CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

CYBERLINK:

COMPUTER ACCESS FOR PERSONS IDENTIFIED

WITH MULTIPLE DISABILITIES

A graduate project in partial fulfillment of the requirements

for the degree of Master of Arts in Special Education,

Moderate, Severe, and Multiple Disabilities

by

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ABSTRACT

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Data collected were from four subjects, identified with multiple disabilities, while they used a hands-free computer interface system called Cyberlink Brainfingers. They ranged in age from nine to twenty, attended one public special education school, and were restricted in their ability to access curriculum, communication, or leisure activities at the start of this study. The results of this study indicated that these subjects achieved effective switch and mouse access controlling the Cyberlink system. The subjects reached a level of expertise with the Cyberlink that allowed them to interact with a computer and operate software independently from the researcher. At the beginning of the study, the subjects were unable to create effective muscle control signals at their forehead, but by the end of the study, the subjects were able to effectively control the Cyberlink by using brainwave frequency signals at their forehead. During the course of the study, functional and behavioral changes were observed from the four subjects. Likewise, all four learned the Cyberlink Brainfingers system at the same rate even though the experimental protocol was designed to allow independent learning rates.

INTRODUCTION

The U.S. Census Bureau (2000) states there are sixty-five million children in the United States between the ages of five and twenty years. Over five million children have at least one type of disability, and within that group, there are over one million children who have two or more types of disabilities, impacting the quality of life and affecting their abilities to enjoy an independent lifestyle (The U.S. Census Bureau, 2000). These disabilities include cerebral palsy, skeletal deformities, vision and/or hearing loss, and health impairments, communication disorders, and/or developmental delays.

Children who have two or more disabilities are identified as having multiple disabilities. These children commonly are "…individuals with 1) mental retardation requiring extensive or pervasive supports and 2) have one or more significant motor or sensory impairment and/or special health care needs (Orelove & Sobsey, 1996, pg1)." Research suggests that children identified with multiple disabilities have the greatest need for extensive support for assistive technology services to limit barriers so the children can be active participants in society (Alliance for Technology Access, 2000; Doe, 2002; Downing, 1999; Light, Beukelman, & Reichle, 2003; Orelove & Sobsey, 1996).

The Individuals with Disabilities Education Act Amendments of 1997 (IDEA '97), mandates that all children with disabilities have the right to a free appropriate public education (20 U.S.C. '1401(2)). The children's public education must be customized to address their unique needs with supplementary aids and related services (34 C.F.R. §300.308(a)), to support their day-to-day instruction, as defined by their Individualized Education Program (IEP) (20 U.S.C. '1414(d)(3)(B); 34 C.F.R. §300.346(a)(2)(v)). The

IEP should also detail individualized assistive technology needs of the children to facilitate progress in the general education curriculum (*see* 34 C.F.R. §300.347 (a)(3)(ii) and (iii)).

In spite of the research and federal mandates concerning assistive technology, special education is lagging behind on the implementation and use of high technology computer hardware and software. Tinker 's (2001) research demonstrates this high technology lag in special education due to the need for specialized, non-standard hardware and software that is expensive to purchase and often difficult to learn and operate. Doe (2002), Downing (1999), Light, Beukelman, and Reichle (2003) support Tinker's findings and add that high tech assistive technology can also be more restrictive for individuals' with disabilities by limiting their advancement cognitively and socially. The technology is often slow or slows the individual's use of the equipment, limits choices, does not grow with the individual development, may not be used in many environments, and is often abandoned.

With all of the advancement in technology, I wondered if there was more available to persons identified with multiple disabilities that may not have been readily marketed to the public. During three years of personal research, attending technology conventions, making inquiries, and putting systems and devices into practice in the classroom with individuals with multiple disabilities, I began to look into an interface system that seemed to show particular promise. The system is called Cyberlink Brainfingers. This hands-free computer interface system, "brainfingers," appears to meet the assistive technology needs of individuals identified with multiple disabilities. Brainfinger system's performance seems not to be affected by involuntary movements; is

esthetically pleasing; can be used in many environments; is easily accessible; not too difficult to learn; can be expanded to meet the user's needs; and is not too costly in reference to the amount of access the system theoretically offers the user.

Before the study, I had six months to gain knowledge and skills with the brainfingers system and how it operates. During the learning process, I personally experimented with the system, tested it on friends and family to receive feedback from their experiences, and made an effort to teach its use to persons with one or more disabilities. Six months of testing led to the formulation of the following qualitative case study.

The purpose of this qualitative study was to ascertain if students, identified with multiple disabilities, would be able to achieve computer and software access by operating the brainfingers system. There is a great deal of research on the need for assistive technology for persons with disabilities, but very little on the application of high technology by persons identified with multiple disabilities. Due to this lack of research, it was necessary to examine brainfingers, a high technology system, could be taught to and used by persons identified with multiple disabilities to facilitate communication, curriculum access, and leisure activities.

CHAPTER 1

Review of Literature

The Alliance for Technology Access (2000, pg 29) states that computer access

enhances the quality of life of students' identified with multiple disabilities by permitting

them to operate software for learning "…to communicate without speech or sight, to

manipulate the environment with little or no physical dexterity, and the ability to

demonstrate cognitive abilities in nontraditional ways". The use of technology allows

students identified with multiple disabilities to be involved and progress in the general

education curriculum and participation in extracurricular and other nonacademic

activities as required by the federal law, IDEA '97 (Individual with Disabilities

Education Act, 1997).

Although, the federal law mandates that assistive technology supports and

services be provided in the classroom to support teaching strategies and student

participation, students identified with multiple disabilities have unique computer access

needs. Persons identified with multiple disabilities have two or more challenges such as

movement limitations affecting the ability to move efficiently and affectively; skeletal

deformities; hearing and/or vision loss; verbal communication deficits; seizure disorders;

medical problems; and/or developmental delays (Orelove & Sobsey, 1996).

Repercussions of this uniqueness can result in impeded computer access. Students

identified with multiple disabilities generally are unable to use or operate a conventional

computer mouse, keyboard, track ball, or joystick, as well as many of the marketed

assistive technology devices such as a touch window, alternative keyboard, a pointing

device, or voice recognition software. The ability to push a switch, no matter where it is located around the body, often proves to be impossible (Alliance for Technology Access, 2000; Downing, 1999; Orelove & Sobsey, 1996).

Yet, with all the advances in technology, computer access has not advanced far enough to be accessible to all. Universally designed computer technology is "the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized designs (The Center for Universal Design, 1997)." Computer companies are slowly developing and modifying their products to make computers more accessible in "…providing access – making products and services available to, and usable by, everyone, [and]…removing barriers (Moulton, Huyler, Hertz, & Levenson, 2002, pg 25)" to meet the needs of consumers who require assistive technology (Steinfeld, 1994; Tinker, 2001).

The definition of assistive technology is any item, piece of equipment, or product system, whether acquired commercially, off the shelf, modified, or customized, that is used to increase, maintain, or improve the functional capabilities of individuals with disabilities (The Technology-Related Assistance for Individuals with Disabilities Act of 1988). Accessible technology encompasses three elements; accessibility features, assistive technology products, and compatibility between the operating system, software, and assistive technology products (Moulton, Huyler, Hertz, & Levenson, 2002).

An investigation of assistive technology merchandise available for persons with disabilities revealed varied high technology computer hardware and software products designed to facilitate computer access for students identified with multiple disabilities. The *TouchFree Switch* (Riverdeep Interactive Learning Limited, 2003) is software, that

needs to be combined with a video camera and switch software, that registers small or large muscle movements in and out of a box on the computer monitor to trigger the computer to perform a task, and costs $250. The *Self-Calibrating Auditory Tone Infrared (SCATIR) Switch* (Michigan State University, 2003) is an experimental optical switch that works with a beam of light, and when broken by an eye blink, triggers the computer to perform a task, and costs $1,000.00. Based upon the researcher's appraisal of the product operations, these two systems were deemed to have problems with operation if a person has involuntary body movements because the involuntary movements will disrupt the systems. It was further determined that they both only operate their own specialized software, and the systems cannot be interfaced with any other system to provide universal computer access.

The following computer access systems use cameras and/or light sensors focused to a persons' head to operate the computer. The *Head Mouse* (Origin Instruments Corporation, 2003) offers mouse and keyboard operations using visual scanning and switch triggering by way of two camera sensors detecting head movements, and costs $1,800. The *Smart-Nav Hands Free Mouse* (NaturalPoint, Inc., 2001) costing $300 and *Tracker 2000* with *Series Bundle* (Madentec Limited, n.d.) costing $1,900 to $2,700, both use a reflective 'dot' on the forehead and a camera mounted above the computer monitor that reads head movements and converts the movement into mouse movements. The *Quick Glance Eye-Tracking System* (EyeTech Digital Systems, Inc., 2003) costing $4,000 and *The Eyegaze Communication System* (LC Technologies, Inc., 2003) costing $15,000 to $17,000, both use eye movement and a camera mounted below the computer monitor that is focused onto one eye to move the cursor on the monitor. Based upon the

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researcher's appraisal of the product operations, for both systems the user has to have head control without involuntary facial or head movements, and have good vision. The systems may be strenuous or difficult to learn. The systems may only operate with the companies' own software.

There are two companies that have developed wireless computer interface systems, by way of a headband and a transmitter, to operate computer functions and software without the use of one's extremities. The IBVA Technologies, Inc. (n.d.) system reads thought and emotional brainwaves, and the BioControl System (2003) reads nerve or muscle signals. Based upon the researcher's appraisal of the product operations, both systems have a wireless feature that incorporates a transmitter on a headband. If the person using the system has involuntary head movements and has limited head control, the transmitter will interfere with the person's movements and injury could occur. Also, these two systems are not user friendly due to the complexity of the software and can take a long time to learn.

A third system for computer access is the hands-free Cyberlink Brainfingers system. After investigating this system, as well as others, the preliminary findings suggest that the Cyberlink system would satisfy the needs of persons identified with multiple disabilities. Based upon the researcher's appraisal of the product operations, the Cyberlink system seems to be safe, easily learned, is not affected by involuntary body, facial, and /or head movements, or limited vision, offers specialized and universal computer and software access, and is relatively inexpensive and cost effective long term.

The Cyberlink Brainfingers User Manual (Brain Actuated Technologies, Inc., 2004) states that this interface system can operate a computer completely hands-free, that

head movement will not affect the system, that it will provide universal computer access, and that it can be used to operate commercial software when physical limitations interfere with computer operations. The cost of a Cyberlink system is $2,050. The Cyberlink hardware consists of a headband with three sensors and an interface box. The sensors in the headband detect facial muscle, eye muscle, and brain electrical signals at the forehead. The headband signals are amplifies, digitizes, and transmitted via an interface box and serial connection to the computer. The Cyberlink software decodes and displays the headband signal back to the user as eleven separate frequency bands. The frequency bands are referred to as "brainfingers". The eleven bands or brainfingers are selectively responsive to facial muscle, eye movement, and brain wave activity. These brainfingers are used to operate computer controls to move the cursor; to perform left and right clicks; to click-and-drag; to double click and differentiate computer program keystrokes and switch controls.

There are two research studies on the Cyberlink, which focus on the technical qualities of the Cyberlink technology. Also, there are many Web posted testimonials from persons with significant disabilities on how the Cyberlink enhanced their quality of life by giving them a way to communicate and universal computer access. There is nothing published about applying Cyberlinks educationally to give students, identified with multiple disabilities, computer access and the capability to operate commercial software.

 For this project it was hypothesized that students from the ages of nine to twenty, with multiple disabilities and attending one public special education school, would achieve computer access using the Cyberlink hands-free interface system to operate

software. It was further hypothesized that by having this access to computers the

students identified with multiple disabilities would enjoy a higher quality of life through

the operation of commercial software for learning, communication, and leisure.

CHAPTER 2

Methods

Subjects

The four subjects in these case studies are students attending the same public special education school. The subjects had been assessed in their academic and functional skill areas and were judged to be functioning intellectually at six to eighteen months of age, with an average attention span of thirty seconds, at the start of the project. This level of functioning is considered to be in the severe to profound range of mental retardation. The subjects were dependent for all of their physical, hygiene, and self-care needs. The four subjects experience restricted delayed, and unproductive physical movements and all have seizure disorders and medical issues.

The four subjects are comprised of two males and two females, are of Hispanic descent and living with their biological families. Subject A is a 9-year-old male and Subject B is a 12-year-old female. Both are English language learners and attend the researcher's special day classroom. Subject C is a 15-year-old male and Subject D is a 20-year-old female. Both are English only learners and attend special day classrooms separate from the researcher's classroom. In the past, both subjects have received instruction by the researcher in the researcher's classroom.

