Introduction

Providing computer access, educational opportunity and meaningful employment for persons with severe physical disabilities is an important and challenging undertaking. With the advent of new technological capabilities, what has previously been a noble but impossible dream is now an immediate and pressing obligation. Persons severely disabled because of accident, disease or neurological disorder can, through the use of specialized computer access technology, be released from many of the limitations of these conditions. Communication, that vital linkage between one human being and another, can be enhanced, learning can take place, and, through access to a wide range of informational media, significantly improved opportunities for education, employment and societal contribution become available.

Perhaps more than any other identifiable population, severely disabled persons have been educationally disadvantaged and restricted from meaningful employ ment. It wasn't all that long ago that such persons were routinely labeled mentally retarded and relegated to perpetual care facilities as a matter of course. Recent advances in testing practices and augmentative communication devices have revealed that many such persons possess average to above average intelligence. Faced with this new information, we must now begin to consider innovative and effective methods for educating such individuals.

Education is a process which typically requires extensive communication between teacher and student. Such communication most often takes the form of spoken and written interaction. In the case of severely disabled persons who are unable to speak intelligibly or produce written materials with pencil and paper, the traditional educational process falters. Institutions of postsecondary education have responded to this issue by developing training programs in special education producing graduate instructors with the skills required to work with the severely disabled. Until very recently, however, nothing could be done to effectively reduce the effects of limited communication on the educational process of severely disabled persons. Through the use of adapted computer access systems, much can now be done to correct this difficulty.

The following section, "Computer Access Evaluation Techniques and Strategies for Individuals with Severe Physical Disabilities," describes the requirements of computer access systems for severely physically disabled persons with average to above average intellectual ability. As with the preceding portions of this book, the following text is intended to serve as a guide to what works, rather than a comprehensive discussion of all that is available. Instructors, counselors,
3.2 vocational rehabilitation staff and other members of the helping professions are often called upon to make decisions regarding technology and access issues on behalf of severely disabled individuals. Although access decisions would ideally be made only after a complete evaluation by a team of skilled professionals, travel difficulties, financial limitations and the present day scarcity of trained professionals in the field of computer access often make such ideals almost impossible to achieve. The majority of evaluation procedures and access technology recommendations are presently performed by diligent staff at K-12 institutions, vocational rehabilitation centers and special education facilities across the country. It is our hope that this guide will assist this dedicated group of individuals by providing a set of practical guidelines for evaluating the access requirements of severely disabled persons and selecting appropriate technology.

In general, we will be discussing access technologies for adolescents or adults which are suitable for singly or multiply handicapped, severely disabled persons with at least normal intellectual capacity. Our candidate might have sustained his or her disability through injury, birth defect, disease or neurological disorder. Typically, we would expect to see individuals without independent mobility and requiring fully motorized wheelchairs. Our candidate might be moderately to severely speech impaired or non-oral and require a full or part-time attendant. We would expect to see individuals who fatigue easily and who show evidence of learning disabilities and/or educational disadvantagement.

Unlike previous chapters of this book in which primarily software-based access systems for visually, learning and mild-to-moderately, physically disabled persons were discussed, the technology to provide access for severely physically disabled requires an emphasis on the best of both hardware and software-based access technologies.

Access Evaluation

Accurate access evaluations and technology recommendations for severely disabled persons can only be determined on a case-by-case basis. It is an exacting and lengthy process which should be systematically carried out. Please think of these materials as a set of guidelines and resources rather than a comprehensive "how to" text.

Seating

Seating is essential for effective computer access. Although it may seem odd to begin an introduction to computer access with a discussion of the importance of proper seating, experience has shown that in order for a disabled individual to work effectively, a comfortable, secure and stable seating arrangement must be established. Seating is a highly specialized field and should only be carried out by a skilled professional. It is strongly recommended that the services of a qualified rehabilitation engineer, occupational therapist or orthotist be enlisted to perform this task. Since endurance, range and mobility can be dramatically affected (both positively and negatively) by seating arrangements, any necessary modifications should be made prior to beginning a computer access evaluation.

The focus of this book is on computer access rather than the use of augmentative communication devices. Augmentative communication devices, how ever, will be used and described within their role as alternative keyboard systems.

3.4

Keyboard Access

The computer screen and keyboard are the primary interface between people and computers. Therefore, how the disabled individual will be provided with keyboard access is a pressing question. The first step involved seating issues; the second step addresses matching physical ability to the access options available to the individual. A practical, step-by-step method for determining if a keyboard can be used is available in Chapter 2 of this book. The following text describes systematic evaluation tools for making important access decisions based on the possibilities of a person with limited physical ability.

Since, in many instances, severely disabled persons will be unable to use the standard computer keyboard, alternative systems will need to be provided. Depending upon the individual's physical and cognitive ability, and on what selection options are available, keyboard access will fall within two general categories: direct selection and scanning. *Direct selection systems* provide various methods through which the user physically selects the key to be pressed. This can be accomplished through specially designed keyboards with oversized keys, optical pointers or highly specialized systems capable of determining what letter the user is looking at. Scanning *systems* typically move a selection indicator from one character to the next on a keyboard emulator or graphically simulated keyboard displayed on the computer screen. When the pointer rests on the desired letter or symbol, the user activates a switch which sends the selection to the computer screen as if it had been directly typed from the keyboard.

