to the school and bringing a computer with them. The subject would be asked to do some activities on the computer. It would be the subject's job to use the computer and tell the examiner if the subject liked the software and if it was fun. Upon arrival, the examiner reiterated what the teacher had told the subject. The examiner introduced herself and the accompanying S.E.T. - B.C. Regional Coordinator. It was explained to the subject that others were in the assessment room to determine if they also liked the software and to offer suggestions to the examiner on how to make it more fun. Questions and conversation lasting approximately five minutes took place to establish rapport with the subject. The examiner said "Do you like to use the computer? What do you use the computer for in your classroom? Show me how you use the computer. Do you have a computer at home? Do you like to play games on the computer?" In instances where subjects did not appear to understand the questions, the examiner talked about topics which were more personal to them. Comments were made about the nature of their clothing, hairstyle, friends. For example, the examiner often said "What a nice dress! Is it new? Are those new runners you have on?" Responses were determined through subjects' own mode of communication. In some instances, subjects responded with "yes" or "no" by shaking or nodding their head. In cases where subjects' head control
was more limited, subject responses were determined by monitoring eye gaze, facial expressions and body language. During the sessions, observer comments were written. Afterwards, the researcher made summary evaluations. Administration of the assessment instrument sometimes changed during data collection to allow for the exploration of conditions which facilitated the subject's optimal performance.

Summary of Alterations to the Original Procedure

Some alterations to the original procedure and tasks were made in order to allow some subjects to participate in the study and facilitate optimal performance. Following is a summary list of adaptations to the original procedure which were made during assessment sessions.

Procedures were changed by:

1). Making assessment sessions shorter. (The shortest session was 20 minutes while the longest was 60 minutes).
2). Leaving specific sections out of the assessment (e.g., Letters).
3). Increasing practice time on the computer. (Two subjects were given two to three extra sessions of practice before embarking on the assessment).
4). Increasing practice time off of the computer. (Two subjects were asked to identify items on the overlay three times before doing the assessment).
5). Providing breaks during assessment. (One subject had a ten minute snack break while most other subjects received ten minutes to stretch).
6). Repositioning the expanded keyboard and/or subject to allow for easier access. (One subject sat on the lap of his special education assistant to complete the assessment. The Unicorn board was continually moved for three other subjects).
7). Not requiring items in the memory task to be remembered in sequence. (The tasks were made easier by allowing subjects to remember items presented in any order of presentation).
8). Facilitating motor performance by supporting the arm and wrist, helping the subject to apply pressure and moving the board to locations which were inside the subject's range of motion.

Chapter Three presents the results of the study. A discussion of the results and suggestions for further research follow in the last chapter.
RESULTS

The study aimed to explore how computer-based assessment of students with severe physical and speech impairments can be adapted to permit optimal responses. The stimulus materials were presented under the following conditions:

1. prolonged response time and prolonged stimulus exposure time
2. auditory and visual feedback combined or visual feedback only

The study addressed two main questions.

More specifically, the study focused on the following questions:

1). Does lengthening the stimulus exposure and response time influence students' performance in the assessment protocol?
2). Does enhanced feedback; (visual and auditory combined or visual feedback only) influence students' performance on the assessment protocol?

Results

1). Does lengthening the stimulus exposure and response time influence students' performance in the assessment protocol?

Table 3.0 lists the number of questions answered under each condition, number of questions correct, the number of items remembered from the computer-presented questions, and the average response time under each condition. Not all subjects answered the same number of questions. The category "Questions answered" includes those questions to which the subject pressed a cell on the Unicorn board. Attempts at questions were recorded by the examiner during assessment. No response is indicated by NR. Table 3.0 shows the results of subjects at the Photographs level. Only three subjects were able to complete tasks at the Letters level.
### TABLE 3.0

**Summary of Results of Measures of Memory for Photographs**

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Conditions</th>
<th>Feedback Conditions</th>
<th>Standard</th>
<th>Prolonged</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Visual only</td>
<td>Visual and Auditory</td>
<td>Visual only</td>
<td>Visual and Auditory</td>
<td>Number of Questions Answered</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
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<td>6/6</td>
<td>2/2</td>
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</tr>
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<td>B</td>
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<td>2/2</td>
<td>2/2</td>
<td>Questions Corrected (Items remembered in sequence)</td>
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<td>Items Remembered Randomly</td>
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</tr>
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<td>Average Response Time (in seconds)</td>
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<td></td>
</tr>
</tbody>
</table>

NR = no response
Five subjects participated in the assessment under standard conditions. Two of these subjects attempted to respond to questions but could not complete their motor movements before time ran out. Under standard conditions with visual feedback only, three out of five subjects answered all questions. Under conditions with both auditory and visual feedback, three out of five subjects responded to all of the questions given them. Under prolonged conditions, all seven subjects answered all of the questions. Table 3.1 shows the number of questions presented and the number of questions responded to under prolonged and standard stimulus exposure and response time conditions.

Table 3.1

Comparison of Responses Under Standard and Prolonged Conditions:

Questions Answered

<table>
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<th></th>
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<tbody>
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<td>2/2</td>
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<td>No Data</td>
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</tr>
</tbody>
</table>
Under prolonged exposure and response time conditions with visual and auditory feedback, seven out of eight subjects responded to the questions. All of these subjects were able to complete their responses to questions within the designated amount of time.

The average number of questions responded to under visual/auditory feedback conditions with standard time to respond was 1.8 with a standard deviation of 1.2. Given visual and auditory feedback conditions with a prolonged time to respond, the mean was 2.7 and the standard deviation was .13. This standard deviation may suggest that practice had an effect. The order of presentation was 1). Prolonged (auditory /visual conditions) 2). Standard (auditory/visual conditions. It may be that subjects were beginning to improve as a result of practice. The average number of questions responded to given visual feedback only conditions with a standard amount of time in which to respond was 2.4 with a standard deviation of 2.3. The mean number of questions responded to given visual feedback only conditions with a prolonged amount of time to respond was 2.8 with a standard deviation of 1.6. These results could suggest that motor fatigue had an effect as results deviate from the mean under the standard condition more than under the prolonged condition. The prolonged (visual feedback only) condition was administered as the third set while the standard (visual feedback only) condition was administered last.

Of the five subjects completing the assessment under both types of visual only feedback conditions, (i.e. standard versus prolonged) four subjects performed better at remembering items when given prolonged conditions.

Under prolonged conditions (visual only), the average number of items remembered was 5.2. The highest number of items remembered under this condition was 17 and the lowest was 1. Under prolonged conditions (visual/auditory feedback), the mean was 3.7. The highest number of items remembered was 11 and the lowest was 1. The standard deviation for standard conditions was 3.3 whereas under prolonged conditions it was 1.6. This may suggest that given prolonged conditions,
children with the most severe physical handicaps were able to improve their performance.

More response time also facilitated accurate responses. It enabled subjects time to view, process and respond to the stimuli on the screen. This was especially true for subjects with more severe handicaps. The term "severe" is used here to describe subjects whose movements were characterized by limitations in motor fluidity, range of motion, speed and accuracy.

Two subjects were able to remember items in sequence, and all subjects were able to remember, in a nonsystematic order, at least some of the items presented. Three out of seven of the subjects were able to remember more than 80% of the items under the condition of prolonged exposure and response time (20 second exposure time, 60 second response time). Two out of seven subjects were able to remember 40% of the items presented on the screen under prolonged conditions.

Out of the five subjects who responded to questions under both conditions, all remembered more items under prolonged exposure and response time conditions (auditory/visual feedback). The mean number of items remembered under prolonged conditions was 8.6. Under standard conditions, the average number of items remembered was 5.8. Number of items remembered appears to be dependent upon the time in which subjects had to respond. The highest number of items remembered under prolonged conditions was 21. Under standard conditions, the highest number of items remembered was 18 making the range 18. The range for items remembered under prolonged conditions was 19. The standard deviation under standard conditions was 6.8 whereas under prolonged conditions it was 7.3. This may suggest that although lengthening time to respond helped the subjects to remember items, in this case, the nature of the distribution of the responses did not change. Under standard conditions, half of the subjects remembered more than 78% of the items.