Physically, the four subjects are unique to one another. Subject A has spastic quadriplegia cerebral palsy with a head lag to the right, a long delay in the motor planning for arm and hand movement, and intermittent strabismus of the eyes. Subject B has a mixed type cerebral palsy of spastic quadriplegia and asymmetrical tonic neck reflex (ATNR) with a head lag to the left, and is unable to volitionally move her limbs.

Subject C has rigid choreoathetoid cerebral palsy with very little movement of the head that is positioned at midline, very little purposeful movements of his limbs, and intermittent strabismus of the eyes. Subject D has atonic choreoathetoid cerebral palsy with little head control, hand tremors, a long delay in the motor planning for arm and hand movement, and nystagmus, as well as intermittent strabismus of the eyes.

The school psychologist, the assistive technology professional, special educators, and California Children Services referred the subjects for this study. The prerequisites to participate in this study were that the subjects had to be identified as having multiple disabilities, be nonverbal but demonstrated ability to answer yes/no questions using facial expressions, blinking, and/or head nodding/shaking, and have shown indicators of eye-gaze use for pointing and/or making choices. The final requirement was that subjects had experiences with switches, computer with switch software, and voice output communication devices. None had meaningful access to switch devices to facilitate communication, curriculum participation, or leisure activities.

Setting

This pilot program was conducted in the morning, twice a week, over an eight-week period in the researcher's classroom. Procedurally, the subjects worked individually with the researcher in fifteen-minute increments. As the subjects became more proficient with the Cyberlink and were able to focus their attention for longer periods of time, the researcher faded the 1:1 instruction so that the subjects developed independence with the system. Operation time was increased up to one hour, twice a week.

Materials and Reinforcers

The materials used in these case studies were two large screen laptop/notebook PC computers with Windows 2000 or XP; two Cyberlink systems that included two headbands and three sensors affixed on each; Cybergel that moisturized the skin where the sensors touched the forehead; two interface boxes which transmit the forehead signals to the computers; and the Brainfingers software.

A wide variety of third-party computer software that ranged from very simple and specialized that taught "cause-and-effect" awareness and choice making, e.g., *Soft Touch, Inc.*, *Inclusive Technology LTD.*, *Sensory Software International Ltd.*, to "over-the-counter" or universal software that utilized mouse operations to explore and/or perform software functions, e.g., *Mayer-Johnson, Inc.*, *Gus Communication, Inc.*, *IntelliTools, Inc.*, *Laureate Learning Systems, Inc.*, *Crick Software*, *Inc.*, *Disney Interactive*, *The Learning Company School Division*, *Microsoft Corporation*, *Davidson & Associates, Inc.* This variety of software reinforced the training with the Cyberlink software, created the incentive to continue learning the system, and was adaptable to the subjects' proficiency operating the software.

CHAPTER 3

Procedures

Research Design and Instruments

This single subject design case study investigated the functional changes
exhibited by the subjects operating computers with the Cyberlink. A tally sheet and field
notes were utilized to perform a content analysis. Descriptive data were collected each
time the subjects operated the Cyberlink to document their interactions with software,
progress, and obstacles hindering their performances. Additionally, each subject was
videotaped within the eight-week period for comparison of his or her progress at the
beginning, middle, and end of the study.

The focus of this pilot program was on switch control, mouse/cursor direction
manipulation, and mouse/cursor direction controls with left click, to operate software.
Success was measured by the subjects' ability to do any of the following:

1. Control of switch operations to produce "cause-and-effect" outcomes in
   software programs, e.g., turning the pages of a computerized storybook or to
   state a single message;
2. Control of switch operations to make choices, using visual and/or auditory
   scanning applications featured in specialized software, e.g., a highlighted box
   moving from "YES and NO." A question is asked, and the subject actuates
   the switch utility to answer the question when the choice is highlighted;

3. Control the mouse operations by directing the on-screen cursor (the arrow) to the intended targets on the screen;

4. Control the mouse operations by directing the on-screen cursor to the intended target on the screen and then left click to perform software functions;

5. Employ mouse cursor controls and left clicks to operate conventional software.

Internal Validity

The internal validity of this case study had threats that altered the conditions under which this case study is conducted. The subjects' characteristics threatened this case study by their potential refusal or the lack of motivation to operate the Cyberlink. For this reason many software choices were made available to stimulate and influence the subjects' desire to continue operating the system.

There was the ever-present threat of mortality of the subjects missing days during the case study time period due to illness, medical appointments or absences; change of medication; or an increase in the subject's seizure activity. Health issues were unavoidable and potentially threatened the case study, but doctor appointments and absences were avoided by scheduling the subjects' visits to the researcher's classroom and informing the parents of the schedule so that these potential threats could be minimized.

Another threat to the internal validity of the case study was the risk of performance regression by the subjects operating the Cyberlink. To determine if a pattern of regression was developing, field notes were utilized and examined each time

the subjects operated the system. Another threat to the internal validity of the case study was the potential for mechanical break down of the computer or the Cyberlink. The researcher avoided this problem by utilizing three computers and three Cyberlink systems.

Operational Definitions

As shown in Figure 1, the Cyberlink has many elements that require clarification. The hardware consists of three sensors attached by snaps to a cloth headband, which plugs into an amplifier. The amplifier is connected to a laptop/notebook computer. Before placing the headband around the head, each of the three sensors requires a dab of moistening with a Cybergel. Once moistened, the three sensors need to be centered on the forehead and the headband loosely secured around the head with the Velcro fastener.

Following the attachments of the hardware and activating the Cyberlink, a screen appears with moving multicolored bar graphs, as shown in Figure 2. These bar graphs result from the Cyberlink software deciphering and digitizing the electrical muscle and brain wave signals from the headband and displaying the brainfingers as eleven colored bars on the computer screen. Displayed from left to right, the first three blue bars display frequency changes that are primarily sensitive to eye muscle activity such as left/right glances of the eyes. The next three green bars display frequency bands of alpha brain wave activity. Typically these alpha brainfingers increase as the brain becomes 'quiet or still.' The next four red bars display beta brain wave activity. Typically an increase in beta results when the brain is 'excited'. The eleventh brainfinger displays facial muscle activity at the forehead, it is displayed as a yellow bar in the software.
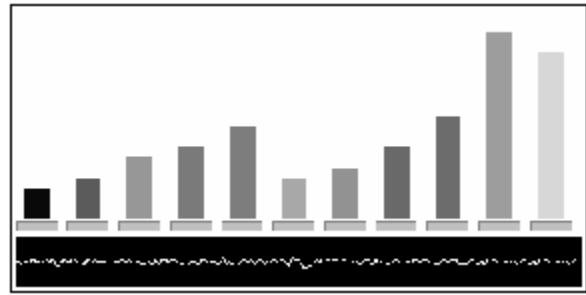
Figure 1	Figure 2
	Brainfingers Frequency Band Display

Note. From brochure "Cyberlink Brainfingers Hands-Free Computer Interface: Bringing the Gift of Hand-Free Access to the World," by Brain Actuated Technologies, Inc., 2004. Copyright 2004, Adapted with permission from Andrew M. Junker, C.E.O.

Fundamentally, it is these frequency bands that allow one to operate the computer functions to provide switch access and mouse control. These frequency bands can be customized to improve the link between subjects and their operations of the computer. This link is customized by mapping effective frequency bands to mouse and keyboard functions, by increasing or reducing the strength of the subjects' signals coming into the computer and by increasing or decreasing the sensitivity of the brainfinger response to the subjects' effort to generate these signals. Once an effective and efficient link is determined and adjusted, the Cyberlink can be employed to operate the computer hands-free and/or operate third-party software.

Teaching Strategies

The teaching strategies for instruction, support, and redirection varied depending on the subjects' individual needs, and were often combined. Approaches used were

modeling, direct verbal instruction, indirect verbal instruction, pointing, choice making, and trial and error applications, and praise for effort and accomplishment.

Modeling the Cyberlink Brainfingers interface system was briefly utilized the first time the subjects were introduced. The researcher showed and talked about the headband, put it on and played 'Pong,' a game in which the subject controls one paddle while the computer controls the other. Scores are made when the ball passes by the opposing side's paddle. This modeling of wearing the system was conducted to minimize the subjects' fears and apprehensions, make evident that the headband would not cause pain or discomfort, and to generate interest to try the system.

Likewise, modeling was utilized throughout the study by way of the researcher manipulating the cursor with the touch pad on the laptop/notebook to show the subjects where to move the cursor for training purposes. For example, while manipulating the cursor on screen, the researcher pointed to the screen and stated, "This thing moving on the screen, this arrow, it's called a cursor. Can you move the cursor to the …" and the researcher moved the cursor to the target, then returned the cursor back to its' initial position. Then the researcher verbally instructed, "Now it is your turn. Move the cursor to the …."

Direct verbal instructions were used for teaching purposes, as well as to do adjustments to the operation signals, e.g., relax, move the cursor to, etc. Incorporated with the direct verbal directions, when necessary, the researcher used pointing prompts to the computer screen to guide the subjects' cursor directional movements. The use of indirect verbal instructions were employed to observe if the subjects were knowledgeable

of the implementations, e.g., "How do you exit the program?" and to redirect them back to task, e.g., "Show me what you are working on."

Praise for efforts was utilized to generate interest and motivation by the subjects to learn the system, to decrease the subjects' insecurities and failure anxieties, and to minimize learned helplessness. As the subjects became more proficient, confident, and independent with the system, praise decreased. Also, with their increased abilities to operate the Cyberlink, opportunities to make choices of desired software to operate was made available.

The trial and error approach permitted the subjects to experiment with the system to discover their technique of access with the system. In the beginning, the training in the Brainfingers software and the software applied with the system, the subjects were successful. However, as the subjects learned how to control the system and apply it to software, they had opportunities to be unsuccessful to discover different methods and approaches, problem-solve, and to learn software applications.

Implementation

Introduction Day

This pilot program began with the subjects being introduced to the Cyberlink and subjects trying it. Each subject had two fifteen-minute sessions in the researcher's classroom with the researcher. The first session, the subjects were videotaped being asked by the researcher to turn on a radio by way of a switch, and were timed, to examine how efficiently and effectively they could do the task. The second session was to generate the subjects' enthusiasm and motivation to learn the Cyberlink by briefly

introducing the system through the modeling teaching strategy, as well as to give the

subjects an opportunity to direct and control the system.

Moreover, this introduction gave the researcher a chance to set the subjects'

preliminary frequency band baseline within the Brainfingers software utilizing the

Brainfinger window and the 'Grow Game' window. By observing the frequency bands

on the screen, the researcher was able to uncover which frequency bands could be

utilized for various computer functions. The following are facial behaviors the subjects

were to perform and how it was to be achieved to form the signal baselines.

Relax -
The subjects were directed to relax or to "Make the color bars go down."   If the
subjects were unable to perform the action, then the 'Grow Game' was
implemented to teach relaxation by directing the subjects to "Make the circle
show up. Now make the circle go away."

Stare –
By placing a motivating object in front of the subject at eye level and directing the
subject to look at it, e.g., a small brightly colored Koosh Ball that is lightly shaken
to keep attention briefly.

Look Right and Look Left –
The researcher, while twiddling fingers to the right or left side of the screen,
directed the subjects to look at the fingers.

Close eyes -
The subjects were directed to close their eyes. If unable to follow the direction,
the researcher placed a hand over their eyes, which then facilitated the subjects to
close their eyes.

Lift eyebrow –
The subjects were directed to lift their eyebrows. If unable to follow the
direction, the researcher would gently lift their brows and release, and then
request the subject to "Lift your eyebrows."

Bite –
The subjects were directed to bite as if they were eating.

Clenching jaw -
The subjects were directed to pretend that they did not want to eat.

Finally, the subjects played the Brainfingers' 'Brain Candy' game. In this game the subjects gained knowledge of simple "cause-and-effect" relations with visual and auditory feedback. These games enabled the subjects to discover that their facial actions created a reaction on the computer screen that was observable by both the subject and the researcher.

Day 1

The first day of this pilot program, which was videotaped, was the day for the subjects to actuate the Brainfingers software for computer access, for the researcher to shape the baseline for access, and to generate and encourage the subjects' motivations to learn the system. The subjects began learning how to click as if using a single switch, or the left click of the mouse. The facial muscle signal was the first frequency band employed because it was the easiest signal for the subjects to maneuver and control, for the researcher to provide instruction in its use, and is observable on the subjects' faces. The Brainfingers 'Switch Setup & Practice' training software has an algorithm display. When the signal passes above a certain level on the algorithm display created by the subjects, it generates a click, and a 'bing' sound. If the subjects were unable to generate a click or had many false clicks, then adjustments were made to increase or decrease the intensity and the sensitivity of the signal.