3.5

Efficient Computer Use

Once an effective method of keyboard access has been established, the third step in the process can take place: using the computer. In continuing our commit ment to recommending access technologies which work with, rather than replace, commercially used applications software (i.e., WordPerfect, dBASE, Lotus etc.), every effort has been made to utilize techniques which incorporate software- or hardware-based access systems which are transparent to popular software programs. Over the last two years, significant advances have been made in the development of the highly specialized technologies required of computer access systems for persons with severe disabilities. The primary purpose of such systems is to enhance the speed, efficiency and accuracy with which the writing process can take place. The following section will provide you with an understanding of the capabilities such specialized access systems must possess as well as a means for matching access needs of a disabled individual with currently available, reliable, cost-effective access technologies.

To be given an opportunity to provide severely disabled persons with a means for dramatically broadening life's possibilities is a rare privilege. We are deeply grateful for the occasion to share this information with you, the professionals, whose day-to-day work and commitment make the implementation of new technologies a practical reality.

3.6 Computer Access Evaluation Techniques and Strategies for Individuals with Severe Physical Disabilities

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Introduction

Computer access by persons with severe physical disabilities can be facilitated through a variety of hardware and software tools (Brandenburg and Vanderheiden, 1987). These tools, along with strategies for their use, methods for minimizing fatigue, maximizing speed and improving accuracy, are the means for developing efficient use of computer applications. A systematic evaluation approach should be followed in determining the most effective tools and strategies for an individual student. This chapter discusses the tools, strategies, and evaluation methods which comprise such an approach.

Tools and strategies for people with severe physical disabilities include a variety of input devices, enhancement tools, and selection and acceleration strategies (Figure 3.1). Input devices include keyboards, switches, the mouse, joysticks and optical pointers. Enhancement tools are used to modify the input device. These include headwands, mouthsticks, keyguards and trays, or tables, to adjust keyboard height and angle. Selection strategies include the use of direct selection or scanning to select the choices (i.e., alphabet, control characters) to be sent to the computer. In either case, the selection strategies should be transparent to the application software.

The evaluation methods presented in this chapter are intended for use by health care or educational pro-

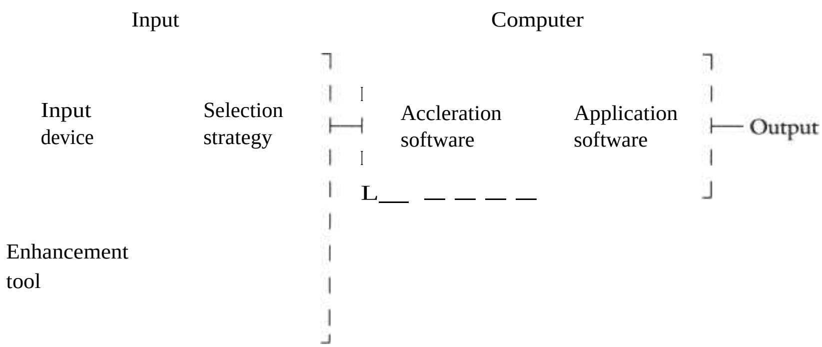


Figure 3.1 Block diagram of an adapted computer system

fessionals, with experience working with computers, and persons with physical disablility. Although these evaluation methods may seem extensive, they are by no means complete, when considering the diverse and complex needs of persons with severe physical disabilities. This chapter presents the practical experience of a multidisciplinary team integrated with a systematic evaluation method described by Barker and Cook (1981) . The multidisciplinary team works with severely physically disabled children and adults at the Children's Hospital at Stanford, Rehabilitation Engineering Center. The team includes a rehabilitation engineer, an occupational therapist and a speech and language pathologist. These evaluation methods will function best when used with persons who are not able to use a standard keyboard and/or mouse; are unable to use a keyboard with adaptations described in Chapter 2; or are able to type only at very slow typing rates (i.e., five characters per minute). Some of the evaluation strategies presented in this chapter are not suitable for children, non-readers or for persons having some types of cognitive impairments.

Input Devices

Input devices are described by characteristics that are relevant to their operation. These characteristics include:

- the number of independent choices or activation sites (e.g., number of keys on a keyboard)
- the size of the input device (e.g., keyboard size)

the size of each activation site (e.g., key or switch size)

the distance between activation sites (e.g., distance between keys)

the sensitivity (e.g., force required to activate the key or switch)

feedback which includes (1) travel (i.e., movement of the activation site), (2) auditory (e.g., mechanical or electronic click), (3) tactile feedback (e.g., resistance felt when pressing a key)

The classes of input devices are based on the number of independent choices or activation sites on the device. These classes include single switches, switch arrays and keyboards. Single switches have one activation site which is used to make one choice, either ON or OFF. Switch arrays (e.g., a group of single switches) include two to 10 activation sites. Keyboards include more than 10 activation sites, and often as many as 128.

Single Switches

Single switches are used to make one choice, ON/OFF. Without complex selection strategies and acceleration software, single switches are very restrictive. Single switches are represented by a wide range of activation characteristics. Activation characteristics include light-to-heavy pressure, movement and puff/sip (Table 3.1). Note that one group of switches is activated by movement and not necessarily by applying pressure.