Table 3.2 shows the comparison between prolonged and standard stimulus exposure and response time on the number of items subjects remembered.
Table 3.2

Number of Items Remembered Correctly Across Condition 1 Standard and Prolonged Conditions

<table>
<thead>
<tr>
<th>Subject</th>
<th>Standard</th>
<th>Prolonged</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>17/18</td>
<td>1/2</td>
</tr>
<tr>
<td>B</td>
<td>0/5</td>
<td>1/2</td>
</tr>
<tr>
<td>C</td>
<td>0/5</td>
<td>0/2</td>
</tr>
<tr>
<td>D</td>
<td>No Data</td>
<td>No Data</td>
</tr>
<tr>
<td>E</td>
<td>2/8</td>
<td>No Data</td>
</tr>
<tr>
<td>F</td>
<td>7/9</td>
<td>5/9</td>
</tr>
<tr>
<td>G</td>
<td>No Data</td>
<td>2/7</td>
</tr>
<tr>
<td>H</td>
<td>No Data</td>
<td>No Data</td>
</tr>
</tbody>
</table>

Under prolonged exposure/response time conditions, many subjects could scan the items on their Unicorn board displays. More than half of the subjects were able to keep their place when looking back and forth between the screen and keyboard under prolonged exposure conditions.

Response times varied widely. The fastest response time was 6.7 seconds while the slowest was 66.5 seconds making the range 59.8 seconds. The average response time was 34 seconds. Subjects with the most severe physical disabilities had the slowest response times. As stated previously, the term "severe" is used here to describe subjects whose movements were characterized by severe limitations in motor fluidity, range of motion, speed and accuracy. Subjects with cerebral palsy of the spastic type in all four limbs had the longest response times. Table 3.5 shows the response times of these subjects.
Table 3.3

Average Response Times of Subjects Classified with Severe Handicaps Compared To Other Subjects

<table>
<thead>
<tr>
<th>Subject</th>
<th>Number of Completed Tasks</th>
<th>Average Response Time (in seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Severely Handicapped</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>5</td>
<td>28.0</td>
</tr>
<tr>
<td>C</td>
<td>4</td>
<td>66.5</td>
</tr>
<tr>
<td>D</td>
<td>4</td>
<td>23.7</td>
</tr>
<tr>
<td>G</td>
<td>6</td>
<td>41.0</td>
</tr>
<tr>
<td>II. Other</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>16</td>
<td>6.7</td>
</tr>
<tr>
<td>E</td>
<td>9</td>
<td>17.0</td>
</tr>
<tr>
<td>F</td>
<td>13</td>
<td>21.9</td>
</tr>
<tr>
<td>H</td>
<td>Did not complete</td>
<td>Did not complete</td>
</tr>
</tbody>
</table>

Half of the subjects were able to respond to more questions when given more time to respond. The remaining half answered the same number of questions under both conditions. Approximately half of the subjects completing the assessment showed a desire to self correct under both conditions, however only the prolonged time condition gave subjects' opportunities to self correct. All subjects showed a desire to respond before the stimulus exposure time was up and while the stimulus item was still on the screen.

2). Does enhanced feedback; (visual and auditory combined or visual feedback only) influence students' performance on the assessment protocol?
Six subjects were able to complete the assessment with visual feedback only under prolonged conditions while five subjects completed this assessment under standard conditions. Seven subjects completed the assessment with auditory and visual feedback under prolonged conditions while this assessment was completed by five subjects under standard conditions. Table 3.4 shows the results of assessment under the auditory/visual and visual feedback only conditions.

**Table 3.4**

| Number Of Items Remembered Correctly Across |
| Condition 2 - Visual Only and Visual/Auditory Feedback |

<table>
<thead>
<tr>
<th>Subject</th>
<th>Visual Only</th>
<th>Visual/Auditory</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standard</td>
<td>Prolonged</td>
</tr>
<tr>
<td>A</td>
<td>17/18</td>
<td>17/18</td>
</tr>
<tr>
<td>B</td>
<td>0/5</td>
<td>2/5</td>
</tr>
<tr>
<td>C</td>
<td>0/5</td>
<td>1/5</td>
</tr>
<tr>
<td>D</td>
<td>No Data</td>
<td>2/5</td>
</tr>
<tr>
<td>E</td>
<td>2/8</td>
<td>2/5</td>
</tr>
<tr>
<td>F</td>
<td>7/9</td>
<td>7/9</td>
</tr>
<tr>
<td>G</td>
<td>No Data</td>
<td>No Data</td>
</tr>
<tr>
<td>H</td>
<td>No Data</td>
<td>No Data</td>
</tr>
</tbody>
</table>

When the subjects were presented with both visual and auditory feedback (prolonged condition), subjects responded to an average of 2.7 questions whereas under visual feedback only conditions (prolonged condition), subjects responded to an average of 2.8 questions. (It is probable that these findings were greatly influenced by the effect of practice but tempered by the influence of motor fatigue).

The highest number of questions responded to under visual feedback only (prolonged) conditions was 6 and the lowest was two. Given prolonged conditions with visual and auditory feedback, the highest number of questions responded to was four.
and the lowest number of questions responded to by a subject was two. Under conditions with visual and auditory feedback (prolonged), the standard deviation was .13 and it was 1.6 without auditory feedback. Auditory and visual feedback appeared to help the students given enough time in which to respond.

All subjects were able to remember some items. Under auditory/visual (standard) conditions, the highest number of items remembered was five and the lowest was 0. The average number of items remembered was 1.8. Subjects were able to remember 54% of the items presented under auditory and visual feedback conditions as opposed to 69% under visual feedback only conditions. The average number of items remembered under visual feedback only (standard) conditions was 5.2. The highest number of items remembered was 17 and the lowest was zero. The standard deviation under visual feedback only (standard) conditions was 6.4 whereas under conditions with both types of feedback, it was 1.6. It may be that

Under conditions with auditory and visual feedback (prolonged), subjects answered only four out of 29 (14%) of questions correctly whereas in the visual feedback only (prolonged) condition, subjects were able to respond correctly to 11 out of 33 (33%) of the questions correctly. Under visual feedback only conditions, three subjects scored above 40% in memorization of items. Subject A, the most academically advanced, performed better given visual feedback alone. This may be due to the effect of practice since visual sections of the assessment were presented second and last. The standard deviation given visual feedback (prolonged) conditions was 5.6 compared to 2.9 in visual/auditory feedback (prolonged) conditions. This suggests that less variance is seen among scores when combined feedback is given.

Response times varied from a low of 4.0 seconds under standard (visual feedback only) conditions to a high of 18.3 seconds, compared to prolonged conditions (with visual feedback only), which had a low of 7.8 and a high of 56 seconds. Given standard (visual and auditory feedback) conditions, the lowest response time was 6.5 seconds and the highest was 19.0 seconds, compared to a high of 57.5 and a low of 8.5
seconds under prolonged (visual/auditory feedback conditions). The slowest response time under prolonged (visual versus auditory/visual) was 56.1 compared to 56 under visual only conditions. Given standard exposure and response time conditions (visual versus auditory/visual conditions), the fastest response time was 6.5 seconds compared to the fastest response time of 4.0 seconds under standard (visual only feedback). For standard (auditory/visual conditions), the slowest response time was 19.0 and 18.3 for conditions without auditory feedback. Table 3.5 shows the subjects' average response times across the two conditions. Response times varied widely.

Table 3.5

Comparison of Subjects' Average Response Times Across Condition 2 - Visual Only and Visual/Auditory Feedback

<table>
<thead>
<tr>
<th>Subject</th>
<th>Visual Only Feedback</th>
<th>Auditory/Visual Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5.9</td>
<td>7.5</td>
</tr>
<tr>
<td>B</td>
<td>13.0</td>
<td>29.0</td>
</tr>
<tr>
<td>C</td>
<td>37.7</td>
<td>28.0</td>
</tr>
<tr>
<td>D</td>
<td>29.5</td>
<td>18.0</td>
</tr>
<tr>
<td>E</td>
<td>19.9</td>
<td>14.2</td>
</tr>
<tr>
<td>F</td>
<td>22.3</td>
<td>18.9</td>
</tr>
<tr>
<td>G</td>
<td>No Data</td>
<td>41.0</td>
</tr>
<tr>
<td>H</td>
<td>No Data</td>
<td>No Data</td>
</tr>
</tbody>
</table>

Under conditions with auditory feedback, subjects alerted to the screen presentation and searched out an "effect" on the screen in response to the Unicorn "beep" and to the auditory presentation of words. They showed awareness of the responses they had made as a result of these features. As a consequence, 50% of the
subjects showed a desire to confirm and self correct answers. Subjects looked back and forth between the screen presentation and the keyboard under both conditions, but auditory feedback appeared to aid in this process as subjects did not lose their place as often. The data appears to support the notion that auditory feedback may help students to maintain their attention to tasks.

It appears as though subjects took advantage of the extra amount of time they had in which to respond under prolonged conditions. Fast response times under standard conditions belonged to one subject who was not severely physically handicapped. Practice may have had an effect on this subject. His fastest response time was seen during the last set of questions administered. Responses given by other subjects were much slower. There are many more "no responses" seen under standard conditions. The type of feedback appeared to make little difference to response times among subjects.