Once the initial facial muscle signal was established, the subjects played the Brainfingers' 'Click Game.' The objective of this game is to click when a large colored box appears on the screen. When clicked, with the auditory feedback of a 'bing' sound,

the colored box disappears and another large colored box appears somewhere else on the screen. The researcher utilized the teaching strategy of modeling, verbal instructions, and as needed, cues to "click" to instruct the subjects. Also, this game gave the researcher an opportunity to fine-tune the click signal.

After the researcher established the clicking signal, continuing with the facial muscle signal, the subjects managed the signal in the Brainfingers 'Grow Game' to create baseline and sensitivity signals of muscle activity for up/down actions on the computer screen. When the subjects raised their signal levels above the baseline, a ring of colored circles would appear on the screen with auditory feedback. When the signal went below the baseline, the colored circles would disappear and no sound was produced. Likewise, operating the same game, the subjects learned how to use left and right eye glances to produce circles and auditory feedback. The researcher utilized the teaching strategy of verbal instruction and praise to instruct the subjects. Also, this game presented opportunities to adjust the intensity and the sensitivity of the signal.

When a baseline was established in the Brainfingers 'Grow Game,' it was time for the subjects to play the game 'Pong' within the Brainfingers software using the subjects' up and down muscle signal. The goal of 'Pong' was to create a desire by the subjects to continue learning the system so that they could play games. The researcher applied verbal instruction, pointing, and praise to instruct the subjects in the game. The trial and error approach was also utilized to offer the subjects opportunity to attempt the game on their own. Also, the paddle and ball were enlarged to maximum, the movement of the ball was slowed and the game ending score against the computer was reduced to eight. Pointing to the subject's paddle, the researcher directed the subject to "Move that paddle

like you did to make circles." When the paddle was moved, the subjects were told, "That is you moving the paddle. When you see the ball going to your paddle, try to stop the ball with your paddle." The same procedure was applied when instructing the subjects on how to play 'Pong' utilizing their left and right eye glances.

The final step of the first day to engage and motivate the subjects to operate the Cyberlink system was to give the subjects some cursor control. The subjects played 'Easy Maze' and 'Labyrinth' in the Brainfingers software. The teaching strategies used were verbal directions, modeling, pointing, and a trial and error approach. The researcher moved the cursor, pointed to the screen, and stated "This thing moving on the screen, this arrow, it's called a cursor. Can you move the cursor to the sun or the house?" as the researcher pointed to the sun and house. Then the researcher observed to see what would transpire in the subjects' efforts.

Day 2

The foundation was set on day one to provide control on day two to operate single switch software, which was videotaped. All of the subjects knew the software and had experienced employing a single switch to a computer, but they were not proficient or successful implementing a single switch in previous attempts. This was observed by the researcher as the subjects tried and failed to operate the software due to their ineffective and slow motor responses.

Included in the Brainfingers software is a 'Launch' window that permits hand-free control of the computer and the operation of third party software. Mapping and configuration of Brainfingers to mouse and keyboard events is through Launch Buttons.

One of the buttons called 'Switch Control' was selected and activated giving the subjects switch control of the computer by way of the headband connections.

The researcher offered the subjects choices of software to operate, but in a systematic progression, to establish the 'cause-and-effect' relationship. The switch software offered was the *SoftTouch, Inc*. Switch Basics (2002), Teach me to Talk (2002), and Teen Tunes Plus (1998); the *Inclusive Technology, Ltd.* SwitchIt Bundle (1999), Drumkit (2001), and SwitchIt Gadgets (1999); and the *Sensory Software International Ltd.* Single Switch Connection (2002).

In view of the fact that the subjects were already familiar with the software, no instruction was needed to teach them how to operate the software. Similarly, the switch software has its own computer generated cues to guide the subjects to click. These cues are either visual, e.g., a hand touching a switch or a switch appears on the screen, and/or auditory cue, or auditory, e.g., a clicking sound or voice cue such as "push the switch." In addition, the subjects did need an occasional verbal prompt to 'click,' or make the computer go 'bing,' to redirect the subjects' attention back to the computer.

Once the subjects were able to control switch operations with the Cyberlink to produce 'cause-and-effect' outcomes, the switch access training to make choices was started. Prior to this case study, the subjects had been given opportunities to make choices from two or more visual objects by looking at their choice, by answering yes/no questions to auditory choices, and had experience operating software, by way of a switch, to make choices from two or more options utilizing visual and/or auditory scanning. But, they were unsuccessful in these endeavors. Visual scanning is an option in certain software that highlights, or boxes, an object on the screen for a few seconds then moves

to the next object. Auditory scanning is an option in certain software that states what is being highlighted or boxed.

For example, the SwitchIt Bundle has a series called Opposites that can be designed with two to three choices to be scanned visually by a colored box around the object scanned. If working on the opposites of "large and small" by way of three choices, a large ball and two small balls could be displayed on the screen. A computer-generated voice states, "Which is large" and then a square bounces from each ball. When the square is on the correct choice and the subject clicks, a monster character reinforces the correct choice with auditory feedback. If the choice is incorrect, the monster character shakes its' head 'no' with auditory feedback. Similarly, many voice output communication devices and communication software have visual and/or auditory scanning capabilities. If a desired pictorial/auditory/print word or sentence choice is highlighted and/or stated and the switch is triggered, that which was chosen is verbalized aloud to provide a listener a message.

The subjects were instructed as to how to operate the programs and its' scanning design to make choices. Through trial and error, verbal directions, occasional verbal prompts to make a choice, and pointing prompts, the subjects made choices using visual and/or auditory scanning applications featured in specialized software. The researcher selectively offered choices of programs to the subjects based on their prior abilities operating scanning software. Switch software offering visual and/or auditory scanning characteristics that can be obtainable by a switch and setup to be controllable with Brainfingers, was presented for preferences to the subjects. The software was the *SoftTouch, Inc*. Teach me to Talk (2002), Teen Tunes Plus (1998), and Switch Basics

(2002); *Inclusive Technology, Ltd.* Drumkit (2001), Disco (2000), SwitchIt Gadgets

(1999), SwitchIt Bundle (1999), and SwitchIt Arcade Adventure (1999); and the *Sensory*

Software International Ltd. Single Switch Connection (2002).

Day 3

The third day of this pilot program was the day for the subjects to actuate the

Brainfingers software for cursor control and to shape a baseline of access. The 'Cursor

Setup Two Axis Pointing' window was used. This window combines two frequency

bands to operate up/down and left/right axes to maneuver a cursor on a blue screen. The

meaning of *axis* is the separateness of using the facial muscles, eye movements, or alpha

and beta brain waves to direct a cursor on the screen. When the axes are combined, the

cursor can be maneuvered in a way comparable to using a hand mouse to maneuver the

cursor.

The objective of the Two Axis Pointing window is to fine-tune the up/down and

left/right signal adjustments, as well as for the subjects to practice moving the cursor

around the screen. The researcher placed a glittery happy face sticker on a brightly

colored post-it and placed the post-it on the computer screen. Then the researcher

instructed the subjects to move the cursor to the post-it or the happy face. When the

subjects were able to maneuver the cursor near, or touch, the target, then the subjects

played the Brainfingers' 'Easy Maze,' and the 'Labyrinth' mazes, where they

maneuvered the cursor around the mazes to one of the two targets on the screen. When

needed, the researcher pointed and verbally directed the subjects "Take the cursor to the

house or sun." Otherwise, the subjects maneuvered the cursor through the mazes by way

of the trial and error approach.

Day 4

The foundation was set on day three for cursor maneuver control. In the Launch window, the button called 'Mouse Control' was activated and the launch button triggered giving the subjects cursor maneuver controls of the computer by way of their Cyberlink headband. Practicing with the product templates within the following software, the researcher verbally directed the subjects where to move the cursor on the screen with as needed pointing prompts to facilitate their learning. The software offered to the subjects was the *IntelliTools, Inc.* IntelliMathics (2001) and IntelliPics Studio (2001), and the *Crick Software, Inc. C*licker 4 (2001).

After working with the curriculum access software, and being directed what to do, the subjects were given the opportunity to operate the software independently, as well as review their Cyberlink clicking skills. The launch button called 'Switch Control' was selected to give the subjects this switch control.   Acquainted with the storybook software from watching and listening to the stories, as well as the subjects' prior history of attempting to turn the pages of the stories with a switch, direct instruction only was minimal needed. The researcher activated the story and manipulated the cursor on the screen to the icon that turned the pages forward. When the first page being read aloud was completed, the subjects were instructed, "Now, click and go to the next page," and then the subjects were to continue turning the pages of story through trial and error.

The underlying principle of this approach was to explore if and when the page was concluded, if the subjects were attentive to the natural cue when there was no stimuli coming from the computer, to click to continue the story. The software offered to the subjects was the *Disney Interaction* animated storybooks of "The Lion King" (1998);

"Pocahontas" (1995); "Winnie the Pooh and the Honey Tree" (n.d.); and "101

Dalmatians" (n.d.) and *The Learning Company School Division* Living Books Collection

of Dr. Seuss's "Green Eggs and Ham" (1998) and "A B C" (1995); Marc Brown's

"Arthur's Birthday" (1997), "Arthur's Computer Adventure" (1998), and "Arthur's

Teacher Troubles" (1994); Mercer Mayer's "Just Grandma and Me" (1993), "Just Dad

and Me" (1996), "Just Mom and Me" (1996), and "Little Monster at School" (1994);

Aesop's Fable's "The Tortoise and the Hare" (1993); Janell Cannon's "Stellaluna"

(1996); and Tomie dePaola's "The Art Lesson" (1998).

Day 5

The fifth day of this pilot program was for the subjects to attempt to actuate the

Brainfingers software for cursor directional control, combined with left clicking. The

'Mouse Set-Up' in the Brainfingers software was utilized as a training tool and used to

shape the baseline of access for each subject. The researcher placed the glittery happy

face sticker on the brightly colored post-it on the computer screen and instructed the

subjects to move the cursor to the post-it and click, or make the 'bing' sound. This

training session encouraged the subjects to attempt the mouse capabilities of the

Cyberlink.

Recognizing that the subjects were not adept in their cursor maneuvers, and

needed refining in their signal adjustments, the researcher had the subjects play the

Brainfingers 'Acquire Game.' This game was programmed by the researcher to work on

single axes of either up/down or left/right cursor movements. The objective of the

Acquire Game, using a trial and error approach, was for the subjects to touch a black box

with the cursor. Each time the box was touched, the box disappeared and another black

box appeared somewhere else on the screen. The goal was for the subjects to make contact with the boxes ten times, designed for either the up/down or left/right cursor movements.

Day 6

Based on the day prior, the researcher determined that the subjects' lacked ease with cursor maneuverability, and needed their frequency bands for up/down and left/right signals remapped and adjusted. As the subjects operated the single axes of the 'Acquire Game,' using 'touch point,' the researcher made modifications. After making adjustments to the single axis signals, the subjects practiced maneuvering the cursor using both the up/down and left/right axes in the Acquire Game. The intent, using the trial and error approach, was for the subjects to touch the cursor to a black box on the screen. Each time the box was touched, the box disappeared and another black box would appear at another point on the screen. The goal was for the subjects to make contact with the boxes ten times using both the up/down and left/right cursor movements, as if physically moving a computer mouse.

Continuing the training of the single axis of up/down and left/right, the subjects played 'Pong.' The subjects played, without instruction or cues, and the researcher observed to see if the new signals were more effective or if another frequency band was needed for cursor maneuverability.

Likewise, the subjects' clicking aptitudes were remapped and adjusted due to the continual false clicking affecting their software performance. Ensuring the clicking adjustments were adequate, the subjects briefly practiced clicking operating Brainfingers Switch Setup & Practice window.

Day 7

Building on the foundation set on day six for cursor maneuver control and left click, the button called 'Mouse Control' was activated and the launch button triggered so that the subjects had cursor maneuver control and left click control. Practicing with the product templates within the following software, the researcher verbally directed the subjects where to move the cursor on the screen with as needed pointing prompts, as well as offer opportunities for the subjects to utilize the trial and error approach to explore the pictorial pages for communication purposes. The communication software with voice output used was the *Gus Communication, Inc.* Gus Multimedia Speech System (2002) and *Mayer-Johnson, Inc.* Speaking Dynamically Pro (2003).

Within the software when the cursor touched a picture, the picture was voiced and highlighted. For example, if the subject maneuvered the cursor to a picture of a school bus and touched the picture, the software would highlight and state "school bus." Then, if the school bus picture was clicked on, the software would either state, "Is it time to go home?" or it would open another window of pictorial choices like a house and a school and if clicked upon, these would state "Is it time to go home?" or "Is it time to go to school?" Hence, the subjects got the opportunity to use two methods of employment for communication purposes.