Table 3.1 Activation characteristics of commercially available single switches

Activation characteristic	*Product name*	*Manufacturer*
Heavy pressure	Tread	Zygo Industries, Inc.
	Treadle	TASH, Inc.
	Single rocking lever	Prentke Romich Company
	Thumb	Zygo Industries, Inc.
	Square pad	TASH, Inc.
	Plate	Don Johnson Developmental Equipment, Inc.
Light pressure	Touch	Zygo Industries, Inc.
	Lever	Zygo Industries, Inc.
	Mounting	Don Johnson Developmental Equipment, Inc.
	Pushbutton	Zygo Industries, Inc.
	Pressure	Luminaud, Inc.
	Platform	TASH, Inc.
	Plate	TASH, Inc.
	Plate	Zygo Industries, Inc.
	Pinch	Steven E. Kanor, Ph.d., Inc.
	Pillow	TASH, Inc.
	Membrane plate	Crestwood Company
	Bite	DU-IT Control Systems Group, Inc.
Movement	Tip	TASH, Inc.
	Tilt	Steven E. Kanor, Ph.D., Inc.
	Mercury tilt	Luminaud, Inc.
	Infrared switch	Words +, Inc.
	Photo cell switch	Steven E. Kanor, Ph.D., Inc.
	P-switch	Prentke Romich Company
	Magnetic finger	Luminaud, Inc.
Puff/sip	Sip and puff	Steven K. Kanor, Ph.D., Inc.
	Pneumatic	Zygo Industries, Inc.
	Pneumatic	TASH, Inc.
	Pneumatic	Prentke Romich Company
Voice	Voice activated	Steven E. Kanor, Ph.D., Inc.

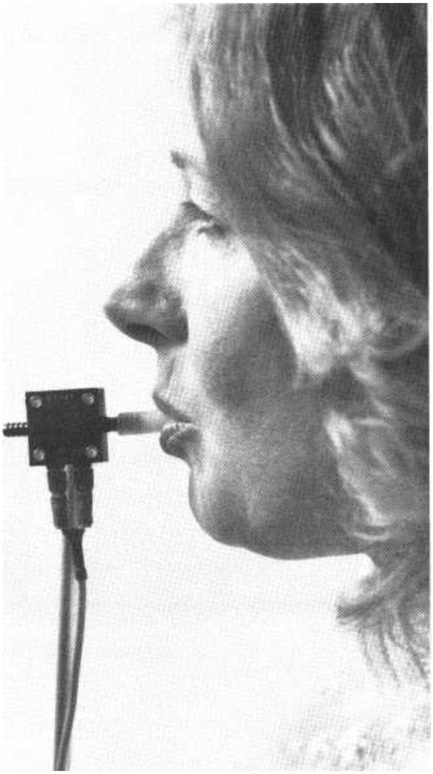


Figure 3.2 Pu,ffsip switch

Another group of switches, puff/sip (Figure 3.2), are not necessarily controlled by breath (e.g., air flow from the lungs) but by the change of air pressure. A puff/sip switch placed in the mouth can be activated by the change in pressure in the oral cavity. As a result, this switch can be used by people who are dependent on a respirator.

Switch Arrays

Switch arrays (Figure 3.3) provide two to five independent choices using a group or array of single switches. When used with computer applications, switch arrays are used for mouse emulation (e.g., to move a cursor around a display and make selections from a menu). Switch arrays are often packaged to stabilize the switches and increase their ease of use.

Joysticks

Joysticks can also be used for mouse emulation. Joysticks are either discrete or proportional. A discrete joystick can provide four to nine choices and is used like a switch array. A proportional joystick produces

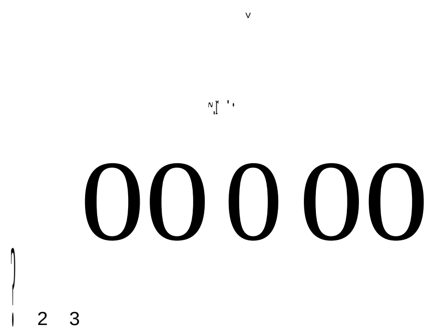


Figure 3.3 Commercially available switch arrays

an output that can take an infinite number of different values between zero and some maximum value. This is the type of joystick typically used with most of the popular computer games as well as to control a power wheelchair. A proportional joystick is dependent on the resolution of the computer or the input system (e.g., augmentative communication system). If the user is an extremely controlled driver of a powered wheelchair, and does not have the range or strength to use a standard keyboard (perhaps a student with Muscular Dystrophy), a joystick should be considered as an input device.

Keyboards

Keyboards range in size, number of keys and activation characteristics. Size is usually delineated as standard, mini or expanded (Figure 3.4). Keyboards consist of raised keys or a smooth membrane with activation sites. Keys are usually the most desirable due to the multisensory feedback provided by a key when it is pressed. Keys that click and move when depressed provide visual, auditory and tactile feedback. Membrane keyboards do not usually provide such feedback. The user must examine what is printed on the monitor of the computer system to determine if the activation has been registered. The primary advantage of the membrane keyboard is the wide range of keyboard sizes and number of keys. Overlays with words and phrases, pictures or icons, as well as the alphabet, can be used to label the activation sites on a membrane keyboard. It is difficult to relabel raised keys with words and phrases (when using macros, for example.) Additionally, few raised-key keyboards offer the range of key sizes (very large to very small) found on membrane keyboards.