Subject Profiles

Subject A

Subject A was eager to begin his work with the computer and completed both Photographs and Letters sections. No procedural adaptations were made. The length of the session was approximately 60 minutes. He adapted well to the assessment environment shaking his head for "yes" and "no". The subject looked intently at the examiner and computer monitor and shifted his attention appropriately. During the Practice phase of the assessment, he entered his responses quickly. He looked from the questions on the screen to the expanded keyboard, scanning the board and then targeting the appropriate squares with apparent ease. Each time a question appeared on the screen, the subject pulled his hand away from his lap quickly and attempted to locate the matching item on the board.
This subject's body language and facial expression indicated that he was motivated by the computer and appeared to view the assessment with a competitive spirit. This subject was familiar with the computer. He appeared to understand the mechanics of the task with no problems. During extended viewing times, he was restless and would wriggle in his seat and look around the room, his frustration mounting. During prolonged time in which to respond, the subject would look to the computer monitor and check his work. One time he recognized an answer as incorrect and showed concern.

Subject B

Subject B was assessed in her own classroom but could not hear the speech feedback from the computer because of the noise level. The assessment had to be delayed until her classmates left for Physical Education. Once the session began, the only distraction was occasional whispering by staff at the back of the room. This subject completed both Photographs and Letters sections of the assessment. this took approximately 60 minutes. The assessment was given in the order set out in the original design, however, it was noted that more practice time to master the mechanics of the task may have facilitated better performance. She appeared eager to please and looked to those present for reinforcement after each response. She often attempted to answer questions before the screen presentation of items was completed. This was especially notable under standard time conditions. This subject was easily fatigued and answered fewer questions at the end of the session. the subject had difficulty negotiating a motor movement in time to respond under standard time conditions. Twice she did not have time to respond at all and showed great concern. Later, she gave up. She appeared much more comfortable under prolonged time conditions. The subject had difficulty activating cells appropriately with her fist. It appeared that the size of the square on the overlay was too small. The expanded keyboard had to be tilted to facilitate the subject's ability to make responses. The board was moved to various
positions while the subject attempted her responses in an attempt to reduce the number of arm movements needed to respond and, thus, facilitate optimal performance. Given prolonged time in which to respond, this subject looked to the computer monitor and checked her work. This subject's attention drifted when the stimulus exposure time was prolonged and she was required to wait before responding. This subject looked at the screen presentation less often with auditory feedback. This behavior did not occur under conditions with visual feedback only.

Subject C

This subject's assessment took place with the subject's teacher, assistant, S.E.T. - B.C. Regional Coordinator and examiner in attendance. The assessment was administered in the usual order but the subject gave no response to questions under standard conditions. The assessment took approximately 30 minutes. Subject C waited for thirty minutes while research personnel arrived and the computer equipment was set up. Once it was time to begin the assessment, the subject appeared agitated. While instructions were given the subject looked around the room and stared at the ceiling.

Despite his frustrations, each time the subject hit a cell, he searched for an effect on the computer screen. Auditory feedback helped him to orient himself to the task being presented on the monitor. His limbs and vocalizations quieted, and his body and gaze would orient toward the screen. At other times however, the auditory feedback appeared to confuse him and encourage incorrect answers. He would press a cell and the computer would provide the auditory feedback by labeling the item. The subject would hear the auditory presentation and hit the same cell again. Prolonged viewing times made him impatient even though he needed a prolonged time in which to respond. the subject had difficulty hitting the cells on the overlay which he had intended (his fist was too big for cell), and he often activated other cells unintentionally. To help alleviate this problem, the board was continually moved to within the subjects range of movement. While the computer alleviated the problem of the subject's slow motor
response rates, misunderstanding of the task prevented him from demonstrating his ability. While the computer helped the subject orient himself to the task, it also appeared to confuse him. Practice at performing a task plays a large role in allowing students to show their true abilities and this practice is best done on the tool which is to be used during the assessment process. Subject C only participated in the Photographs level of the assessment.

Subject D

This subject was tired and ill during the assessment. Owing to his condition, his mother stayed throughout the session. Also in attendance were the examiner, S.E.T. - B.C. Regional Coordinator, teacher and assistant. There were several other distracters throughout this session. The door opened and closed four times as the itinerant support teacher entered the room to check on "how things were going". In addition, those in attendance whispered in low tones while the assessment was in progress. At these times, the subject looked away from what he was doing and it is likely that these distractions had an additional influence on the subject not performing at his best during the assessment.

Procedural changes for this subject's session included increased practice time off the computer and on the computer. The subject received three extra practice sessions on the computer at the Photographs (auditory plus visual feedback) level of the assessment. During assessment, the subject had to be repositioned at the computer in order to complete the session. In addition, the subject's responses had to be facilitated by physically moving the expanded keyboard to areas where the subject could reach. This subject completed the Photographs level of the assessment only. The assessment procedure was changed. This subject did two sets (visual and auditory combined and visual feedback only) under prolonged conditions. Prolonged conditions (auditory and visual feedback) were applied first and prolonged (visual feedback only) conditions were applied next.
The subject's medical diagnoses is characterized by limb disfigurement and short stature and he would squirm and wriggle in his chair during his struggle to reach the targeted square. To facilitate ease of access, the subject was repositioned. The subject's assistant sat in a chair in front of the computer and the subject was placed on her lap. The expanded keyboard was placed in midline and tilted toward the subject to reduce the number of arm movements necessary to produce a response. Using this method the subject was able to target more cells and complete more answers without hitting cells unintentionally.

This subject used the auditory feedback portion of the assessment as a cue to respond. The auditory feedback was successful in orienting his attention to the screen and creating an opportunity for him to check his work. In one case, this subject showed concern when he realized he had given an incorrect response. Prolonged response time enabled this subject to self check his work.

Like other subjects, this subject lost interest in attending to the screen when exposure time was too long. This may have partially contributed to the number of incorrect responses.

Subject E

This subject's assessment took place in a quiet room with few distractions. While motivated at the prospect of using the computer, he did not appear comfortable with research staff. This may have had an influence on his performance during the assessment. Present were the S.E.T. - B. C. Regional Coordinator and examiner. Three procedural changes were made for this subject. This subject received extra practice off of the computer. He was asked to identify various pictures on the board (by pointing). This was done to familiarize Subject E with the keyboard overlay. He received extra practice on the computer as well. The first set - Photographs with auditory feedback was administered two times to help familiarize the subject with the task. Next, the subject was given the Photographs set under prolonged conditions with
visual feedback only. Finally the subject was administered the Photographs level of the assessment under standard/visual feedback only conditions. Another procedural change was to reposition the board and monitor to allow the subject easier shift of gaze between the two. This subject's session took approximately 60 minutes.

This subject responded well to the computer's auditory feedback; alerting to the screen presentation and then maintaining attention to the presentation by shifting his gaze from one item to the next. This subject appeared to enjoy being able to "cause" things to appear on the screen and seemed to appreciate the fact that now everyone present could see him producing work.

Under prolonged response time conditions, the subject was able to perform much better than under standard time conditions. Under standard time conditions, this subject showed increased anxiety and less motor accuracy. This occurred with much less frequency under prolonged conditions. Ample time to respond allowed this subject more time to concentrate on his motor movements.

This subject's motor impairment was characterized by slow, uneven and uncontrolled movements. Although the computer facilitated motor responses for this subject, it was necessary to make other physical adaptations to reduce the demands of the task and facilitate optimal performance. While looking between keyboard and screen, this subject had difficulty keeping his place. The distance between the keyboard and monitor was reduced in order enable him to shift gaze easier.

Subject F
This subject appeared comfortable despite the S.E.T. - B.C. Regional Coordinator and examiner being new to her. The only interruption to her session was a small 10 minute snack break needed owing to a metabolic disorder. During assessment, the subject was able to attend and understand instructions given her and respond to the questions presented under both standard and prolonged conditions. The assessment began by having the subject practice identifying squares on the expanded
keyboard by pointing to them while the computer was not on. Subject F was given two practice sessions with both feedback conditions in order to acquaint her with the mechanics of the task and the expanded keyboard layout. She completed both Photographs and Letters sections of the assessment. Her session lasted approximately 60 minutes.

This subject's cerebral palsy was characterized by slow and laboured arm movements. Although she could hold books and turn pages, she had difficulty with more sophisticated fine motor tasks such as holding pencils or crayons and writing. Although she responded to all questions, answers were not always completed under standard conditions. Subject F lost her place when shifting gaze between keyboard and monitor more frequently under standard conditions. Under prolonged conditions, the subject lost her place less often and looked to the monitor to check her work more often. The Unicorn board allowed her to devote her attention to the skill of successfully shifting her gaze from screen to board by removing complicated motor demands involved in producing a response.