Day 8

The eighth day was the mid-point of the pilot program and the subjects were videotaped. The subjects continued to practice with the communication software. The researcher would either verbally direct the subjects to maneuver the cursor to a particular pictorial, or the researcher would ask a question and the subjects would attempt to answer

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by way of the communication software and the Cyberlink. The subjects continued to have the two approaches of access to utilize for communication purposes; maneuvering the cursor to scan pictorials with voiced meaning and left click on the pictorials to generated a statement.

Day 9

Prior to day nine, the researcher's focus was to establish the fundamental groundwork with the Cyberlink for the subjects to have computer control to operate specialized software. This was accomplished and it was time to move on to develop the subjects' cursor directional controls and left click.

In the Brainfingers software is a game called 'Cellar' that fosters the understanding of universal software. It gives the impression of being a video game, but it is actually a training tool to further augment cursor controls and click functions. The researcher utilized the teaching strategy of verbal instructions accompanied with modeling, occasional verbal encouragement to "keep on trying," and praise for effort.

The objective of the Cellar game is to move the cursor, which is a hand, to one of many bottles and click to pick up a bottle. Once a bottle is in the hand, the hand needs to be moved to an empty space on a wine rack. When the bottle is over the empty space in the wine rack, if the subject clicks the hand will put the bottle into the wine rack. If the subject clicks before the bottle is over the empty space in the wine rack, the bottle falls to the floor and breaks.

Day 10

The researcher modified the teaching strategy. The subjects' went from working separately with the researcher to small groups of two. This was done so that the subjects

could observe each other operating universal software for modeling and motivation purposes. Likewise, the researcher determined that the subjects needed to apply the cursor maneuvers and left click to software that was interesting, stimulating, and more age appropriate to encourage and challenge the subjects to aspire to new experiences. In the Launch window, the button called 'Mouse Control' was activated and the launch button triggered so that the subjects had cursor maneuver controls and left click. The choices of software the subjects operated, for ages 6-10 years, was the *Microsoft Corporation's* Scholastic series of The Magic School Bus Explores (2000) of "Inside the Earth," "In the Age of Dinosaurs," "The Ocean," and "The Rain Forest."

The 'Magic School Bus' software gave the researcher an opportunity to observe how the subjects interacted to the experience of using the Cyberlink system to operate universal software. The teaching strategy utilized by the researcher incorporated pointing prompts with verbal directions, as well as a trial and error approach.

Day 11

Based on the day prior, the researcher determined that the subjects' lacked ease with their left/right cursor maneuverability and adjusted their signals, as well as the speed of the cursor movement on the screen. Going back to 'Mouse Set-Up,' the researcher made the adjustments and modification. Following the revisions, in the Launch window the subjects practiced the changes using specialized software from Laureate Learning Systems called "The Language Activities of Daily Living Series (1997)." This software permitted the subjects to utilize their mouse maneuvers and clicking skills, as well as become familiar with how to explore pages to operate the software. The researcher

utilized the teaching strategy of verbal directions, as needed pointing prompts, and a trial

and error approach.

Day 12

Using the foundation set on day eleven, cursor maneuver control and left click to

explore pages of software was undertaken. In Launch, the button called 'Mouse Control'

was activated and the launch button triggered so that the subjects had cursor maneuver

controls and left click. The researcher began the subjects operating switch software to

practice maneuvering the cursor to targets and left clicking. The switch software gave

the researcher the ability to modify the programs by enlarging the target sizes and the

numbers of targets. Likewise, due to the subjects' aptitude to operate the software

independently the researcher had the opportunity to examine the subjects' software

operation and choice making proficiencies. The software offered to the subjects was the

Inclusive Technology, Ltd. Drumkit (2001), SwitchIt Bundle (1999), and SwitchIt Arcade

Adventure (1999).

Afterwards, the subjects had choices from the following universal "Living Books"

software to practice their mouse functions. The researcher utilized the teaching strategy

of the trial and error approach, with occasional instructions from the researcher such as;

"click here and see what happens." The software offered to the subjects was *The*

Learning Company School Division Living Books Collection of Dr. Seuss's "Green Eggs

and Ham" (1998) and "A B C" (1995); Marc Brown's "Arthur's Birthday" (1997),

"Arthur's Computer Adventure" (1998), and "Arthur's Teacher Troubles" (1994); Mercer

Mayer's "Just Grandma and Me" (1993), "Just Dad and Me" (1996), "Just Mom and

Me" (1996), and "Little Monster at School" (1994); Aesop's Fable's "The Tortoise and

the Hare" (1993); Janell Cannon's "Stellaluna" (1996); and Tomie dePaola's "The Art Lesson" (1998).

Day 13 – 16

The final four days of this pilot program were scheduled for the subjects' to perform software exploration and increase their independence operating universal software. The thirteenth day, the subjects continued developing their independence operating and exploring the "Living Books" software. The subjects then attempted to operate unfamiliar early educational software. The choices of educational software the subjects were offered were; *The Learning Company School Division* Reader Rabbit Educational Programs of "Toddler" (1998) and "Reading Development 1 Library" (1997), and "Zoboomafoo Animal Alphabet" (2001); *Davidson & Associates, Inc*. Fisher-Price's "Little People Discovery Farm" (1997), "Sing Alongs Barnyard Rhythm & Moos" Volume 1 (1995), and "Ready for School – Kindergarten Edition" (1996); and the *Microsoft Corporation* Playskool's "Puzzles" (1995) and "Play-Doh Creations" (1995).

The researcher utilized as needed verbal instructions, modeling, pointing prompts, and a trial and error approach. On the sixteenth day, the subjects were videotaped.

CHAPTER 4

Narrative Results

Descriptive and tally data were collected each time the subjects controlled the Cyberlink. The data were organized to display the subjects' daily accomplishments, their software interactions, and obstacles hindering their performances to manage switch applications, mouse/cursor direction maneuvers, and mouse/cursor direction control, with left click to operate software. These results are presented in Chapter 5.

The daily observation provides details about the experiences that contributed to the progress of the subjects and the researcher's conclusions. These observations are presented below.

Introduction Day

During the first fifteen-minute session the subjects were timed and videotaped being asked by the researcher to turn on a radio by way of a switch. The purpose of this was to examine how efficiently and effectively they could accomplish the task. The subjects had much difficulty coordinating their bodies to trigger the switch to activate the radio to play.

> Subject A's motor response was delayed a minute and-a-half before he was able to lower his arm to trigger the switch.

> Subject B's right foot is the only limb that has purposeful movement. However, her motor response was delayed four-and-a-half minutes before she could lower her foot to trigger the switch.

> Subject C has impaired movement throughout his body. He struggled to trigger the switch with his head and after several adjustments to the head switch; he

finally was able to trigger the switch once. But the switch became wedged in the headrest of his wheelchair.

Subject D attempted to trigger the switch with her left hand but was unsuccessful and her attention shifted. When her left hand was placed on the switch, she continuously tapped her hand on the switch without purpose.

The second fifteen-minute session produced the subjects' enthusiasm and motivation to learn the Cyberlink in conjunction with providing the subjects the opportunity to direct and control the system. Concurrently, the researcher adjusted the baseline of the subjects' facial muscle signal while the subjects performed directed facial behaviors of relaxing their face, staring, looking right, looking left, closing their eyes, lifting their eyebrows, biting, and clenching their jaw. Through the teaching strategies implemented, all four subjects were able to perform to the researcher's instructions and a facial muscle signal was obtained, together with possible signals for other computer functions.

After performing the facial behaviors, the subjects played the Brainfingers' 'Brain Candy' game. All four subjects played the game effortlessly and performed distinct events on the computer screen. Likewise, the researcher observed the subjects' facial behaviors in association with the activities on the computer screen, and the 'Brain Candy' bar graph at the bottom of the screen, to monitor if the subjects demonstrated their knowledge of "cause-and-effect" relations.

Day 1

Based on the initial facial muscle frequency band signal obtained on the introductory day, the subjects worked on the Brainfingers software to operate the algorithm display. The teaching strategy the researcher implemented was instructing the

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subjects with a pointing prompt, "See that yellow line. Make that yellow line go above the green line and make the computer go 'bing'." As the subjects performed the activity, the researcher adjusted their signal levels so the subjects could suitably click. All four subjects, when asked, were proficient in generating a click by extending their signal above the baseline.

Once the initial facial muscle signal was established, the subjects played the Brainfingers' 'Click Game.' Through modeling, the researcher played the game once with four single colored-box indicators, with verbal instructions. Each subject played the game, and each needed at least one verbal cue to 'click' to direct his or her attention back to playing the game. All four subjects were able to generate purposeful clicks to play the 'Click Game' with eight single colored-box indicators.

Continuing with muscle signals, the subjects played the Brainfingers 'Grow Game' to establish and adjust their facial muscle up/down signal and then their left/right eye glance signal by the researcher verbally directing the subjects to "Make the circles bigger or smaller or stay the same." When the baselines were established, the subjects played 'Pong' beginning with the up/down muscle signal, twice, and then twice played using left/right eye glance signals against the computer, to a score of eight. The first time subjects played the game controlling one of their axes, the researcher instructed, cued, and praised. The subjects achieved no score. However, when the subjects played the second time, they all achieved a score from one to five for each signal.

The final undertaking challenged the subjects and was videotaped. The subjects played 'Easy Maze' and 'Labyrinth' in the Brainfingers software. They had to move the cursor through the mazes to one of two targets. After instructing the subjects in what to

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do, the researcher observed to see how the subjects would perform the activity. In the 'East Maze,' the subjects attempted to maneuver through the maze twice. All four could direct the cursor to the sun, which was at the top/left of the screen, but they all had difficulty directing the cursor to the house at the top/right of the screen. Likewise, the subjects attempted to maneuver the cursor through the 'Labyrinth' maze, but no one could control the cursor to either of the targets. This difficulty did not prevent the subjects from trying. The difficulty the subjects were displaying indicated to the researcher that further adjustments were needed within the Brainfingers software.

Day 2

Based upon what had happened the prior days, it was determined by the researcher that the click timing needed to be adjusted. The computers were continuously 'binging,' or false clicking, while the subjects were performing activities on the computer. These false clicks are like endlessly left clicking a computer mouse; it is unproductive and interferes with computer and software functions. After the adjustments, all four subjects continued to have false clicks, and the researcher continued to make adjustments. As the subjects improved in their control, the false clicks became less frequent. During the videotaping, the 'binging' sound from the false clicks can be heard in the background.

Also, it was determined by the researcher that Subject D could not utilize her facial muscles for click or up/down control. Her muscle frequency brainfinger stayed at its maximum signal level even when the baseline adjustment was at its lowest level. She was unable to click effectively. The researcher reviewed Subject D's data collected from the Brainfinger window and a secondary Brainfinger frequency band was selected for

clicking and up/down control. An alpha wave, or B6 Brainfinger, was chosen. Once this frequency band was mapped for clicking and up/down, control Subject D operated the 'Grow Game' while the researcher made signal adjustments. She played one game of 'Pong' where she scored a five.

Following adjustments, the subjects operated switch software. However, as soon as the subjects saw the programs on the computer screen, the subjects' faces became distressed, they vocalized loudly, they became easily distracted by the environment, or they lost interest operating the Cyberlink and refused to look at the computer screen. The researcher determined that the subjects, because of their past history of being unsuccessful operating software with a switch, had either failure anxiety or were bored by the software. Attempting to encourage the subjects to operate the Cyberlink, the researcher offered the subjects' choices of software to operate. The software offered was in a systematic progression from 'cause-and-effect' to choice making software. Despite the subjects' reluctance to work with the switch software, the subjects did do the activities efficiently and needed occasional redirection to 'click,' or make the computer go 'bing.'

Day 3

Through the Brainfingers software, the subjects became acquainted with cursor control utilizing the 'Two Axis Pointing Setup' program to combine two frequency bands to operate up/down and left/right axes cursor maneuvers. All four subjects were able to maneuver the cursor near, or to, the post-it target at least five times within a five-minute period. Subjects A, B, and D also maneuvered the cursor around and reached both targets in the Brainfingers' 'Easy Maze,' and 'Labyrinth.' The subjects appeared to like that

they completed the mazes because they would hear a conclusion melody. They would smile and vocalize each time they completed a maze, which they did three times each. The subjects were also asked each time they completed the maze if they wanted to do the particular maze again. The subjects responded with their individualized yes/no response.

Subject C refused to do the mazes. He would not maneuver the cursor or look at the computer screen, and he vocalized his disapproval loudly. The researcher motivated Subject C to practice maneuvering the cursor by way of the universal software "Reader Rabbit Toddler," which has a dwell cursor. For approximately fifteen minutes, Subject C maneuvered the cursor, which was a crayon, around the computer screen to color two pictures. Then he became agitated and refused to operate the system. The researcher, using the same software, motivated Subject C to maneuver the cursor, which was a hand, to pick up shapes and then maneuver the hand towards the shapes' matching slot on the screen. For fifteen more minutes he played the puzzle program and completed three puzzles, which was videotaped. Then he displayed a painful look on his face and vocalized loudly. The researcher asked him if he was done with the computer and he responded with a slight smile.