Membrane keyboards usually provide better pro-

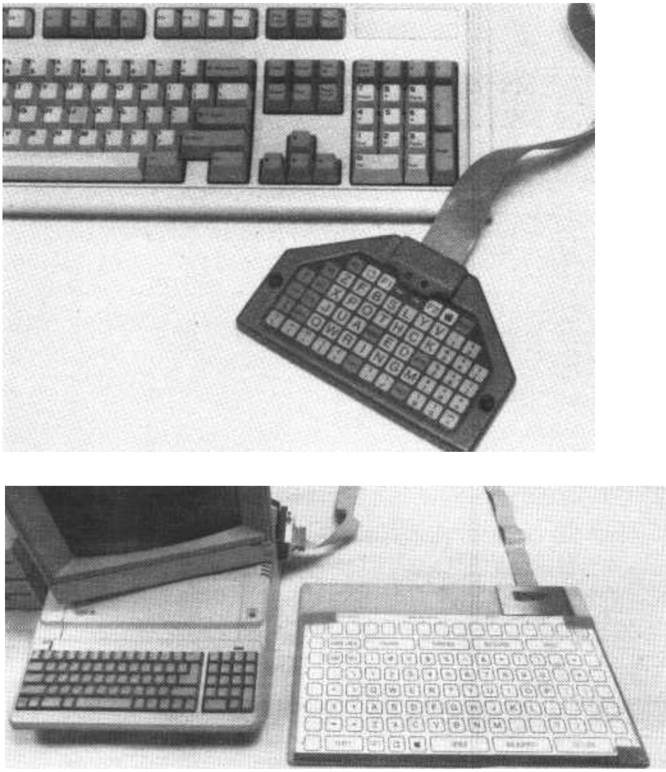


Figure 3.4   Examples ofkeyboards

tection of the electronics in the keyboard. However, plastic protective covers can be used on keyboards with raised keys providing protection from moisture and grime, thus extending the life of the keyboard. Plastic covers can also be used to temporarily relabel a keyboard. Letters, words and color coding can be attached to the cover. The layout of the alphabet and control characters can be rearranged on the keyboards of many commercially available computer keyboards. Macro and keyboard redefinition programs, included with

Figure 3.5 Optical pointer

many computers or available as commercially available software, can be used for this purpose.

There are keyboards that are activated by methods other than pressing a key. These methods include looking at a choice (i.e., eye gaze); pointing at a choice using a light (i.e., optically activated [Figure 3.5]); or voice (speech recognition). These methods can facilitate direct selection and produce faster typing rates for people who otherwise might use a single switch or a headwand.

Mouse, Trackball

The mouse and trackball offer an output similar to a proportional joystick. Memory resident software is available that facilitates the selection by a mouse or trackball of a character from a display on a computer monitor (Figure 3.6) The mouse requires some range of motion from the shoulder and hand grasp if operated by pushing it around with the hand. The trackball remains in place, and the fingers, a mouthstick or a headwand can be used to rotate the ball in place.

If a mouse is required for an application and a mouse or trackball cannot be used, mouse emulation should be considered. Mouse emulation can be ac complished by using switch arrays or a discrete joystick. These alternate input devices require an interface

Figure 3.6   Using a trackball for alphabet selection

board, that plugs into an expansion slot inside of the computer, or an interface device with a cable, that plugs into a parallel or serial connector on the computer.

Enhancement Tools

Enhancement tools can make it possible to use an input device with more independent choices (keys or switches) by minimizing errors and maximizing speed. Typically, these tools are hardware add-ons to the input device. Enhancement tools include tables and other surfaces with adjustable height and/or angle for input devices, keyguards for keyboards, slot controls for switch arrays, headwands, hand-held pointers and mouthsticks and their docking systems. (Docking systems are devices which allow mouthsticks or other pointers to be "parked," when not needed, and then retrieved for later use.)

During the evaluation process, enhancement tools should be considered as a method for improving student performance using an input device. It is impor tant to realize that enhancement tools can interfere with, as well as improve, performance with a particular input device. For example, a keyboard keyguard may reduce the number of errors but, at the same time, significantly reduce typing speed. The ratio of benefits versus disadvantages should always be carefully weighed when identifying the best combination of input device and enhancement tools.

Selection Strategies

The effective use of any input device is dependent on the selection strategies. Input devices are used to make selections which might include letters of the alphabet or control characters. Choices are presented to the input device user on a selection display. The selection display can be laid out on the keys of a keyboard, on the computer screen to resemble the keyboard, or on a separate panel (such as those used for scanning with a single switch or for optical pointing). Selection strategies include the position of choices on a selection display and the method of selection. Direct selection and scanning are two types of selection techniques.

Direct Selection

Direct selection is the independent selection of each choice. Direct selection is used with keyboards, optical pointing and eye gaze systems.

3.18 Alternate keyboard layouts (Figure 3.7) may facilitate faster or more accurate use of a keyboard. The standard typewriter keyboard layout (Qwerty) is designed to slow a typist down. It was developed at a time when keyboards were mechanical and many people's fingers could type faster than the keyboard could accommodate. The Dvorak keyboard is strategically designed so that the keys pressed most often are under the strongest fingers. Dvorak keyboards are designed for both hands as well as independent left or right hand use.