During conditions without auditory feedback, the subject would look to the examiner upon completion of an answer as if wanting feedback regarding her response. The auditory feedback assisted the subject in orienting her attention to the screen.

Subject G

This subject appeared tired and according to his teacher, was not motivated by the computer at any time. Despite these things, the subject was cooperative and attempted to respond to questions given him. Subject G was given extra practice at the Photographs (prolonged - auditory plus visual feedback) level. He was given two practice sessions. This subject's session was shortened owing to fatigue and was approximately 30 minutes long. Towards the end of the session, the subject's performance had to be facilitated by giving support to his arm and wrist and moving the
board to various locations which reduced the motor demands involved in producing a response.

Subject G had great difficulty understanding the tasks and he hit cells randomly. He attempted to target and depress cells on the board, but his slow and laboured movements caused his arm to drag and activate cells unintentionally. It became clear that it was more reliable to monitor the subject's eye gaze to determine whether a response was intentional than to rely on the expanded keyboard providing a reliable alternative for motoric access. In this case, the best method of access to the computer was not, in fact, the expanded keyboard. The board had to be physically moved to where the subject could reach it. Although the subject tried several times to activate the cells on the board, the keyboard was not sensitive enough to register some of his responses. The squares were too small to accommodate his fist. He became frustrated at these times. To help him respond, once he had targeted a cell with his eyes, support was given at the wrist and pressure was applied to his hand to allow him to activate the intended cell. This procedure seemed to appease him.

Subject H

This subject's assessment took place on a Friday afternoon in the learning assistance centre. His mother, S.E.T. - B.C. Regional Coordinator, examiner, teacher and teacher aide were present. At times the district support teacher entered the room to observe but this did not appear to distract the subject. Once equipment was set up, the subject was wheeled into the room. He immediately became excited. Subject H's movements were quick, impulsive, uncontrolled and involved all four limbs. There were many loud shrieks and vocalizations. When positioned at the computer, he glanced momentarily at the screen then slapped the expanded keyboard wildly. Time was given for him to explore the board. The subject proceeded to hit each square in what seemed an attempt to see what would be spoken by the computer. He became very excited by the "beep" and speech feedback and would attempt to hit the squares to make the
speech feedback repeat. All the subject's responses were recorded by the examiner because the computer caused the subject to become too excited and his subsequent movements uncontrolled. At the suggestion of the school staff, the subject's wrist was weighted down with a wrist band to facilitate more controlled movement. Support at the elbow was also given. When it became clear to the subject that instructions were about to be given, he quieted momentarily and appeared to listen.

During the assessment, the subject would locate and attempt to hit the same items repeatedly. It was apparent that he did not understand the task. The subject was extremely motivated by the computer - but unfamiliar with its use. Since no computer results could be recorded and the excitement caused by the computer put the subject at some medical risk, the session was ended early, lasting only 20 minutes.

These subject profiles were intended to demonstrate some of the difficulties these children face during assessment.

Difficulties which were faced by students during the computer based assessment were a lack of time to respond, complete responses, and check their work. They had difficulty waiting an extended period of time before responding. When practice was not given, they sometimes became confused over the task to be done. Motor and physical fatigue made it difficult for subjects to complete tasks. Limited time meant there were limited opportunities to change incorrect answers. Often the subjects were not able to make desires/needs (or confusion over the task) known to the examiner. In addition, in some cases the board was not sensitive enough to register subjects' responses and the overlay or expanded keyboard was inappropriate for the subject's motor needs. Subjects sometimes had difficulty not activating other cells on the overlay and sessions were often too long and tiring.

The problems students faced during assessment were summarized here. These problems are discussed in further detail in Chapter Four.
CHAPTER FOUR
DISCUSSION AND CONCLUSION

Discussion

While this study began as an exploration of the effects prolonged exposure and response times and enriched feedback might have on eliciting optimal performance among this population, it turned into a study of the variety of factors influencing optimal performance. The original procedure underrated the difficulties inherent in assessing children whose disabilities limit their performance. Several themes emerged from the study. It is important to include a discussion of the factors which appeared to have an influence on students showing their optimal performance.

This discussion will consist of a description of the discoveries which were made as a result of the journey examiner and student took together through the process of computer based assessment. Themes which emerged during the study are presented and their implications discussed.

One of the difficulties encountered were the rooms assigned for the assessment. While most subjects were able to carry out their assessment in a room that they had been introduced to previously, most subjects had not frequented these locations. This may have unduly highlighted the significance of the assessment and caused subjects undue pressure and anxiety.

Subjects' unfamiliarity with the examiner and S.E.T. - B.C. staff that attended sessions (as did various school and district staff and occasionally parents) could very well have raised performance anxiety. These departures from the original design of the study, were not under the investigator's control. In one case, the subject's mother stayed throughout the session because the subject was ill. In another case, S.E.T. - B.C. staff were approached to deal with a technical problem. In some assessment circumstances there were numerous other distractions reducing the likelihood that the subject's best performance was seen. In Subject D's session, two itinerant district staff
interrupted the session several times. In the sessions of Subjects A, B, C, and G, whispering between the S.E.T. - B.C. Regional Coordinator and school staff person familiar to the child went on while the subject was undergoing assessment. Conditions, to repeat, were not under the control of the examiner. For a better exploration into the benefits of the computer during assessment, a more laboratory like situation is necessary.

While familiarity of the subject with the examiner was a concern, the familiarity of the examiner with the subject was also of special significance. It quickly became apparent that there was a need for the examiner to be well acquainted with the subtle, nonverbal behaviors of the subjects in order to interpret their wants and needs. In instances where desires were expressed through facial expressions, vocalizations and gestures, alterations to the assessment could be made accordingly. However, less universal expressive behaviors went unnoticed and school staff had to intervene as a result of the examiner's unfamiliarity with the subject's repertoire of subtle cues. The difficulty in assessment of nonspeaking children is confirmed by Kraat (1984), who stated that students' nonverbal behavior is often misread or misinterpreted. It is important to ensure that assessment be administered so as not to bias and penalize children with impaired speaking ability. The results of assessment should not reflect the child's impaired ability to speak. One way of ensuring more reliable results might be to ensure familiarity of the examiner with the student being assessed. There are several, covert subskills needed to perform tasks in assessment. Receptive language skills are needed in order to understand the task to be performed. Examiner familiarity with the subjects' more subtle expressive cues would have enabled subjects to receive instructions more appropriate to their level of receptive language functioning. At times, the struggle to get messages across to the examiner, subjects' attention was diverted from the task at hand. This precluded subjects showing their best performance and often lead to needless frustration for both examiner and subject. More importantly, it
may be that the subjects' understanding of the task to be performed was over or under estimated as a result of misinterpreting the subjects' nonverbal behaviors.

Lack of familiarity with the task and the keyboard overlay played a significant role in determining whether a subject's best performance was seen. Subjects brought varying abilities and backgrounds to the assessment. One subject understood the mechanics of the task immediately while the remaining seven needed to practice. Others needed occasional prompts to remember what to do. In at least two cases, the use of the expanded keyboard was confused with the function it was used for in the classroom. One subject used the expanded keyboard in an attempt to label items while another used it as a communication device in order to express his wants and needs. The former subject became passive while the other began a tantrum. As subjects became more familiar with the task, the number of correct answers increased. The results of Subject F demonstrate remarkably well the effects of practice.

All subjects spent several seconds attempting to locate the items on the overlay. It quickly became apparent that lack of familiarity with the keyboard was an intervening factor which put subjects at a disadvantage during assessment. Many mistakes which were made during assessment could have been due to the lack of familiarity with the keyboard rather than the task itself. The data suggests that long response times may have been due to unfamiliarity with the keyboard. This concurs with the findings of Lillie, Hannum and Stuck (1989) in a study done with children who were nonhandicapped. They found that mistakes were made for reasons other than not knowing the correct response. As the assessment continued, there was a general trend for response times to improve, suggesting that practice played a key role in acquainting the subject with the symbols on the keyboard overlay and their locations. Without practice, the assessment became more of a test of the subject's ability to locate items in the time given rather than an assessment of the subject's memory. Unfamiliarity with the keyboard overlay caused slower response rates among all subjects and caused
frustration among Subjects C, and G, creating conditions which did not facilitate optimal performance among subjects.