Day 4

For first software, chosen by the researcher, each subject averaged ten minutes maneuvering the cursor towards, or to, the targets as directed by the researcher and attempted to left click to operate the IntelliTools and Clicker 4 software templates. Subject B, C, and D needed several redirections to refocus their attention to the computer screen.

When the subjects chose their second software from a software group selected by the researcher for the subjects to practice their clicking functions, the subject operation minutes increased to fifteen and the redirections reduced. The subjects independently operated the software by responding to the cues derived from the software. For example, with the storybook software, when the page was finished being read aloud and no stimuli were coming from the computer, this natural cue for the subjects to click to go to the next page was responded to. However, the subjects continued to produce many false clicks that interfered with their effectiveness to click decisively to operate software.

Day 5

Through the Brainfingers software, the subjects became acquainted with cursor control and left click operations utilizing the 'Mouse Set-Up.' All four subjects attempted to maneuver the cursor near, or to, the post-it target but had difficulty controlling the cursor. Moreover, the continual false clicks interfered with software functions. Even when playing the Brainfingers' training tool, 'Acquire Game,' the subjects' performance did not improve.

Day 6

Upon reviewing the subjects' data collected from the 'Brainfingers' window and the daily field notes, the researcher had the subjects test new frequency bands to achieve specific outcomes. Also, it was determined that the subjects were having difficulty operating the up/down and click signal with the same frequency band. In an attempt to reduce signal conflict, the subjects sampled a third frequency band as their method of computer access.

While the subjects were in the Brainfingers' 'Acquire Game,' the up/down frequency band selection was made based upon the results from the 'Brainfingers' widow data, concentrating on the second strongest frequency band. After adjusting the signals of the new up/down frequency bands, the subjects played the 'Acquire Game' by maneuvering the cursor to touch a black box when it appeared ten times. The speed and accuracy the subjects displayed while moving the cursor to the target was observed. It was determined that Subject A and B had better control with the beta brain wave B8, Subject C with alpha brain wave B6, and Subject D with beta brain wave B7.

Likewise, changes in access were needed in the left/right eye glance signal for Subject B and C. Subject B has a substantial head lag to the left and was having difficulty maneuvering the cursor to the left. Subject C often had his head turned forty-five degrees to the right from midline. Yet, his eyes were directed to the left, constricting the eye muscle control to maneuver the cursor to the left. For these reasons, Subject B and C needed their signal remapped from using both the right and left eye glances to right eye glance, to maneuver the cursor. The right glance operates by the subject looking to the right or left. The cursor then maneuvers to the right. If the eyes stay still, the cursor maneuvers to the left.   After further adjustments were made to the left/right signal, the subjects played the 'Acquire Game' by maneuvering the cursor to touch a black box when it appeared ten times. All four subjects were successful in acquiring the boxes ten times after the adjustments were made.

Changes in access were needed for clicking. Subject A could click well using the muscle signal and Subject D continued to progress operating the alpha brain wave B6 for clicking. However, Subject B and C continued to display difficulty and were having

continual false clicks. By reviewing the subjects' Brainfinger window data, and then

have the subjects use the Brainfingers' 'Switch Setup & Practice' window, frequency

bands were remapped and signals were adjusted. For Subject B and Subject C the third

highest frequency band, Brainfinger B6, of the alpha brain wave band was selected.

Once adjusted, the subjects' false clicks lessened substantially.

After making adjustments to the Cyberlink, the subjects played the 'Acquire

Game' in 'Full Field Two Axis' by maneuvering the cursor using both the up/down and

left/right axes together, to touch the black box. All four subjects were able to maneuver

the cursor and touch the black box ten times no matter where the boxes were on the

computer screen. At this time the researcher realized the subjects had enough mouse

operation control to direct the cursor to an intended target effectively. However, the

subjects frequently lost control of the cursor by the cursor dashing across the screen.

To ensure the frequency bands and signals were adjusted efficiently, all four of

the subjects played the Brainfingers' 'Pong' game operating the up/down or left/right axis

using the large paddle and ball, and with the ball moving at a slow pace. The subjects

played each axis twice, and each won at least one game without assistance from the

researcher.

Day 7

The subjects put into practice operating the Cyberlink to activate communication

software. The researcher chose to have Subject A and D operate the 'Speaking

Dynamically Pro' communication software. Utilizing the products templates, the

subjects delighted in maneuvering and manipulating the cursor to pictorials to voice a

phrase or statement, and having the researcher respond to what was said. Also, the

colored pictorials were familiar to the subjects from their educational communication board experiences.

Subject B and C operate the 'Gus Multimedia Speech System' communication software, but did not exhibit a fondness to the software. The researcher was cognizant that the pictorials developed by 'Gus' were in black and white and the subjects had never experienced the 'Gus' pictorials. Despite their lack of enthusiasm for 'Gus,' the subjects did maneuver the cursor to voice a phrase or statement utilizing the product templates.

Overall, supported and directed by the researcher, all four subjects were capable of actuating the communication software. However, the subjects continued to have many few false clicks and the unremitting loss of cursor control despite further signal adjustments

Day 8

Due to the subjects' seventh day experience, and the familiarity with the pictorials in the "Speaking Dynamically Pro" software, all four subjects were videotaped actuating the software templates, or researcher made communication boards. The researcher would either verbally direct the subjects to maneuver the cursor to a particular pictorial, or ask a question so that the subjects could reply. The subjects continued to have the same cursor and clicking difficulties.

Day 9

The researcher initiated playing the Brainfingers' 'Cellar Game' by modeling the game and directing the subjects how to play it. As the subjects attempted to play the game, the researcher instructed the subjects how to grab the bottles with the hand cursor by clicking, pointed on the screen where to take the bottle, and instructed how to put the

bottle in the wine rack by clicking. The subjects had little difficulty grabbing the bottles but struggled to put the bottles into the wine rack and often dropped and broke the bottles. Considering that the subjects' had a substantial amount of control of the Cyberlink, and despite their difficulty with cursor maneuvers and clicking executions, the subjects could have been intentionally dropping the bottles to break them instead of putting the bottles into the wine rack.

Day 10

Working with the subjects in pairs, the researcher witnessed the subjects observing each other operating the Cyberlink, as well as each other's efforts to operate the "Magic School Bus" software. It was observed and noted that when the researcher instructed one subject on what to do to operate the software, the other subject would on his or her own initiative attempt to accomplish the same effect. The same outcome occurred when one subject was prompted or redirected.

The subjects chose which of the universal software they wanted to operate from the "Magic School Bus" series. However, the subjects' interaction with this software was discouraging to both the subjects and the researcher. The cursor was always residing at the top/right of the computer screen. When the subjects tried to gain control of the cursor, the cursor would not move despite the researchers adjustments to the signals. All four of the subjects' communicated their aggravation for the lack of cursor control. Several times they were caught with one of their hands on the touch pad of the computer, attempting to move the cursor with their hand. The reaction of the subjects' illustrated their motivation to control the computer and software. Also, the subjects displayed their knowledge of the computer by trying to create an effect with the touch pad. It is assumed

that the subjects understand the function of the touch pad from observing the researcher operating the touch pad.

The researcher was compelled to ascertain why the subjects lost computer control. After reviewing the field notes and reflecting on the day's events, the researcher concluded the following. Undeniably, the subjects had never been exposed to, nor had an opportunity, to operate universal software. Likewise, the "Magic School Bus" software is very stimulating with all of the background movements and noise incorporated into the ambiance of the series. The exposure to this software overwhelmed the subjects in three ways, 1) the subjects were not knowledgeable about how to explore or direct the software due to lack of exposure; 2) the over stimulation of the software's background interfered with the subjects' alpha and beta access signals causing the cursor to stay at the top of the computer screen; and 3) in the subjects excitement to operate the software, they tensed their eye muscles causing the cursor to reside to the right of the computer screen.

Due to these affect dynamics, the researcher determined that the subjects needed to learn how to explore and direct software, by way of operating early elementary software. Also, in the process of examining the day's events, the researcher explored the Brainfingers' software and discovered a way to slow the cursor maneuvers so that the subjects would not lose control, and how to adjust signal levels for each eye for left/right maneuverability.

Day 11

This was a breakthrough day. After the adjustments were made and the click timing further lowered, for the first time the subjects displayed absolute control by operating the Laureate Learning System software. For example, when the researcher

would say, "Take the cursor to the fire truck and click," the subjects maneuvered the cursor directly to the fire truck and clicked without producing a false click. Similarly, the subjects followed the directions promptly when instructed by the researcher where to maneuver the cursor. Apart from Subject D who was ill and fell asleep ten minutes into her session while operating the software, the other subjects explored several of the software pages to practice their abilities and were efficient in their performance, despite the needed redirections to focus their attention back to the apparently uninteresting software.

Day 12

The researcher decided that Subject D needed the opportunity to operate the Laureate software to develop access capabilities. However, she was still ill and after fifteen minutes, her session was concluded. She was, though, able to demonstrate her cursor directional and clicking control.

Based on the previous day's experience and beginning with familiarity, the researcher chose the switch software for the subjects to operate to further develop their cursor maneuvers and clicking. However, the subjects were despondent with the researcher's choice and needed a lot of coaxing to actuate the software. After a lot of persuading, the three subjects did operate the software to make choices within the software proficiently and independently.

After tolerating the ten to fifteen minutes operating the switch software, the researcher offered the subjects a choice of computer storybooks from the "Living Books" series. The subjects made their choices; the researcher set up the software for them to 'play,' and then subjects, on their own initiative, explored and turned the pages.

Occasionally, the researcher prompted the subjects to "Click here and see what happens." Only Subject C tired of his choice of storybook and wanted another choice. With both story choices, he never did reach the end.

Day 13

Beginning again with familiarity, the subjects were offered choices of storybook software from the "Living   Books" series to explore and turn the pages, but this time without any prompts from the researcher. Subject D did need five minutes of instruction and modeling to learn how to operate the software, but after that, she was completely independent. On the other hand, Subject C rejected the storybook software by not making a choice. Hence, the researcher had to offer him a different set of choices, and omitted the storybook training.

The subjects were taught how to pick and choose activities within software, by way of early educational software. Once the subjects made a choice of software, the researcher activated the software and explained to the subjects, with modeling, how to operate the software. For example, the subjects were taught how to pick a program within the opening software page, how to exit a page to go back to the software-opening page to make another choice, and how to explore the pages to see how to 'play' the pages. Once the subjects were given the control to operate the software, the researcher provided little guidance. The challenge was for the subjects, through trial and error, to make an effort to discover the programs within the software. As a result, the subjects performed the activities with enthusiasm. Some pertinent results came from this day:

Subject A attempted to operate the Fisher-Price "Sing Along Barnyard Rhythm & Moos" software. He was able to make the choice but was unable to locate the small

'start' button to play his song choices. He had no problems, however, operating and making choices from the Fisher-Price "Discovery Farm" or the "Green Eggs and Ham" story.

Subject B attempted to operate the Fisher-Price's "Ready for School – Kindergarten Edition." She tried to operate one program where she had to sort out shapes by size, but was unsuccessful because she needed to click-and-drag the shapes to it's' receptacle using the click and drag capability of the Cyberlink which had not been taught. So, she went back to the opening page and chose another program where she played music when she clicked on a letter of the alphabet. She quickly became uninterested with the software and wanted a change. She chose the story of "The Tortoise and the Hare" where she enthusiastically explored the pages.

Subject C chose to play The Learning Company's "Zoboomafoo Animal Alphabet", instead of the storybook software. He spent a lot of time manipulating this software. He, too, ran across a problem of needing to click-and-drag, but would exit the page to explore somewhere else in the software. Later, he chose to play with Playskool "Puzzles," in which he did well operating and displaying his cognitive skills. He was counting in rote to five and matching letters.

Subject D played one program, of her choice, in the Playskool's "Puzzle" software. The program entailed a dot-to-dot where she had to click in rote the numbers to complete the outline. She completed one then wanted to change software. She chose the storybook "Stellaluna" where she explored the pages.

Day 14

The subjects continued to increase their computer access and software

performance by operating early educational software. While the subjects were

controlling their software applications, the researcher became aware of an occurrence that

warranted further attention. There were two sessions that day. Subject A was paired

with Subject B and Subject C was paired with Subject D. What caught the researcher's

attention was that Subject B and D were playing Reader Rabbit Toddler, and in fact

operating the software. They were entering and exiting the pages, playing in programs,

and despite the software having a dwell cursor, they were clicking to speed up the action.