When using a single pointing device with which to type (headwand, mouth stick, single finger, etc.) students frequently need to look at the keyboard in order to locate the desired key. Although the Qwerty keyboard can be used, an alphabetically arranged keyboard can help with the search process. Centering the location of the letters on the keyboard layout (using Smartkey or any other keyboard recon-

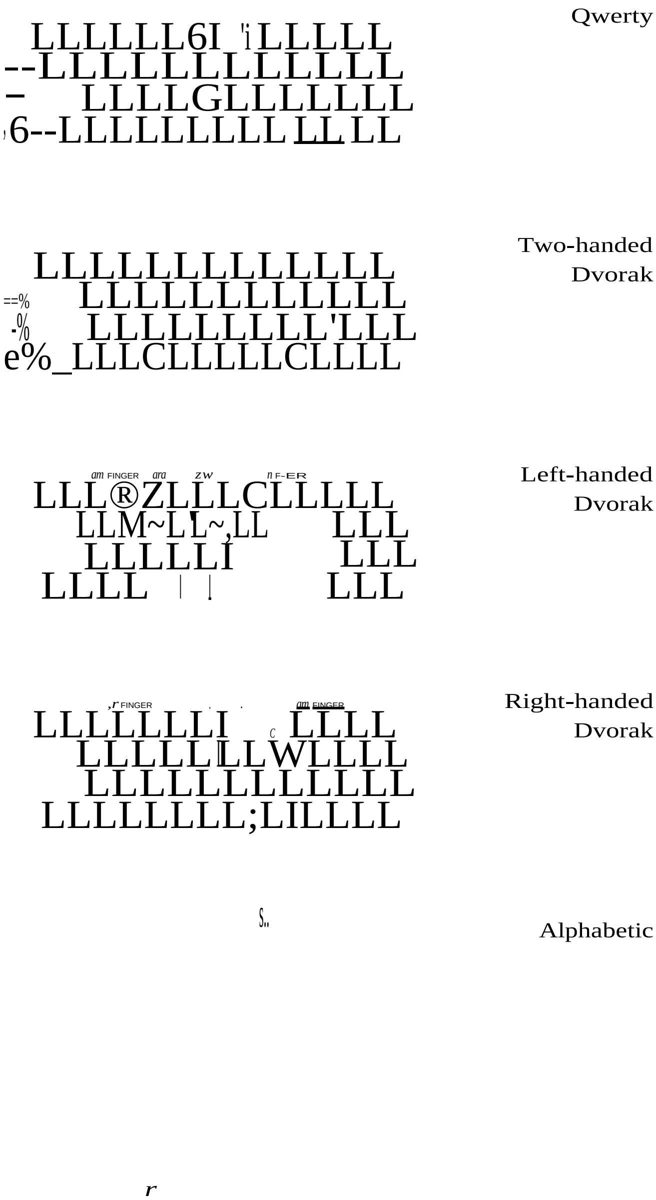


Figure 3.7 Keyboard layouts

figuration software) is also helpful when using a pointer, as it limits the range that must be travelled when making a selection. Repeatedly used words or phrases can also be included in the layout for some keyboards.

Morse Code requires the use of one, two or three switches to type out a code for the letters of the alphabet and control characters. The Morse Code can be a very powerful technique when using switches. For some disabled students, it can be faster or easier to use than the scanning techniques. It is particularly useful for individuals with visual-perceptual problems.

Scanning

Scanning is the sequencial presentation of choices and is used with a single switch or a switch array.
3.20 Switches are used to control the scanning and to select the choice. When using a single switch or a switch array, scanning methods are used to facilitate choices from a selection display of the alphabet, control characters, words and phrases. There are several scanning methods. The most appropriate method for a particular individual will maximize the speed and accuracy of his/her ability to send characters to the computer while taking into consideration the student's physical control of the input device and visual perceptual skills.

Selection strategies are either resident in the computer memory or are incorporated into an input device that is connected to the computer. In either case, the selection strategy should be transparent to the application software.

Step or manual scanning. Step or manual scanning is used with one or two switches. Each time a switch is pressed, the scan moves to the next choice

(A to B to C, etc.) Selection can be made with a second switch or can occur automatically if the pointer remains on a selection for a set period of time.

Auto scanning. Auto scanning is the automatic presentation of each choice. A switch is pressed to start and stop the sequential presentation of all the choices. The speed of scanning can be slowed or speeded up according to the needs and abilities of the user.

Row-columm scanning. When using a scanning system, choices can be presented one after another in a linear fashion or as groups. When present ing choices as groups, the switch is used to select the group and then a choice within the selected group. A common group presentation strategy is row-column scanning. On a matrix of choices, the rows are presented one at a time. The switch is used to stop the scan at the row with the desired choice. The scan then proceeds through the selected row, one choice at a time, and the switch is used again to stop on the choice. Group-row-column scanning (Figure 3.8) can be faster than row-column or linear scanning but requires more switch activations. Grouping can be in the form of the top and bottom half of a scanning matrix or three or four sections moving from the left to the right of the display.