In addition to the problem of lack of familiarity with the keyboard overlay, each subject brought different motor or "keyboarding" ability to the assessment situation. Subjects for whom motor ability was severely impaired appeared to benefit the most from the expanded keyboard. The larger area in which to maneuver made it easier for these subjects to negotiate a motoric response accurately. It was easier for the examiner to interpret the unreliable motor movements of subjects because of the clearly defined response areas on the overlay.

However, the expanded keyboard did not meet the motor needs of all the subjects. In at least two cases, subjects with severe motor impairments still had difficulty in producing a response. In the cases of Subjects B, C, and G, inaccuracies were noted because the size of the area displayed on the expanded keyboard was not large enough to accommodate the subject's fist or trembling movement. In some cases, subjects had difficulties producing responses which were outside of the subjects' range of motion. These subjects (B, C, G, and H) needed extra physical help from the examiner in order to answer questions. It was necessary to move the board to various locations in front of these subjects to reduce the number of arm movements necessary in producing a response. In the case of Subject B, the board was not sensitive enough to register the light pressure the subject applied to it. Subject G needed support to the hand and wrist in order to prevent him from dragging his arm across the board and activating several cells unintentionally. Accidental hits of the board increased in frequency as the assessment progressed. It is highly likely that this was due to motor fatigue.

The ability of the Unicorn expanded keyboard to meet the needs of these subjects was very poor by the end of these assessment sessions. It is clear that the Unicorn expanded keyboard is not a cure for all. There is a need for the development of a tool which will meet the fluctuating motor needs of this population. Assessment
sessions for subjects whose motor needs were not met by the use of the expanded keyboard became assessments of the subject's patience and physical endurance instead of an assessment of their memory. Subject G's session was ended early for this reason. An overlay with the appropriate sized cells in which to maneuver and display symbols in the areas of the board within the subjects' range of motion may have facilitated better performance from them.

Despite the problems with physical suppprt to subjects and the shortcomings described, the computer did provide the examiner with an opportunity to observe and give help to the subject during assessment. The computer had the ability to present questions quickly or slowly, give feedback, pause for a response and tabulate answers. This meant that the examiner could observe subjects and attend to possible problems which arose during assessment (as is illustrated above) without pausing or ending the assessment. This advantage has been noticed by others who studied nonhandicapped people (Fitch et. al. 1984; Hasselbring 1984; Walton 1985; Gardner 1985). They reported increased opportunities to observe students during assessment as a concomitant of computer augmentation.

There is little doubt that the response time given to subjects affected subjects' capacity to perform at their best. Even when the expanded keyboard proved to be an appropriate response mode for the subject, inadequate time to respond to a question often prohibited subjects from answering. It is not only the response mode which contributed to the subject's ability to respond, but also the time allowed to negotiate a motoric response. Although the Unicorn expanded keyboard suited the needs of most subjects, on several occasions subjects were not able to demonstrate their knowledge due to the short amount of time in which they had to respond. Two subjects (B and C) made attempts to respond but were not able to activate any cells as a result of the limited amount of time given in which to respond. When subjects were able to respond, limited time did not allow some subjects to complete their responses. This caused frustration and anxiety to subjects. This frustration was probably exacerbated by the
presence of spectators. Later these subjects gave up and did not attempt to respond. Subjects' movements became more rigid and uncontrolled under conditions with limited time to respond. It is probable that motor fatigue was exacerbated by limited time conditions. This is consistent with results obtained by Anastasi (1988), and Reavis (1990).

Even so, there are disadvantages to long response times for some subjects. When response time was longer than the subject needed to negotiate a motoric response, subjects became distracted and bored. Their attention wandered. In one case, the subject began to add extra items to his response making his answer incorrect. These factors appeared to contribute to less than optimal performance. Response time given to subjects must be gauged and provided with care. It appears necessary to adjust response time specifically to the motor needs of the individual to facilitate optimal performance. For this reason, it will be important to develop software that responds immediately after the last depression of a key (or cell) by going on to the next question, or to have a human tester present that can monitor the assessment situation and make stimulus and response time adjustments as needed. In this assessment, the computer could not approach the ability of the "human" to be flexible and to make fine adjustments to the assessment procedure as needed.

It is also necessary to adjust stimulus exposure time to suit the needs of the subject. When stimulus exposure time was protracted (60 seconds), all subjects became distracted. They wriggled in their seat, looked away from the computer screen and appeared bored. The extended period of time to wait coupled with distractions may have caused subjects to forget items which were presented reducing the likelihood that best performance was seen. When auditory feedback was not given, subjects' attention was not brought back to the task. Consequently, response time needed was longer. This suggests that response time given to subjects needs to be based partially upon the individual's ability to maintain attention to the task. The computer technology that was used was unable to instantaneously adjust response time to the subject and task.
The need for stimulus exposure and response time to be adjusted according to the needs of the student illustrates the need for examiners to be intuitive and flexible. The computer equipment was not capable of making adjustments instantaneously causing less than optimal performance to be seen. However, it was possible for the examiner to make some adjustments to the assessment procedure when needed.

Auditory feedback had a remarkable influence on subjects' ability to perform well. It helped almost all subjects to orient to the task. Their attention was brought to the screen and the questions anticipated as a result of the beep and speech feedback. As each item was announced by the computer, subjects' eye gaze simultaneously followed the items being displayed on the screen. Most subjects' attention was maintained throughout the duration of the auditory feedback. Studies by Hinchley et al. (1977) confirm that auditory feedback involves students more actively in the instructional process. Iacono and Miller (1989) also say that the computer helps students with handicaps to attend to the relevant stimuli in tasks.

However, there were some exceptions. Subject B did not look at the screen when auditory feedback was given. Instead she tried to scan and locate the items on the keyboard as they were announced. Although auditory feedback appeared to cause attention to be diverted from the screen, this behavior was likely a strategy to overcome a lack of familiarity with the keyboard overlay. Further familiarity with the keyboard may have enabled this subject to attend to the screen presentation and facilitate better performance. Subject C became confused as a result of the auditory feedback. Although this subject began the assessment understanding the task he was to perform, auditory feedback seemed to cause incorrect answers. This subject would respond to a question and the item would be labeled by the computer. Each time an item was labeled, the subject attempted to locate this item on the overlay causing both the subject and computer to generate the same item repeatedly. It appeared as though the subject thought that the task was an auditory matching exercise. This problem would likely
have been remedied by providing a more stable understanding of the task through increased practice.

The most remarkable impact auditory feedback had on the assessment process was its ability to provide opportunities for the examiner to observe the responses of the subjects. The "beep" feedback which occurred after each response enabled subjects to determine if their answer had been registered by the computer. Traditionally, assessment has been difficult with this population because of involuntary motor movements, forcing the examiner to make interpretations about the student's intentions. Feedback helped the examiner to determine whether the subject had isolated the cell which was intended because it made subjects more aware of the response which they had produced. The resulting image on the screen made their work public knowledge. Both examiner and subject were able to acknowledge that a response had been made, what it was, and whether the answer was recognized as correct or incorrect by the subject. In all cases, subjects looked to the screen as a result of the feedback which they heard from the computer. Three of these subjects (A, B, F) checked their work, recognized when answers were incorrect and showed some concern or a desire to change these answers. The computer and its capacity to generate auditory feedback enabled the examiner to make a more precise interpretation of subjects' responses and make new discoveries about the subjects' awareness of the nature of the responses which were made.

The importance of allowing subjects time to practice before embarking on computer assisted assessment cannot be underestimated. Practice appears to be needed in order to understand the mechanics of the task to be performed, familiarize subjects with the response mode, (its sensitivity and beep feedback), and familiarize subjects with feedback mechanisms (the computer monitor and audio output). Extra practice time off of the computer was given to Subjects D and E in order to help them become familiar with the expanded keyboard overlay. Subject F received extra practice on the computer. While all could locate some items faster, the number of items that
Subjects D and E remembered correctly remained the same given equal conditions. However, Subject F's performance was remarkably improved. This subject completed both Photographs and Letters levels of the assessment. At the first and less abstract level, the subject needed prompts to look at the screen, scan the items on the board, remember items in the correct order and reproduce them. When the second and more abstract level was introduced to her later, fewer prompts were needed and more answers were correct. Out of the five subjects completing tasks at the Photographs level, three subjects' response times improved. This appears to indicate that practice helped subjects to become more familiar with the overlay, helped familiarize them with the mechanics of the task, and gave them time to practice their motor skills. In cases where response times did not improve, behaviors were noted that indicated motor fatigue may have been an influencing factor. These behaviors were especially apparent during the assessment sessions of Subjects B, C, D and G. These subjects were also noted as being the more severely physically handicapped or were ill or tired at the beginning of the session.