Their partners were watching intently what they were doing.

Subject A chose to operate the Playskool's "Puzzles" and "Play Doh Creations" and demonstrated cognitive abilities of matching numbers and letters. Subject C chose to operate the storybook "Green Eggs and Ham" and explored the pages. Still wanting to work on the computer, but not with the software choices available, the researcher offered him a choice to play the Brainfingers 'Cellar Game.' He preferred that choice to all of the choices presented to him.

Day 15 - 16

When offered a choice of what software they wanted to operate, all four subjects chose "Reader Rabbit Toddler" and performed with 100% independence. They also discovered, despite the dwell cursor, if they clicked while touching an item the item event would happen faster. On the sixteenth day, the subjects were videotaped while demonstrating independent operation of the software "Reader Rabbit Toddler."

CHAPTER 5

Summary of Results and Other Outcomes

Drawing from the tally sheets, field notes, and observational data the following figures and tables were created to provide additional insights into results of this study.

Figure 3 illustrates the levels of control subjects achieved with the Cyberlink. On days 1 and 2, the subjects were able to produce observable "cause-and-effect' behavior. Using switch control the subjects were able to select correct visual and/or auditory scanning choices. The subjects' facial movements were consistent to produce a conscious click when prompted or cued. However, access was not precise or functional due to the subjects' unconscious muscle activity, which caused false clicks.

Figure 3

Subjects' Cyberlink Access Occurrences
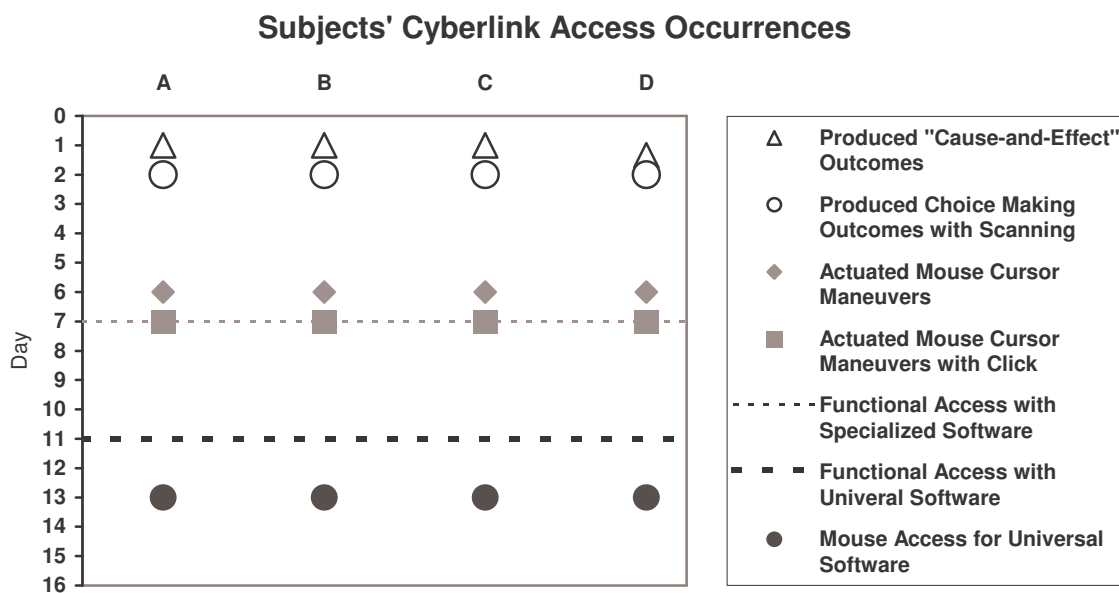
On day 6 in Figure 3, the subjects continued to produce false clicks while performing clicking control, and continued to have difficulty directing the cursor to targets. This performance suggested some other frequency mapping was needed. Based on data collected from the Brainfingers window during the second session of the Introduction Day (see Appendix A), each subject was given the opportunity to experiment with frequency bands, which were observed to have potential as a control.

By observing the frequency bands on the screen in the Brainfingers window, the researcher was able to uncover frequency bands that could be utilized for various computer functions. These are shown in Tables A1-A4 found in Appendix A. Knowledge gained from six months of experimentation and learning the Cyberlink was used as a foundation from which to construct Tables A1-A4.

Once the determination of which frequency bands were most effective to actuate clicks and maneuver the cursor (see Table 2), the subjects improved their control. The subjects directed the cursor towards, or to, a target no matter where it was on the screen, and continued to lessen their unconscious false clicks.

On day 7 the subjects actuated mouse cursor and mouse left click control, and exhibited functional access to operate specialized software. Based on the subjects' aptitude to operate communication software by moving the cursor to a picture and clicking to voice a statement, otherwise known as direct selecting, the subjects had effective access to specialized software. Yet, occasionally, the subjects continued to have the unconscious false clicks, as well as lose control of the cursor when maneuvering to a target. When control was lost, the subjects would move the cursor back to the initial target to complete the task or activity.

On day 11 adjustments were made to slow the speed of the Brainfinger controlled cursor. With these changes it was observed that the subjects had functional access and control of the Cyberlink system to operate universal software. The subjects gained cursor control and rarely produced the unconscious false clicks. Also, the subjects learned how to operate universal software to execute activities.

On day 13, the subjects demonstrated that they had mouse access to operate universal software, as well as independence to control the software themselves.

Figure 3 suggests an outcome that emerged from this study that was not anticipated. All subjects' rate of improvement and understanding occurred at the same times. This linear occurrence is noteworthy.   The intention of this pilot program was for the subjects to become proficient at their level of performance. Yet, all four subjects learned exactly the same operations and applications at the same time. Subjects used the Cyberlink system on common days, and operated related software at the same times, with the exception of Subject D on the first day of implementation.

Default settings for mouse cursor control and switch control provided as part of the Cyberlink software were used for all subjects at the beginning of the study. The mapping of frequency bands or brainfingers is presented in Table 1. On day 6 it was decided to select a different configuration for the subjects with the hope the new selections would improve the subjects' performance. Subsequent results confirmed this. The final mapping of frequency bands to cursor and switch control is shown in Table 2.

Table 1

Cyberlink Default Setting

	Subject A	Subject B	Subject C	Subject D
Clicking	Muscle B11	Muscle B11	Muscle B11	Muscle B11
Cursor Up/Down	Muscle B11	Muscle B11	Muscle B11	Muscle B11
Cursor Left/Right	Left/right eye Glances B2	Left/right eye Glance B2	Left/right eye Glance B2	Left/right eye Glances B2

Note. B = Brainfinger or Band and the numbers means which band counting from left to right.

B1 – B3 = Muscle activity of eyes left/right glances; B4 – B6 = Alpha brain waves;

B7 – B10 = Beta brain waves; and B11 = Facial muscle activity

Table 2

Final Cyberlink Settings

	Subject A	Subject B	Subject C	Subject D
Clicking	Muscle B11	Alpha B6	Alpha B6	Alpha B6
Cursor Up/Down	Beta B8	Beta B8	Alpha B6	Beta B7
Cursor Left/Right	Left/right eye Glances B2	Right eye Glance B2	Right eye Glance B2	Left/right eye Glances B2

Note. B = Brainfinger or Band, number means which band counting from left to right.

B1 – B3 = Muscle activity of eyes left/right glances; B4 – B6 = Alpha brain waves;

B7 – B10 = Beta brain waves; and B11 = Facial muscle activity

Figures 4 and 5 present a mapping of times spent learning the Cyberlink for all subjects. For each of the daily sessions, of sixteen days, the subjects were allotted up to 60 consecutive minutes of time-spent learning. Figure 4 is the first eight days of the study. The subjects learned and operated the training tools in the Brainfingers software then applied the training to control specialized software. Figure 5 presents the last eight days of the study (days 9 – 16) during which time the subjects used the Cyberlink to operate universal software

As shown in Figure 4, the subjects' session times steadily increased over the first eight days. There was then a drop on the ninth day (see Figure 5). On the ninth day the subjects applied their control of the Cyberlink to operate more intricate and uncommon software compared to the switch software they already knew. This change challenged the subjects by engaging them to concentrate more. Twenty minutes of operation was all the subjects could tolerate then indifference occurred.

Figure 4

Time Spent Learning the Cyberlink System

Subject A · Subject B · Subject C · Subject D

Figure 5

Time Spent Applying the Cyberlink System to Universal Software

Subject A · Subject B · Subject C · Subject D
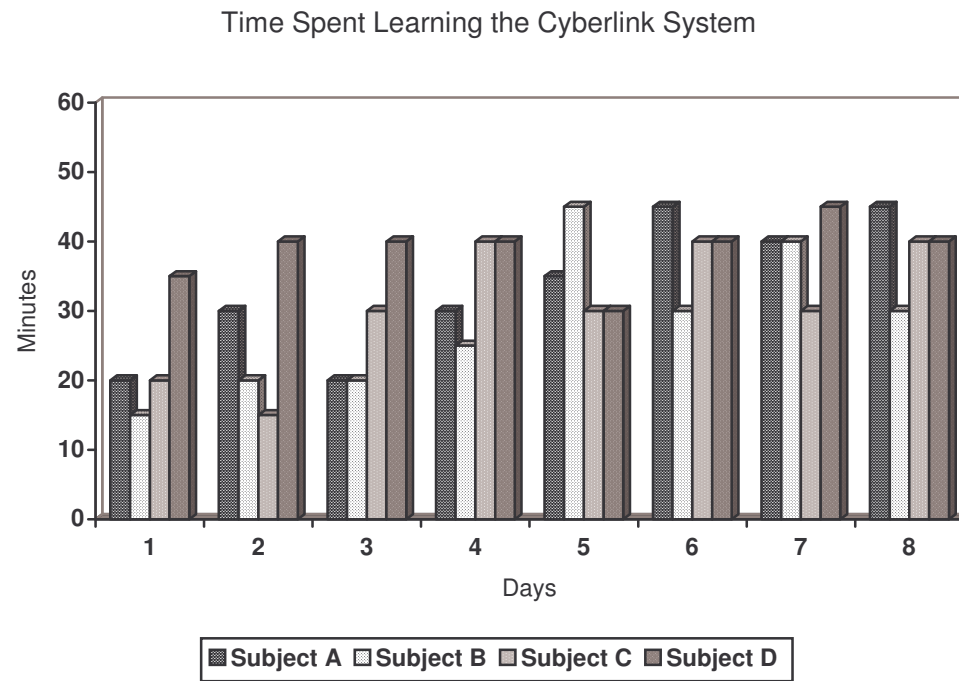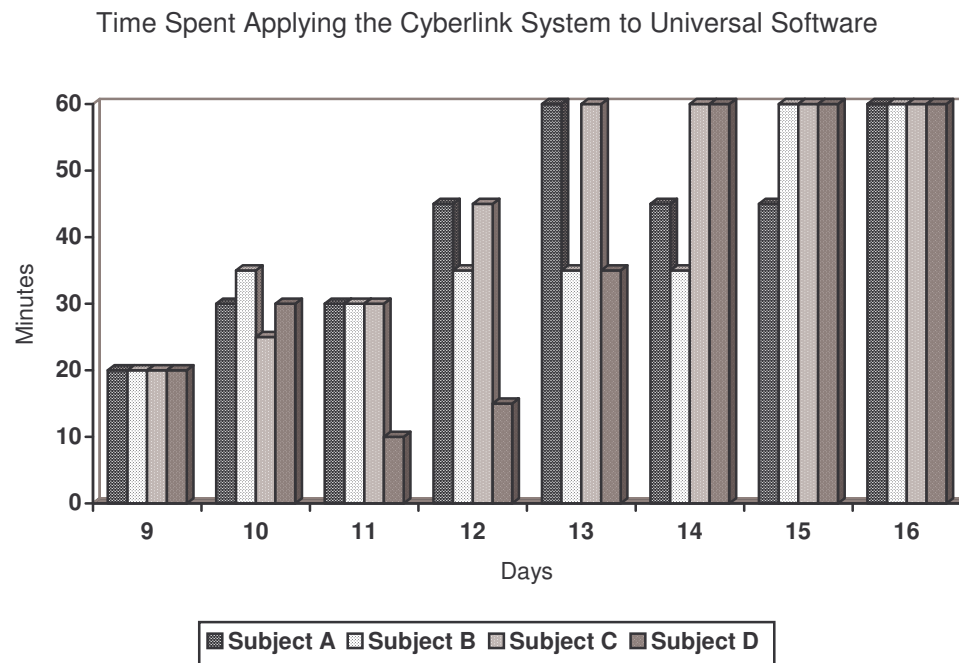
On day 10 in Figure 5, the subjects continued to be challenged with the Cyberlink system's control when applied to universal software. On day 11 a further refinement in the subject/Cyberlink connection was made. The change was to slow down the cursor speed.