Directed scanning. Directed scanning can be used with two to five switches. A switch is selected for the direction of the scan. For example, with 4 switches: one switch is used to move the scan in a upward direction, one to move down, one to move left and one to move right. A choice is selected after a set period of time or with a fifth switch. A directed scan with two switches can use one switch to scan vertically up or

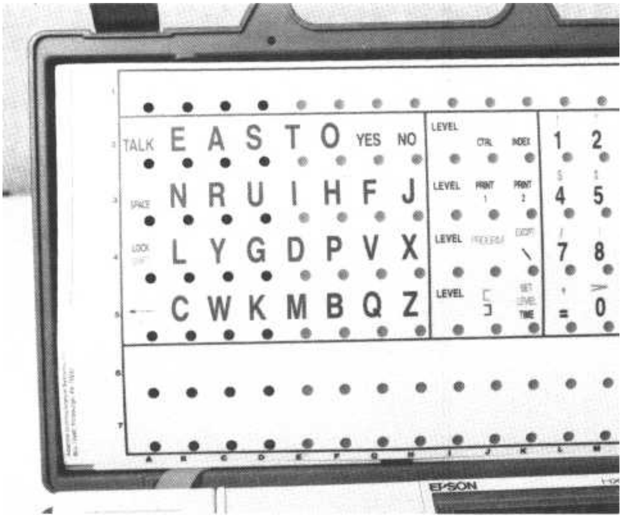


Figure 3.8 A highlightedgroup ingroup-row column scanning

down and the other switch to scan horizontally left or right. Directed scanning has the potential to be a faster scanning technique than group scanning presentations but it requires more user control.

Auditory Scanning. For people with visual impairments or visual perceptual problems, auditory scanning can facilitate the use of a single switch. Each choice is spoken during auditory scanning. Auditory scanning tends to be slower than visual scanning but can improve accuracy for people with anticipation problems or those that are able to process auditory information more easily than written information. It is very useful for non-readers.

Automatic Scanning. Automatic scanning techniques can be very difficult to use. Many people attempt to anticipate the movement of the scan and, as a result, tend to jump the gun and activate the switch before the desired choice is presented. Alternately, the physical control of a person's motor movement may be restricted by an abnormal reflex pattern that results in pressing the switch after a choice has been presented in the scan. These problems can often be resolved by slowing down an automatic scan, using a step scan or by training scanning strategies. The key to using automatic scanning at a fast scan rate is to look only at the desired choice and activate the switch when that choice is highlighted or presented (Weiss, 1983). Users must be discouraged from following or tracking the scan with their eyes.

Non-linear scanning speeds. Non-linear scanning speeds, currently available only on the Zygo Industries, Inc. Tetrascan, can also decrease the time to make a selection. The scanning speed at the top of the scanning matrix starts out slow and increases. This makes it easier for some people to make an accurate selection at the beginning of a scan without having to maintain the slow scan for the rest of the matrix.

Fixed and Transient Scanning Arrays

Scanning arrays and matrices are either fixed, with all of the choices visible to the user at the same time, or transient. The choices in a transient array change when a selection is made. For example, a section of a computer-based dictionary of words can be selected with a letter from an alphabet array. Transient arrays are presented on a monitor or an electronic display (i.e., LED, LCD) where the position of the selections can be easily changed. Transient displays are used to increase the number of choices available for selection. The capacity of such systems to present frill words and phrases is particularly useful for individuals with spelling problems or those who make selections slowly when using a single switch and scanning. However, persons able to use fast scanning speeds may find that a transient display can actually slow down their selection rate.

Acceleration Strategies

Acceleration strategies are used to increase speed and accuracy when using application software. These strategies are included in software that is either incorporated into an input system or available in the memory of the computer running the application software. Acceleration strategies include the storage and recall of words, phrases and sentences and prediction or anticipation techniques. Often used vocabulary stored in
3.24 the memory of an input device or a computer system can be recalled using number codes, abbreviations or other symbols (e.g., pictures, icons). Additional programs are available which reside in computer memory and predict letters (characters) or words based on the frequency of use or recency of use.

Acceleration strategies typically focus on reducing the number of keystrokes for typing words and phrases. For individuals with slow typing rates, acceleration strategies can be extremely useful. Conversely, for persons with fast typing rates, acceleration strategies may reduce input speed. It is important to note that persons with typing speeds in excess of about 15 to 20 characters/minute may find such programs more of a hindrance than a help.

Many features of word processors and other application software can also improve a user's efficency. Spelling checkers, thesauruses and grammar checkers are valuable tools.

Augmentative Communication Systems

Augmentative communication systems (ACSs) can incorporate an input device, and selection and acceleration strategies. ACSs can be used as an input system (e.g., keyboard) to a computer running typical software applications (such as word processors, spreadsheets and database managers). ACSs are typically specialized portable computers. The software run in the computer of an ACS is dedicated to producing written or printed output for communication. Some of these systems can be used as basic word processing systems but tend to be very limited. An ACS is typically used when its unique input system matches the abilities of a severely physically disabled person. Many individuals will also use an ACS for spoken communication. Spoken communication requires optimal speed and accuracy to be effective. If a person is already a good user of an ACS, the system should be seriously considered as an input to a computer as a means of running other application software.

ACSs can output to a speech synthesizer or a visual display (i.e., monitor, LED or LCD display) and can send a code (i.e., ASCII characters in parallel or serial RS-232 formats) directly to a computer. Those ACSs capable of sending a code to the computer are suitable for use as keyboard emulators. ACSs usually require interface boards that are plugged into expansion slots inside the computer running the desired application software.

For individuals who are not able to use their speech to communicate, a stationary computer system can be used as part of their ACS. It is absolutely essen tial, however, that the speech impaired person have a portable augmentative communication system which can be used in all the environments in which the individual needs to communicate.