The problem of motor fatigue was a common one throughout most subjects' assessments. For this reason, Subject G's session was shortened. Subject D's session ended early owing to illness. A snack break was given to Subject F owing to a metabolic disorder. In all cases, providing a short interval between sets seemed to help the subjects restore their energy and they returned to the assessment with renewed interest. In the case of Subject D, the subject was repositioned to reduce the effort involved in producing a response. This seemed to help lessen motor fatigue also. This suggests that it is important to consider the medical conditions of the subjects among this population in order to provide them with an environment that will best facilitate optimal performance.

A large factor in determining whether subjects' best performances were seen appeared to be the suitability of the task. If tasks presented were too hard for the subject, response times were slow, number of correct answers and number of items
remembered were low. Frustration and anxiety were seen. Subjects' movements became more uncontrolled and subjects' muscle tone became more rigid. This complicated the subjects' ability to respond, and evoked more frustration and anxiety. To enable the participation of subjects who could not remember items in sequence, the task was changed to allow memorization of the items in any order. Tasks needed to be simplified in this way for all subjects except Subjects A and F. Although tasks were simplified as indicated, the software had been written to branch to the next question in response to the subject memorizing and reproducing items in the correct sequence. Simple memorization of items in any order was counted as incorrect by the computer and the computer would end the session instead of going on to the next question. (The examiner later counted the number of items remembered by the subjects which had been tabulated by the computer). As a result of the software being written in this way, subjects had to wait on several occasions while the examiner manually adjusted the program to present the next question. These waiting periods lasted approximately 60 - 90 seconds and had a partial influence on subjects' ability to maintain their attention to the task. Accordingly, it was likely that best performance was not seen. It is likely that had the software allowed for the level of the task to be adjusted to the ability of the subject, waiting periods and frustration would have been reduced for these subjects. An environment which would have been more conducive to eliciting optimal performance among the subjects might have been created.

In addition, it is evident that assessment on the computer is only as good as the software allows. While the function of the computer is to provide a more detailed assessment of the learner according to Brinker (1982), the computer cannot do its job well if the software does not meet good educational standards and is flexible. Stimulus exposure, response time, feedback and level of task difficulty must all be considered when developing software for this population. No assessment mode, especially any that entails computers, will revolutionalize assessment practices unless proper assessment principles are respected.
The results illustrate the heterogeneity of this population. All subjects approached and responded to the computer based tasks presented to them differently. Problems arose for different reasons and were approached in different ways. To meet the needs of students in a population such as this, there is a need for both examiner and computer to be highly flexible. The software used in this study was rudimentary and did not incorporate the flexibility or human touch that the human assessor brings to the assessment situation. Further, the computer was not able to make sensitive adaptations to the assessment instantaneously while the examiner possessed this ability. The computer was unable to instantaneously adjust for stimulus exposure and response time or vary feedback and presentations. It was unable to adjust the level of task difficulty. The computer was unable to apply these adjustments continually and with sensitivity. There is a need for this flexibility in the assessment of any children - and especially with children with the special needs that handicaps present.

In summary, specific elements of the computer based assessment which appeared to facilitate better performance were an appropriate response mode, prolonged time to respond, practice and familiarity with the task and keyboard overlay, appropriate tasks, short assessment sessions, examiner - subject familiarity, auditory feedback and reduced motor fatigue and waiting periods.

It is highly likely that a superior computer based environment would have facilitated better performance among these subjects if exposure and response times, keyboard layout and feedback were adjusted specific to the needs of the subject and if time to practice the task was given.

Conclusion

While this study was intended to pilot an assessment program and to explore the benefits of computer - assisted assessment of non speaking children with multiple handicaps - including conspicuous physical handicaps, the study suggested that many factors have to be taken into account when assessing students with severe disabilities.
Although the study set out to explore the benefits of prolonged exposure and response
time and enriched feedback conditions, many unanticipated questions were unveiled
which appeared to have a great influence on these students' ability to perform their best.
The heterogeneity of the population and the factors which complicate students'
performance were illustrated.

In order to exploit the usefulness of the computer during the assessment
process, it is crucial that the computer be used with an attentive and nimble examiner
present. The benefits of using the computer during assessment of this population are
minimized for both examiner and student unless it is augmented with human tact,
intelligence and responsiveness. While the computer is capable of generating and
varying feedback and can offer a response mode for students with physical and
nonspeaking handicaps, its power depends on the examiner. The examiner's role must
be perceived as one of equalizing opportunity for the child in order to facilitate the child's
optimal performance. To do this, examiners must know the needs of the children they
are assessing - regardless of the use of sophisticated computer equipment and
software. It is important for examiners to determine the kinds of presentation modes
that help students to demonstrate their abilities. Furthermore, since these fluctuate or
vary, it is necessary for examiners to be present to monitor and change feedback
conditions when necessary. The sound and display should match children's' current
interests and abilities in order to provide and maintain their motivation. This means the
examiner must also determine the appropriate response mode in order for the child to
reach, manipulate, and respond to a stimulus. The computer environment must be
structured accordingly.

While the computer and examiner are partners in the assessment process, the
computer's role must be perceived as one of augmenting the role of the "human"
present. The computer is capable of taking care of the chore of presenting tasks,
scoring answers and enables the examiner to make in depth observations about how
best to take advantage of the computer's flexibility in presenting information, offering an
alternate response mode and providing an appropriate amount of time in which to respond.

The ability to demonstrate knowledge has been a problem among children who are physically handicapped and nonspeaking. Lack of ability to demonstrate knowledge has influenced attitudes and caused low expectations. The computer is capable of structuring conditions which make students' responses more observable and identifiable. It was the "beep" response that created opportunities for the examiner to observe students' awareness of responses and recognition of incorrect responses. Student responses were displayed on the computer screen. Auditory feedback drew students' attention to the screen. They looked, searched for an effect and checked their answers. It was possible for both examiner and student to acknowledge that a response had been made, observe the resulting image on the screen and note if an answer was correct or incorrect. If the computer is capable of making responses more observable and allowing for a more precise interpretation of student responses, then it shows promise for progress in the assessment of these children. However, in order for the computer to remain useful, the examiner must recognize his/her role to be one of yielding continual, astute and sensitive observations about student responses and the nature of the conditions which best facilitate optimal performance.

This study revealed some intervening factors which appeared to have an important influence on facilitating optimal performance. Care must be taken to monitor the level of motor fatigue, give tasks at the appropriate level, provide practice at the task to be performed, increase familiarity with the keyboard, create student - examiner familiarity and rapport, reduce waiting intervals, give short assessment sessions, provide students with an appropriate response mode and provide appropriate time to view and respond to questions. To ensure that the examiner can take these factors into account, assessment sessions need to be distributed across a period time. Only an examiner familiar with the student can read the nonverbal behaviors of the student which may indicate fatigue, possible frustrations in communication, cognitive and motor
areas. It is also important to determine student skills which were evidenced but not credited by the computer. Examiners run the risk of over or under estimating students' abilities unless assessment sessions are carried out over an appropriate amount of time and the examiner is familiar with the student. Computers can augment the examiner's resources. The examiner needs to be able to see both the possibilities and limitations of the computer to create conditions which best facilitate the student's performance. Examiners should be well trained in making observations of students and make procedural variations which facilitate optimal performance from the student.

The data suggested that the Unicorn expanded keyboard helped the majority of children by meeting their limited response capacities. The Unicorn keyboard allowed subjects with uncontrolled and spastic movements to be given an assessment. Although the computer with the Unicorn expanded keyboard effectively provided a response capacity for some students, it was noted that in some cases, the board lacked enough sensitivity to register student responses. There was no mechanism which prevented students from accessing keys which they did not intend to activate. In order to make the Unicorn board accessible to students with a wide variety of needs, this assessment tool needs refinement. There may be several solutions to this problem. One solution may lie in refining the hardware. By creating a Unicorn board with the flexibility to provide keys with less sensitivity than others, it may be possible for the student with laboured movements to accidentally hit keys without activating them.

This group of subjects was unique. The members of the group were more different from one another than alike. A different claim is not likely to have been produced by a bigger sample. Both tool and approach need to be individualized - including the software which is used. Software needs to be developed which will allow for the heterogeneity of this population. Assessment tools need to be flexible allowing conditions to be adjusted to suit the diverse and fluctuating needs of these children. A feature which can be adjusted to suit the response rates of this population is needed to increase opportunities for these students to complete answers and provide correct
answers. If an adjustable feature were included that matched the task and criterion level for success to student ability, then conditions might be created which enable students of varying abilities to respond. It is important to include a practice session in the assessment process to ensure that students understand the "mechanics" involved in the task and in producing a response. Software should be developed which can create opportunities for students to become familiar with the keyboard overlay, practice the task, respond to questions, confirm their response, and change their response if needed (i.e. provide an erasure).