The software was designed to help the user learn how to perform software functions. Subject A, B, and C could only focus on the software for thirty minutes due to their apparent lack of interest. After the day 11 modifications, the subjects' time spent learning increased progressively to 60 minutes subsequent to the subjects' capability to access universal software. Subject D was ill for day 11 and 12 and is why her operation time dropped.

Another outcome emerged from this study based on the subjects' motivation to control the Cyberlink system and apply the system to operate software. The performance motivation was designed to be encouraging and positive to facilitate independence. For the first eight days each session began with something easy to operate and known by the subjects then ended with something more difficult but stimulating to give the subjects an idea of what was forthcoming in their experience. The last eight days began with challenging tasks, such as operating universal software, to encourage the subjects to experiment with their newly found control and independence. It was observed that the subjects were the most attentive during this time. The sessions ended with something easily accessible to practice and improve the subjects' access controls to ready the subjects for the next session's challenges.

The motivation for the subjects was the opportunities to make selections from forty-four choices of software to operate. The names of choices are listed in Appendix B.

Table 3 depicts the subjects' time spent operating each of the software choices they made daily, when the researcher made the choices, as well as the number of prompts or cues needed to focus the subjects' attention back to perform the computer and software functions.

When the researcher made the choice of software, less time was spent on operating the software and more prompts or cues were needed. When the subjects made the choice, more time was spent operating the software and less prompts or cues occurred, with the exception of the "Magic School Bus" software on day 10. Likewise, as the subjects became more proficient with the Cyberlink system to operate universal software, they made fewer choices and focused more on each individual piece of software.

Table 3

Software Selected By either the Researcher or the Subjects

	Subject A			Subject B			Subject C			Subject D		
	R / S	Day& Min	# of Cues	R / S	Day& Min	# of Cues	R / S	Day& Min	# of Cues	R / S	Day& Min	# of Cues
Teach me to Talk	S	2/10m.	|||||							R	2/10m.	
Teen Tunes Plus	R	2/10m.	||||| |||				S	2/5m.	|||			
Switch Basics				R	2/5m.			R	2/5m.			S	2/20m.	
Disco				S	12/10m.								
Drumkit							R	2/5m.	||||			
SwitchIt Bundle	R	12/15m		R	2/5m.	|||				R	2/10m.	|||
Arcade Adven.	S	4/15m.					R	12/10m.					
Switch Connect.				S	2/5m.	|||||						
IntelliPics	R	4/10m.					R	4/10m.	|||||				
IntelliMathics				R	4/10m.	|||						
Clicker 4	R	4/5m.		S	4/15m.	||				R	4/10m.	|||
Gus Multimedia				R	7/40m.		R	7/30m.					
Speaking Dyn.	R R	7/40m. 8/45m.	||	R	8/30m.		R	8/40m.	|||	R R	7/45m. 8/40m.	
Magic Scl. Bus	S	10/30m.	||||| ||	S	10/35m.	||||||||||	S	10/25m.	|||||	S	10/30m.	|||||
Laureate	R	11/30m.	||	R	11/30m.	|||	R	11/30m.	||||	R R	11/10m. 12/15m.	||||| |||||	
"ABC"	S	12/30m.											
"Green Eggs"	S	13/15m.		S	12/25m.		S S	4/15m. 14/40m.	||	S	4/15m.	
"Lion King"							S	4/15m.					
"Pocahontas"										S	4/15m.	
"Little Monster"							S	12/15m.					
"Teacher Troub."							S	12/20m.					
"Discov. Farm"	S	13/20m.											
"Sing Alongs"	S	13/25m.											
"Ready for Scl."				S	13/10m.								
"Tortoise/Hare"				S	13/25m.								
"Puzzle"	S	14/25m.					S	13/20m.	||	S	13/10m.	||
"Zoboomafoo"							S	13/40m.					
"Stellaluna" N										S	13/25m.	
"Creations"	S	14/20m.											
RR Toddler	R S	15/45m. 16/60m.		S S S	14/25m. 15/60m. 16/60m.			R R S	3/30m. 15/60m. 16/60m.	|||||	S S S	14/60m. 15/60m. 16/60m.		

R = Researcher's Choice. S = Subject's Choice. The day the software was used / Minutes operating software (m.).

Talley marks is how many times the researcher redirected the subject to operate the software.

The daily total times spent controlling the Cyberlink are listed in Table 4, along with the daily prompts. As the subjects progressed to operate universal software, the subjects increased their time-spent learning the Cyberlink and needed less prompt or cues from the researcher to perform.

For this study, odd days were Tuesdays and even days were Thursdays. Looking at the tally marks, on average the odd days needed more prompts or cues. The motivation factor was a major determiner of performance time and increased the subjects' attention span. Even when the subjects operated two to three pieces of software a day, at the end of the study they focused on one piece of software for the full 60 minutes.

Table 4

Subjects' Overall Minutes Comparable To Decrease of Need for Researchers' Prompts

Allotted Time - 60 Minutes Daily	Subject A		Subject B		Subject C		Subject D	
	Session Minutes	Number of Prompts	Session Minutes	Number of Prompts	Session Minutes	Number of Prompts	Session Minutes	Number of Prompts
Day 1	20	||||| ||||| |||	15	||||| ||||	20	||||| |||||	35	|||||
2	30	|||||	20	||||| |	15	||||| |||	40	|||
3	20	||	20	||||	30	||||| ||	40	|
4	30		25	|||||	40	||||| ||||	40	|||
5	35	||||| ||||	45	||	30	|||||	30	||||
6	45		30		40	|	40	||
7	40	||	40		30	|	45	
8	45		30		40	|||	40	
Total	265 m. 4.25 h.	31Xs	225 m. 3.45 h.	26 Xs	235 m. 3.55 h.	39 Xs	310 m. 5.10 h.	18 Xs
9	20	|	20	||	20		20	
10	30	||||| ||	35	||||| ||||| |	25	|||||	30	|||||
11	30	||	30	|||	30	||||	10¹	|||||
12	45		35	|	45	|	15¹	||||| |
13	60		35	|	60	||	35	||
14	45		25²	|	60		60	|
15	45		60		60		60	
16	60		60		60		60	
Total	335 m. 5.35 h.	9 Xs	300 m. 5 h.	19 Xs	360 m. 6 h.	12 Xs	290 m. 4.50 h.	19 Xs
Grand Total	600 m 10 h.		525 m. 9.35 h.		595 m. 9.55 h.		600 m. 10 h.	

Note. m. = minutes; h. = hours; Xs = times. ¹Subject was ill and ²Subject's medication was changed. Adverse Conditions for number of prompts for all subjects:

Day 1 – First day learning the Brainfingers software

Day 2 – Previously known switch software

Day 3 – Instruction on how to move cursor and signal adjustments

Day 5 – Fine tuning cursor adjustments

Day 10 – Magic School Bus software

Day 11 –Utilizing Laureate software to instruct on software exploration

Days 15 & 16 – Independently operating Reader Rabbit Toddler

Prior to the study, the subjects' had been assessed by a school psychologist, the

assistive technology professional, special educators, and California Children Services.

The subjects were judged to be performing academically, functionally, and intellectually

between six to eighteen months of age. As shown in Figure 6, the subjects' performance

levels increased while controlling the Cyberlink. This determination was based on what

universal software was being operated and the activities, or "games," managed within the

software, e.g., matching letters, numbers, shapes, and words. The subjects' performance

levels were judged to have increased to 4 - 5.5 years based on the Brigance Diagnostic

Inventory IED-II: Inventory of Early Development (2004), for birth to seven years.

Figure 6

Average Performance Levels Before and After Universal Access
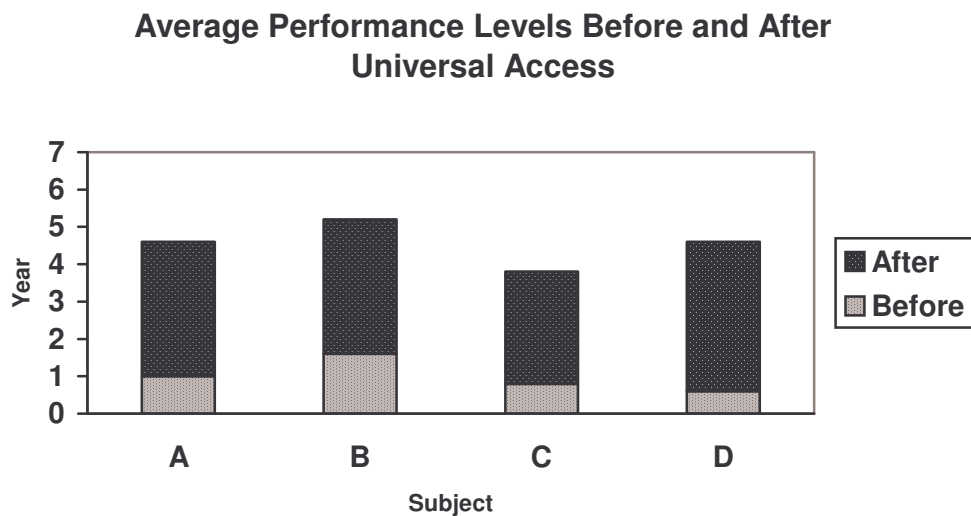
CHAPTER 6

Discussion

This qualitative study investigated components, positive outcomes, and difficulties faced during the eight weeks, or sixteen days, controlling the hands-free interface system called Cyberlink Brainfingers. Since there are no publications of the Cyberlink system educationally to give students, identified with multiple disabilities, computer access and the capability to operate commercial software, this study examined the process and outcomes of achievement and access.

The purpose of this study was to examine if Cyberlink, a high technology system, could be taught and used by persons identified with multiple disabilities to facilitate curriculum access, communication, and leisure activities. The focus was on switch control, mouse/cursor direction manipulation, and mouse/cursor direction controls with left click, to operate a variety of software to reinforce the training with the Cyberlink system. With the use of tally sheets and field notes, a content analysis was completed describing how each of the subjects operated the Cyberlink system, and their interactions with software, progress, and obstacles hindering their performance. Additionally, the subjects were videotaped for comparison of his or her progress at the beginning, middle, and end of the study.

The four subjects, who attended the same public special education school, were between the ages of nine to twenty and had been identified as having multiple disabilities. The subjects had been assessed in their academic and functional skill areas and were judged to be functioning intellectually at six to eighteen months of age with the average

attention span of thirty seconds. Likewise, the subjects are nonverbal, but had demonstrated the ability to answer yes/no questions using facial expressions, and/or head nodding/shaking, and can make choices or point using eye-gaze. Finally, the subjects have no meaningful access to switch devices to facilitate curriculum participation, communication, or leisure activities.

The subjects worked individually with the researcher beginning in fifteen-minute increments. As the subjects perfected their control of the Cyberlink system and were able to focus their attention for longer periods of time, the researcher's instruction faded. The subjects developed independence with the system and the time increased to one hour per session.

As the subjects actuated the system, other abilities began to emerge or were noticed. In the process of developing control of the Cyberlink and applying the operations to software, it became apparent that subjects understood more than previously assessed. Through the various teaching strategies of modeling, verbal directions, pointing prompts, indirect verbal instruction, praise, choice making, and the trial and error approach to teach the subjects how to control the Cyberlink and operate software, the subjects were able to show that they not only could learn and they were able to put into practice everything learned in a very short period of time, but to an independent level of access.

Reviewing the first day of the pilot program, the subjects' attempted to move the cursor around the Brainfinger games; 'Easy Maze' and 'Labyrinth'. The aptitude necessary to determine where the cursor needed to go through a maze to reach a target represents a higher cognitive level than the level previously assessed. On the third day,

Subjects A, B, and D were able to maneuver through and complete the mazes three times. Likewise, the steps required to play the game 'Pong' requires a higher cognitive level to be able to predict, strategize, and to act upon the scheme to play the game. All four subjects were able to play the game, score, and even win a game or two by the sixth day of the pilot program.

As the researcher continued to make adjustments of the system and asked the subjects to perform particular tasks so that the adjustments could be made, it became apparent that the subjects learned the computer terminology and demonstrated this knowledge by following the researcher's verbal directions. The terminology used most often by the researcher was; exit program, exit window or program, click, cursor, screen, and main window or page. For example, the researcher would instruct or direct the subjects to "exit the program," and subjects would maneuver the cursor to the icon to exit and click to complete the operations.

Once more effective brainfinger frequency bands were determined on day 6, access was more controlled, and the skills learned were applied to software. It became apparent that the subjects' motivation for learning the system improved. As shown in the results (Table 4), the subjects wanted to make choices of what software to operate. They wanted the control and independence. Likewise, they wanted to operate universal software. As stated in the results, when the subjects had opportunities to make choices of the software to operate, their performance was better. When the researcher made the choices, refusals occurred. The same occurrence transpired after day 11, towards the end of the study when the subjects acquired total control with early education software. In the process of instructing the subjects in how to operate the software, when asked to

maneuver the cursor to a target, they often did the opposite in an attempt to get a reaction

out of the researcher or as an indication that they wanted to do it themselves. The

subjects' motivation to control the Cyberlink system to operate software, and the use of

the teaching strategy of trial and error, developed the subjects' problem-solving skills and

encouraged them to use the skills to initiate and perform activities.

The researcher tried to have the subjects use and operate software for typical

curriculum access, but due to their inattentiveness and lack of enthusiasm to operate the

software it was discontinued for this study. The subjects enjoyed communicating with

the researcher with the communication software, it was not particularly beneficial.

Communicating with the researcher in a restricted setting is not enough for the subjects to

generalize the communicative experience to others. Also, the subjects needed their own

communication system, which required the researcher to spend more in development and

was not available during this short study. Likewise, the researcher needed the expertise

of the speech and language pathologist to develop the individualized communication

systems for each of the subjects.

However, the subjects did exhibit communication skills using their vocalizations

when they had difficulty with the software, when the computer was not operating, or

when they had completed the tasks. The subjects asked for help because they sought to

work more on the computer. This was also evident when the subjects tried to operate the

"Magic School Bus" software on the tenth day by trying to manipulate the computers'

touch pad. Also, the subjects 'wanted' to learn. Whenever the subjects were asked if

they wanted to work on the computer, their yes/no response and body language always

indicated a 'yes' with enthusiasm.

The subjects' interest in the computer extended further. When the subjects attended the researcher's classroom for their sessions, it was during the time when class was being conducted. Despite external disruptions of classroom noise and movement, all the subjects remained on task. If the subjects' attention was interrupted, they could independently redirect their attention back to their task. As described in the Brigance Diagnostic Inventory IED-II: Inventory of Early Development (2004), the subjects' demonstrated six-year-old skills.

Finally, there was a result from this study that was not at all expected. Parents and educational professionals verbalized to the researcher about behavioral changes they were observing from the subjects during the course of the study that were not exhibited before the study. All four subjects were more attentive, Subject A, C, and D demonstrated increased alertness, Subject A, B, and C understood what the word 'relax' meant and could display it physically, and Subject A, C, and D initiated social interactions with others.

CHAPTER 7

Conclusions

The results of this pilot program exceeded the researcher's expectations. The four

subjects identified with multiple disabilities achieved computer and software access

through hands-free control of the Cyberlink in less than sixteen hours over eight weeks.

Results suggest that the Cyberlink system could satisfy the needs of persons identified

with multiple disabilities who have physical limitations that interfere with computer

operations. The Cyberlink was found to be safe to use, easily learned, not affected by

involuntary body, facial, and/or head movements, or limited vision, and offered

specialized and universal computer and software access.

It is concluded that the Cyberlink Brainfingers system removed access barriers to

computers and enhanced the subjects' quality of life by permitting them to operate

software for communication, learning, and leisure, and enhanced their abilities to enjoy

an independent lifestyle. The system did advance the subjects' cognitively or socially,

provide speed to use the technology, made choices available, grew with the individual's

development, and could be used in many environments. Based upon the researcher's

perspective and experience, the Cyberlink system would not be usable by persons 1) who

are blind and deaf due to the lack of visual and auditory feedback, 2) who seize

excessively, and 3) who lack the motivation to learn the system.

The researcher found the Brainfingers software challenging to use, even with the

six months of examination and experimentation. As referred to in the results, the

researcher had to continuously re-examine and revise the Cyberlink control interface as a

result of observing unsatisfactory computer access. Considerable flexibility was

demonstrated by the subjects in their struggle with the control operations and to follow

directions while the researcher regularly altered the signals.   This allowed the fine-tuning

needed for effective access through the use of brainwave frequency bands.

The impact of different numbers of days between sessions was noted. Generally

the sessions took place on Tuesdays and Thursdays. On Thursdays, because there was

one day between sessions, the subjects took approximately a minute to reacquaint

themselves to the controls of the Cyberlink system. But on Tuesdays, five days between

sessions, it took approximately two to seven minutes for the subjects to recall how to

control the system. It is interesting to speculate what the outcome would have been if the

subjects had operated the Cyberlink daily.

The subjects did access and use the Cyberlink system effectively and efficiently

and applied the controls to universal software. Longitudinal studies are needed to

determine if persons identified with multiple disabilities could achieve further gains with

the Cyberlink system than those reported here. There is a need to provide access and

instruct individuals in other computer functions like the mouse click-and-drag and double

clicks, keyboard functions, and joystick operations. Controls are included in the

Cyberlink software but evaluation of these functions was beyond the scope of this study.

The plausibility of adding other frequency bands to enhance access would be worthy of

exploration.

Studies are needed to examine the possibilities of using the Cyberlink as an

evaluative tool to determine cognitive awareness and intelligence of persons identified

with multiple disabilities. The Cyberlink could be of value in support of day-to-day

classroom instruction to facilitate progress in the general education curriculum. Even nonacademic activities could be supported, such as art and music. Further study could be conducted to evaluate the Cyberlink as a controller for a voice output communication device in which some of the unique control capabilities of the Cyberlink could be optimized.

The research and application possibilities are endless, particularly with advances in technology. Gaining a tool to control a computer, persons identified with multiple disabilities now have the opportunity to operate universal software, access which was conceived of but never made available until now.

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Table A1

Subject A's Brainfingers Frequency Band Fluctuations

	Relax	Stare	Look Right	Look Left	Close Eyes	Lift Eyebrows	Bite	Clench Teeth
LR Glance B1	↓	↓						
LR Glance B2	↓	↓	↑	↑	↓			
LR Glance B3	↓	↓	↑					
Alpha B4	↑	↑			↑			
Alpha B5	↑	↑			↑			
Alpha B6	↑	↑	↓	↓	↑			
Beta B7	↓	↓				↑	↑	↑
Beta B8	↓	↓	↑	↑	↓	↑		
Beta B9	↓	↓				↑	↑	
Beta B10	↓	↓				↑	↑	↑
Muscle B11	↓	↓	↑	↑	↓	↑	↑	↑

Note. ↓ = Signal goes down   ↑ = Signal goes up   X = Poor Affect

Subject A control of muscle for clicking (B7, B9, B10 secondary controls for clicking), B2 for left/right glances, and muscle, B6, or B8 for up/down

Table A2

Subject B's Brainfingers Frequency Band Fluctuations

	Relax	Stare	Look Right	Look Left	Close Eyes	Lift Eyebrows	Bite	Clench Teeth
LR Glance B1	↓	↓						
LR Glance B2	↓	↓	↑	↑	↓			
LR Glance B3	↓	↓	↑					
Alpha B4	↑	↑			↑			
Alpha B5	↑	↑			↑			
Alpha B6	↑	↑	↓	↓	↑	↑	↑	↑
Beta B7			↑			↑	↑	↑
Beta B8	↓	↓	↑	↑	↓	↑	↑	↑
Beta B9	↓	↓		↑	↓	↑	↑	
Beta B10	↓	↓			↓			
Muscle B11	↓	↓	↑	↑	↓	↑	↑	↑

Note. ↓ = Signal goes down   ↑ = Signal goes up   X = Poor Affect

Subject B control of muscle for clicking (B7, B6, or B8 secondary controls for clicking), B2 for left/right glances, and muscle, B6, or B8 for up/down

Table A3

Subject C's Brainfingers Frequency Band Fluctuations

	Relax	Stare	Look Right	Look Left	Close Eyes	Lift Eyebrows	Bite	Clench Teeth
LR Glance B1	↓	↓	↑	↑	↓	↑	X	
LR Glance B2	↓	↓	↑	↑	↓			
LR Glance B3	↓	↓	↑	↑	↓			
Alpha B4	↑	↑	X	X	↑			
Alpha B5	↑	↑	X	X	↑			
Alpha B6	↑	↑	↓	↓	↑			
Beta B7	↓	↓	↑	↑	X	↑	↑	
Beta B8	↓	↓	↑	↑	↓	↑	↑	
Beta B9	↓	↓	↑	↑		↑	↑	
Beta B10	↓	↓	↑			↑	↑	
Muscle B11	↓	↓	↑	↑	↓	↑	↑	

Note. ↓ = Signal goes down   ↑ = Signal goes up   X = Poor Affect

Subject C control of muscle for clicking (B6 or B7 secondary controls for clicking), B2 or B3 for left/right glances, and muscle, B6, or B8 for up/down

Table A4

Subject D's Brainfingers Frequency Band Fluctuations

	Relax	Stare	Look Right	Look Left	Close Eyes	Lift Eyebrows	Bite	Clench Teeth
LR Glance B1	↓	↓						
LR Glance B2	↓	↓	↑	↑	↓			
LR Glance B3	↓	↓	↑	↑	↓			
Alpha B4	↑	↑			↑			
Alpha B5	↑	↑			↑			
Alpha B6	↑	↑	↓	↓	↑			
Beta B7	↓	↓	↑	↑	↓	↑	↑	↑
Beta B8	↓	↓			↓	↑		
Beta B9	↓	↓			↓	↑		
Beta B10	↓	↓			↓			
Muscle B11	⊠↑	⊠↑	↑	↑	⊠↑	↑	↑	↑

Note. ↓ = Signal goes down   ↑ = Signal goes up   X = Poor Affect

Subject D control of muscle for clicking is not an option - signal is at maximum.

B6 or B8 for up/down and or clicks, and B2 or B3 for left/right glances

APPENDIX B

Specialized Software Selections

<u>SoftTouch , Inc</u>.

   http://www.funsoftware.com

      Switch Software

            Teach me to Talk (2002)

            Teen Tunes Plus (1998)

            Switch Basics (2002)

<u>Inclusive Technology, Ltd.</u>

   http://www.inclusive.co.uk

      Switch Software

            Drumkit (2001)

            Disco (2000)

            SwitchIt Gadgets (1999)

            SwitchIt Bundle (1999)

            SwitchIt Arcade Adventure (1999)

<u>Sensory Software International Ltd.</u>

   http://www.sensorysoftware.com

      Switch Software

            Single Switch Connection (2002)

<u>IntelliTools, Inc.</u>

   http://www.intellitools.com

      Curriculum and Communication Software

            IntelliMathics (2001)

            IntelliPics Studio (2001)

Crick Software, Inc.

http://www.cricksoft.com

Curriculum Access Software

Clicker 4 (2001)

Gus Communication, Inc.

http://www.gusinc.com

Voice Output Communication Software

Gus Multimedia Speech System (2002)

Mayer-Johnson, Inc.

http://www.mayer-johnson.com

Voice output Communication Software

Speaking Dynamically Pro (2003)

Laureate Learning Systems

http://www.LaureateLearning.com

"The Language Activities of Daily Living Series" English-Spanish Version (1997)

Universal Software Selections

Disney Interaction

http://DisneyStore.com

The Animated Story Books

"The Lion King" (1998)

"Pocahontas" (1995)

"Winnie the Pooh and the Honey Tree" (n.d.)

"101 Dalmatians" (n.d.)

<u>The Learning Company School Division</u>

http://www.learningco.com

The Living Books Collection

Dr. Seuss	"Green Eggs and Ham" (1998)
	"A B C" (1995)
Marc Brown	"Arthur's Birthday" (1997)
	"Arthur's Computer Adventure" (1998)
	"Arthur's Teacher Troubles" (1994)
Mercer Mayer	"Just Grandma and Me" (1993)
	"Just Dad and Me" (1996)
	"Just Mom and Me" (1996)
	"Little Monster at School" (1994)
Aesop's Fable	"The Tortoise and the Hare" (1993)
Janell Cannon	"Stellaluna" (1996)
Tomie dePaola's	"The Art Lesson" (1998)

Reader Rabbit Educational Programs

"Toddler" (1998)

"Reading Development 1 Library" (1997)

"Zoboomafoo Animal Alphabet" (2001)

<u>Davidson & Associates, Inc.</u>

http://www.david.com

Fisher-Price

"Little People Discovery Farm" (1997)

"Sing Alongs Barnyard Rhythm & Moos" Volume 1 (1995)

"Ready for School – Kindergarten Edition" (1996)

Microsoft Corporation

http://www.mocrosoft.com

Scholastic's The Magic School Bus Explores (2000)

"Inside the Earth"

"In the Age of Dinosaurs"

"The Ocean"

"The Rain Forest"

Playskool

"Puzzles" (1995)

"Play-Doh Creations" (1995)