The field of computer based assessment offers promise in overcoming some of the difficulties currently associated with the assessment of physically disabled students. The computer has the potential to enhance conditions which facilitate the demonstration of students' abilities. The computer has the ability to provide flexible presentation and response modes. Part of the usefulness of computer based assessment rests in the computer's ability to provide examiners with increased opportunities for observation. To exploit this quality, examiners need to be able to anticipate the advantages which computer present while ensuring their limitations don't hamper the human powers examiners possess.

The computer did not match the ability of the examiner to be flexible and adapt or structure the assessment environment to meet the needs of the students on a continual basis. The intelligence of the computer was rigid and limited. It could not determine when to make fine adjustments or make sensitive observations about what kind of adjustments were appropriate. It is clear that it is necessary to be flexible and adjust the assessment environment instantaneously and continually to facilitate optimal performance among these children. Human intelligence is less rigid. It is more flexible and sensitive. Although the computer and human may work as partners in the assessment process, their roles are not equal. The power of the computer rests with the human. It is imperative that the examiner see the computer objectively so that the
computer's limitations do not also limit the powers and subsequent efficacy of the human assessor.

Limitations of the Study

Several variables were beyond control. Room size and time for the assessment session varied among the schools. A tightly controlled laboratory situation is needed in order to explore the benefits of the computer with more validity. Also, familiarity with the examiner was not possible and it is likely that this influenced the subjects' performance. The time subjects were able to spend with the computer based assessment tool was limited and only a short time was available for observation of the subjects in their classrooms. The tool itself included only a small number of assessment items. Subjects also varied in the degree of experience they had with technology prior to the study.

Limitations in funding and time severely constrained the number of times the assessment could be carried out with subjects. Accordingly, a thoroughly test of the effects of practice upon the performance of subjects was not possible. The cost and time involved in carrying out the study may discourage others from attempting to repleat a similar study. The low incidence of youngsters like these in this study and their dispersion is a major factor.

Language competence was not addressed in this pilot project. Undoubtedly, language development would affect the results.

The findings of the present study illustrate the difficulties of assessing children with severe speech and motor handicaps. The small numbers favour an ideographic emphasis (which is necessary for clinical work) but discourages efforts informed by the nomethatic impulse.
Suggestions for Future Research

Evenso, a large, province wide study would be helpful in further clarifying the exact benefits of assessment under different conditions using adaptive peripherals. Also needing further investigation is the influence of students' life experiences as well as computer experience on the assessment process. A study of the effect of providing practice sessions during assessment on the number of correct answers, level of keyboard familiarity and task familiarity would be helpful.

Ongoing evaluation of the impact of hardware and software features on instructional outcomes for students is needed. For this reason, research needs to evaluate the implications of using hardware and assessment software with students.
BIBLIOGRAPHY


Iacono, T. A. & Miller, J. F. (1989) Can microcomputers be used to teach communication skills to students with mental retardation? Education and Training of the Mentally Retarded. 24, 1, 32 - 44.


Appendix A. Sample Overlay
center overlay carefully with this edge flush to top of keyboard. Remove overlay from keyboard before using marking pens that bleed thru paper.

<table>
<thead>
<tr>
<th>BLANK OVERLAY: GUIDE MARKS ONLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Message File Name</td>
</tr>
<tr>
<td>User(s)</td>
</tr>
</tbody>
</table>

- p
- b
- f
- a
- n
- c
- s
- o
Appendix B. The Computer Based Cognitive Measure Form
Computer Based Cognitive Measure
Observation Form

Student's Name: ______________________ Date of Birth: ______________________

How does student show yes/no?_________________________________________
Exposure Time_______ Response Time________Nonspeaking? yes no
Wears glasses: Yes/No Best visual field: Right/Left
Wears hearing aid: Yes/No Best hearing side: Right/Left
Handedness: R/L/mixed On medication? Yes/No
Which? ______________________

Current mode of communication: _______________________________________

________________________________________

PRIOR COMPUTER EXPERIENCE:
Describe the environment in which the student spends the most time (classroom,
learning assistance centre etc.) ____________________________________________

Does the student use a computer in the classroom? yes no
For how long?_____mins./week.

Does the student use a communication device? yes no
For how long?_____mins./week.

What language functions does the student use? (requesting, clarifying, negating
affirming, etc.).

________________________________________

Does the student use a computer in the L.A.C.? yes no
For how long_____mins./week.

Name computer hardware with which student is familiar (incl. communication devices):

________________________________________

Does the student use:
conventional keyboard? yes no
mini keyboard? yes no
Unicorn keyboard? yes no
other expanded keyboard? yes no

If the student uses a computer, how is the keyboard positioned and how does the student use it? (left hand, in midline etc.).

If the student uses a computer, how is the monitor positioned?

Name the types of software with which the student is familiar.

---

**VISUAL PRESENTATION**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Yes</th>
<th>No</th>
<th>Max</th>
<th>Min</th>
<th>Vis</th>
<th>Vis and Aud</th>
</tr>
</thead>
<tbody>
<tr>
<td>Looks at examiner</td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis and aud</td>
</tr>
<tr>
<td>Looks at presentation on screen</td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis and aud</td>
</tr>
<tr>
<td>Looks around the room consistently</td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis. and aud</td>
</tr>
<tr>
<td>Smiles in response to screen</td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis. and aud</td>
</tr>
<tr>
<td>Shifts gaze from examiner to screen</td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis. and aud</td>
</tr>
<tr>
<td>Follows examiner's movements</td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis. and aud</td>
</tr>
<tr>
<td>Follows adult's visual line of regard</td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis. and aud</td>
</tr>
<tr>
<td>Points/gestures to screen presentation</td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis. and aud</td>
</tr>
<tr>
<td>Points/gestures to screen presentation and looks</td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis. and aud</td>
</tr>
<tr>
<td>to adult for confirmation</td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis. and aud</td>
</tr>
<tr>
<td>Shifts gaze between items on screen</td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis. and aud</td>
</tr>
<tr>
<td>Maintains attention to screen</td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis. and aud</td>
</tr>
<tr>
<td>Pauses (may look away) from</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>vis</td>
<td>vis. and aud</td>
</tr>
<tr>
<td>Action</td>
<td>Yes</td>
<td>No</td>
<td>Max</td>
<td>Min</td>
<td>Vis</td>
<td>Vis and Aud</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>-----</td>
<td>----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-------------</td>
</tr>
<tr>
<td>-screen presentation</td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis and aud</td>
</tr>
<tr>
<td>Student looks away from screen presentation</td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis and aud</td>
</tr>
<tr>
<td>Smiles, looks away from screen, laughs, expresses excitement when</td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis and aud</td>
</tr>
<tr>
<td>screen presentation appears</td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis and aud</td>
</tr>
<tr>
<td>Looks back and forth between expanded keyboard and screen</td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis and aud</td>
</tr>
<tr>
<td>Shifts gaze between examiner and expanded keyboard</td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis and aud</td>
</tr>
<tr>
<td>Loses place while looking back and forth between expanded keyboard</td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis and aud</td>
</tr>
<tr>
<td>Keeps place while looking back and forth between expanded keyboard</td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis and aud</td>
</tr>
<tr>
<td>Looks at hand while depressing cell on expanded keyboard.</td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis and aud</td>
</tr>
<tr>
<td>Turns away while depressing cell on the expanded keyboard</td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis and aud</td>
</tr>
<tr>
<td>Searches out an &quot;effect&quot; on the screen after depressing cell</td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis and aud</td>
</tr>
<tr>
<td>Appears to use verbal mediation (may whisper to self) in response to</td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis and aud</td>
</tr>
<tr>
<td>presentations when the following number of items are presented:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1__________</td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis and aud</td>
</tr>
<tr>
<td>2__________</td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis and aud</td>
</tr>
<tr>
<td>3__________</td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis and aud</td>
</tr>
<tr>
<td></td>
<td>yes</td>
<td>no</td>
<td>max</td>
<td>min</td>
<td>vis</td>
<td>vis and aud</td>
</tr>
<tr>
<td>---</td>
<td>-----</td>
<td>----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-------------</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>vis</td>
<td>vis and aud</td>
</tr>
</tbody>
</table>

**Check one.**

- Scans 2 __________
- Scans 3 __________
- Scans 4 __________

**photographs __________**
**line drawings __________**
**letters __________**

**VISUAL AND AUDITORY PRESENTATION**

- **Attends to examiner's voice**
  - yes
  - no
  - max
  - min
  - vis
  - vis and aud

- **Ceases activity when spoken to**
  - yes
  - no
  - max
  - min
  - vis
  - vis and aud

- **Turns head/eyes deliberately towards sound of**
  - digitized speech
  - yes
  - no
  - max
  - min
  - vis
  - vis and aud

- **Alerts and reacts to presentation of**
  - words.
  - yes
  - no
  - max
  - min
  - vis
  - vis and aud

- **Looks to adult in response to word spoken with digitized speech**
  - yes
  - no
  - max
  - min
  - vis
  - vis and aud

- **Maintains attention to sound source**
  - yes
  - no
  - max
  - min
  - vis
  - vis and aud

- **Points/gestures to sound source**
  - yes
  - no
  - max
  - min
  - vis
  - vis and aud

- **Points/gestures to sound source and looks to adult for confirmation**
  - yes
  - no
  - max
  - min
  - vis
  - vis and aud

- **Looks to sound source in anticipation of next word to be presented**
  - yes
  - no
  - max
  - min
  - vis
  - vis and aud

- **Pauses (may look away) from speech presentation**
  - yes
  - no
  - max
  - min
  - vis
  - vis and aud

- **Looks, smiles, may show excitement at speech presentation**
  - yes
  - no
  - max
  - min
  - vis
  - vis and aud

- **Appears to understand digitized speech presentation.**
  - yes
  - no
  - max
  - min
  - vis
  - vis and aud.
Looks to the source of auditory feedback after having depressed a cell

Looks back and forth between expanded keyboard and sound source

Listens for "click" to know when to release pressure from the expanded keyboard

Searches out an "effect" on the screen as a result of hearing the "beep" from the computer

GENERAL
Appears to listen for feedback (beep) from Unicorn after depressing cell

Knows to press Unicorn square again if no "beep" is heard.

Begins to respond before response time is up.

Often seldom never

Shows concern (grimaces, looks to examiner, stops hitting keys) when Unicorn beeps more than once per hit

Shows self correcting behavior in response to:

digitized speech beep from expanded keyboard screen presentation.

80
Student shows correction of error
when given visual presentation    yes  no  max  min  vis  vis and aud
Student shows correction of error
when given visual and
auditory presentation           yes  no  max  min  vis  vis and aud
Student shows awareness of response s/he has made
when given feedback about their responses through:
expanded keyboard beep  digitized speech feedback  screen presentation
yes  no  max  min  vis  vis and aud
Student adds extra items or changes previous response when response time
is longer than is needed to complete question
yes  no  max  min  vis  vis and aud
Student may grimace/vocalize/make body movements, look at examiner/screen
when response time runs out
yes  no  max  min  vis  vis and aud
Student looks to symbols on Unicorn as a cue to the right answer
(eg.to jog recall memory).
yes  no  max  min  vis  vis and aud
Check one. Repeats (using expanded keyboard) the following number of words:
2    _______ 3    _______  4    _______
Attempts question more than once    yes  no
Continues with question despite running out of time    yes  no
Smiles, vocalizes, responds affirmatively
when asked if s/he wants to continue __________________________yes  no
Smiles, makes eye contact when told of computer assessment    yes  no
Looks to screen in anticipation of next item/question    yes  no
Attempts question despite suspicion of previous incorrect answer    yes  no
Student looks at the screen when told to    yes  no
Student looks at Unicorn when told to  yes  no
Student does not attempt question until after screen presentation is gone  yes  no

**MOTOR MOVEMENTS**

Expanded keyboard is adapted using the following:

Angled?  yes  no
Keyguard?  yes  no
Positioned to the right?  yes  no
Positioned to the left?  yes  no
Uses right hand to press target on expanded keyboard  yes  no
Uses left hand to press target on expanded keyboard  yes  no
Uses both hands to press target on expanded keyboard  yes  no
Looks toward or aims to target a square even though action may not be completed  yes  no
Appears to use eyes to direct head toward screen  yes  no
Looks from screen presentation to hand  yes  no
Looks from screen presentation to arm  yes  no
Appears to “motor plan” next motor movement through scanning for next item on overlay  yes  no
Looks away before targetting next
“response square” on overlay yes no
Rests quietly between questions yes no
Movements from cell to cell become slower (after first one or two cells are pressed). yes no
Student does not have hit cell more than once for response yes no
Movements slow when moving past midline on overlay yes no
Shows no sign of needing to shift position to view overlay yes no
Student activates cells other than the target cell in responding yes no
Computer accepts last cell hit as response yes no

SUMMARY OF SCREENING FINDINGS
Student responds to:
photographs ______ line drawings ______ letters _______

Student responds most frequently to:
photographs ______ line drawings ______ letters _______

Under what conditions?________________________________________

MAXIMUM EXPOSURE-MAXIMUM RESPONSE TIME
Estimated number of visual items that are remembered consistently:
1 ______ 2 ______ 3 ______ 4 ______

MINIMUM EXPOSURE-MINIMUM RESPONSE TIME
Estimated number of visual items that are remembered consistently:
1 ______ 2 ______ 3 ______ 4 ______

MAXIMUM EXPOSURE-MAXIMUM RESPONSE TIME
Estimated number of items that are remembered consistently when visual and auditory stimuli are paired: 1 2 _______ 3 _______ 4 _______

**MINIMUM EXPOSURE-MINIMUM RESPONSE TIME**

Estimated number of items that are remembered consistently when visual and auditory stimuli are paired: 1_______ 2 _______ 3 _______ 4 _______

**VISUAL**

**MAXIMUM EXPOSURE -MAXIMUM RESPONSE TIME**

Appears to understand that pictures represent objects. yes no
Remembers last items only (when presented visually). yes no
Remembers first items only (when presented visually). yes no
Identifies (with consistency) Circle one.
Tends to remember all items but in wrong order given visual presentation of: yes no
Number of distractors student appears able to handle. Circle one: 1 2 3 4 5
Mistakes symbols that look similar eg. t,l. yes no

**MINIMUM EXPOSURE-MINIMUM RESPONSE TIME**

Appears to understand that pictures represent objects. yes no
Remembers last items only (when presented visually). yes no
Remembers first items only (when presented visually). yes no
Identifies (with consistency) Circle one.
Tends to remember all items but in wrong order given visual presentation of: yes no
Number of distractors student appears able to handle. Circle one: 1 2 3 4 5
Mistakes symbols that look similar eg. t,l. yes no
VISUAL AND AUDITORY

MAXIMUM EXPOSURE-MAXIMUM RESPONSE TIME

Mistakes words that sound similar eg. ball, doll.    yes    no
Tends to remembers last items only (when presented by the computer) yes   no
Tends to remember first items only (when presented by the computer) yes  no
Check one. Identifies with consistency :
photographs _________  line drawings ____________  letters ____________
Remembers all items (but in wrong order) given auditory presentation of:
photographs _________  line drawings ____________  letters ____________

MINIMUM EXPOSURE-MINIMUM RESPONSE TIME

Mistakes words that sound similar eg. ball, doll.    yes    no
Tends to remembers last items only (when presented by the computer) yes   no
Tends to remember first items only (when presented by the computer) yes  no
Check one. Identifies with consistency :
photographs _________  line drawings ____________  letters ____________
Remembers all items (but in wrong order) given auditory presentation of:
photographs _________  line drawings ____________  letters ____________

MISCELLANEOUS

What distractions were present?
Did the student appear to have difficulty following instructions (re test or otherwise)?
yes    no
What is the amount involved in producing a response for this student? (amount to be remembered, degree of movement available to him/her, degree of effort
How does the student respond when given **too much exposure**
time?

How does the student respond when given **too little exposure**
time?

What other factors appear to be influencing these
results?

How does the student respond when given **too much response**
time?

How does the student respond when given **too little response**
time?

What other factors appear to be influencing these
results?

How does the student respond when given auditory feedback from the computer for
his/her responses?

How does the student respond when given visual feedback from the computer for
his/her responses?

What other factors appear to be influencing these
results?

How does the student respond to **minimal** practice time:
in the Photograph Memory
section?

in the Photo Memory with Aud. Labels
section?
in the Letters section?

in the Letters with Labels section?

How does the student respond to **maximum** practice time:

in the Photograph Memory section?

in the Photo Memory with Aud. Labels section?

in the Letters section?

in the Letters with Labels section?

What other factors appear to be influencing these results?

How does the student respond when using other memory software?

How does the student respond when using other computer software?

Circle those that apply

Alerts especially to music

Alerts especially to animation

Alerts especially to software with purpose

Alerts especially to colour