Table 3.2 Augmentative communication devices (ACD) that can be used as part of a computer access system

ACD	*Manufacturer*	*Input devices*	*Input strategies*
EvaIPAC	Adaptive Communication Systems, Inc.	Keyboard Optical pointer Single switch Switch array Joystick	Direct selection Morse code Row-column scanning Group-row-column scanning Directed scanning
LightTalker/ TouchTalker	Prentke Romich Company	Keyboard Optical pointer Single switch Switch array	Direct selection Averaged pointing Row-column scanning Directed scanning

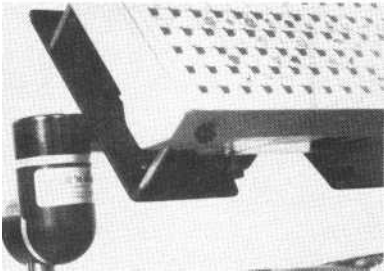
3.26 Table 3.2 is a list of ACSs that have been used as input devices to a computer. The ACSs listed are wheelchair portable. These systems are typically placed on a laptray that is attached to the wheelchair or on a wheelchair mounting kit (Figure 3.9).

Determining an Appropriate Input System

Input Device Identification

The first step in determining an appropriate input system is to identify the input device. The selection and acceleration strategies should not be considered until this first step is complete. The premature introduction of selection and acceleration strategies will interfere with the evaluation process to determine the best input device. There are three basic evaluation steps for identification of an input device (Barker and Cook, 1981):

1. Identification of anatomic sites with voluntary, controlled movement and analysis of the movement
2. Matching the characteristics of anatomic sites to potential input devices
3. Quantitative analysis of potential combinations of anatomic sites and movements with input devices



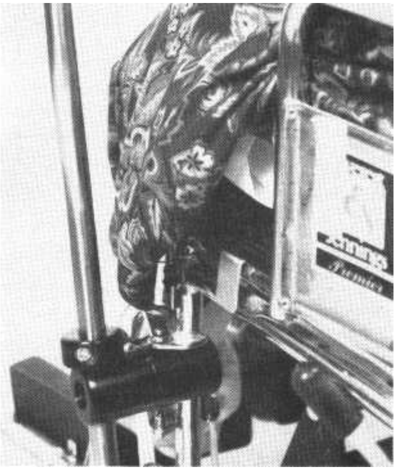


Figure 3.9 Augmentative communication system (ACs) stabilized on a commercially available wheelchair mounting kit

Several tools are essential to the evaluation process presented in this chapter. The Basic Evaluation Kit (Figure 3.10), in addition to a standard computer system, should be readily available to facilitate screening for useful input devices and strategies. By itself the kit may not be complete enough to delineate the optimal input device and strategy. The actual devices and intended application are often needed to substantiate evaluation results. Use of the evaluation process will shorten the time required to determine the optimal input device and reduce the amount of trial and error for the client prior to successful use of an input device and strategy with a computer.

Stop watch (electronic preferrable-quiet)

Tape measure
Protractor
Light and/or tone feedback device (i.e., Trace Multibox, others)
Range sheets (Figure 2.1, made of stiff cardboard covered with
 clear contact paper or laminated)
Switches
 Tread
 Lever or mount
 Light touch
 Puff sip
Mouthstick (dowels with mouthpiece, hard plastic tubing)
Headwand
Optical pointer (lightbeam, Headmaster, LROP, Freewheel)
Height adjustable table for wheelchair access (hospital table,
 computer table [Global])
Dycem, duct tape to stabilize controls
Software
 Multiscan
 Scanning program
  Keyboard speed Filch, others
Evaluation forms (Figures 3.11 and 3.13)

Figure 3.10 Basic Evaluation Kit

Identification of Controllable Anatomic Sites (CASs)

When considering use of keyboard alternatives or input devices other than keyboards and the mouse, there are several possible sites that should be considered. The most likely sites are the hands, head and feet, but any site that a person can voluntarily move should be considered. If any of the sites identified can be used as a pointer, a keyboard should be considered (Refer to Chapter 2).

Range, Resolution and Strength

Begin an evaluation by listing those anatomic sites that the student identifies as controllable as well as those sites that seem to have control based on observa tion. For each controllable anatomic site (CAS) listed, describe the movement by the direction, range, resolution and strength of the movement, as well as the position of the surface acted upon by the movement. These can be quantified by addressing the area which can include the input device or target, the size of the target, the distance between multiple targets and the postion of the target in space.

An evaluation form, Screening for CASs (Figure 3.11), is used to record information and compare the CASs and their movements. During the evaluation, the targets are the squares and corners of the squares on the range sheets (see Figure 2.1). The range sheets are used to evaluate the anatomic sites that have potential for direct selection; the hands, the head with a headwand or mouthstick and the feet. The student should be asked to touch the squares and then the corners of the squares on the range sheets. If a client is able to clearly touch a corner, that client de-

Screening for CASs evaluation form

Client ______________________________ Date

Activation sites (circle)	Head side L/R forhead eyes mouth tongue bite puff/sip chin	Shoulder Upper Arm Elbow Lower Arm Wrist	Hand L/R fingers paler	Upper leg Knee Lower leg	Feet
Movement/angle (describe)					
Range (inches)					
Resolution (fine/gross)					
Strength (weak/strong)					
Vision/hearing					

Comments:

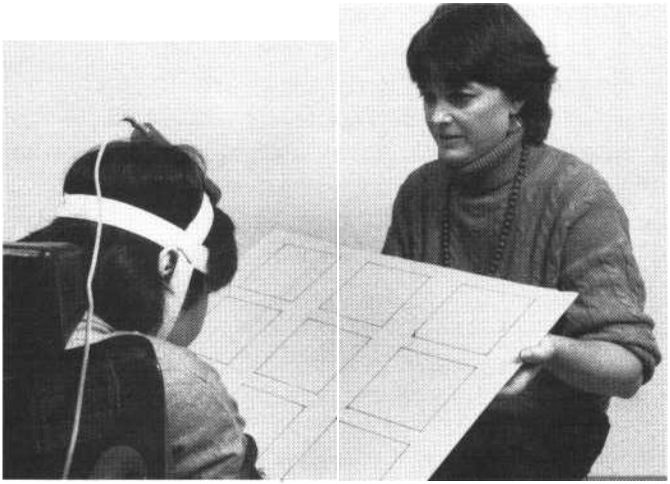


Figure 3.12 Using the range sheet during an evaluation

monstrates fine resolution. If the client is not able to clearly indicate a corner of a square but is able to indicate the whole square, the client demonstrates gross resolution. A range sheet (Figure 3.12) should initially be positioned as directed by the student. It should be repositioned to evaluate and compare other possible movements of an anatomic site. Repositioning is based on attempting to center the range sheet around the center of the functional range of the client. The range sheet should be used on not only a flat surface but angled in space, even considering the vertical plane for placement. 3.31

It is important to use a range sheet for the screening rather than a switch or keyboard. The use of a switch or keyboard at this stage can influence the per formance, requiring more time for the evaluation, and result in selection of an input device that is not optimal.

During the screening process, it should be noted whether there are known hearing or vision problems. These problems can interfere with performance using an input device and strategies, as well as limit the ability to read from a monitor or listen to a speech synthesizer.

Those CASs with the greatest potential for use with input devices are those with:

1. **the largest range**
2. **fine resolution**
3. **controlled strength**
4. no **interference by reflexes or other anatomic sites**

When considering the anatomic sites, also consider speech, eye gaze and head control. The use of speech for computer input is discussed in Chapter 2.

Eye movement can be used to trigger a single switch or to make direct selections. The person must be able to control either eye gaze, eye blink or eyebrow movement (i.e., wrinkle of the forehead). For eye gaze to be useful, there must be no nystagmus (rapid, uncontrolled eye motion) and the person must be able to maintain the eye gaze on a choice for a few seconds, with practically no head movement. Eye blink must be very deliberate.

To evaluate head control, start by analyzing head movement. Measure the rotation and tilt of the head to left and right and how far the person can move the head forward and back. Rotation is the turning of the head to the side. Tilt is moving the ear closer to the shoulder. When using rotation and tilt, it is important to consider what is happening to eye position. Some people cannot separate head movement and eye movement. If a person cannot maintain eye contact with the computer display during these movements, input to the computer will be slowed down. Eye contact is generally easier to maintain when using head tilt.

Matching CASs to Input Devices

The second evaluation step is the matching of the characteristics of the anatomic sites to the characteristics of the potential input devices. The characteristics of the input devices include the number of independent choices or activation sites (e.g., number of keys on a keyboard); size of the input device; size of each activation site; distance between activation sites; sensitivity and feedback, which includes travel (i.e., movement required of the activation site to produce a response); and auditory and tactile feedback.

Three CASs with the greatest potential for use with an input device should be considered. The range and resolution are used to identify the type of device that can be used (Table 3.3). A person's strength, as well as sensory skills, are used to determine the feedback characteristics of the device. For example, if the range and resolution indicate that single switches should be considered, the type of single switch can further be delineated by what is known about the student's strength.

If a person demonstrates a range as large as a standard keyboard and fine resolution, refer to Chapter 2 to evaluate for the use of a standard keyboard.

Head movement can be matched with switch arrays around the head, with a headwand, or mouthstick, and a standard, mini or expanded keyboard, or an optical pointer. When using a headwand, the pointer can come from the chin, the top or side of head. User

Table 3.3 Matching range and resolution to types of input devices

Range	*Resolution*	*Input device*
Large	Fine	Keyboard, mouse
Large	Gross	Expanded keyboard Large switch array
Small	Fine	Small keyboard Trackball Joystick Small switch array
Small	Gross	Single switch

preference is usually the deciding factor during the selection process. The student should have an opportunity to practice with each of these pointer positions. The length of the pointer and the position of the keyboard also play a role in the effective use of a headwand. The length should be the minimum length required to access the full keyboard without requiring the user to bend excessively from the trunk or the neck. The keyboard should be placed at a height just below the user's shoulders. It is often helpful to angle the keyboard at about 30 to 45 degrees. The length of the pointer and the distance between the user and the keyboard should be adjusted to accommodate this position.

When considering the use of a keyboard with a mouthstick or a headwand, also consider using an optical pointer. Try a light beam-type device such as an ACS Light Pointer or the Prentke Romich Company Viewpoint Optical Indicator. Ask the student to point to large targets such as those on the large range sheet

(Figure 2.1). If the student does not have immediate success, the student should be given an opportunity to practice with the device. If the student is able to point to the corners of the squares, devices that use optical pointing should be evaluated.

The optical pointers that can be used as input devices are available with several commercially available products including the Prentke Romich Company LightTalker, ACS EvalPac, Words+ LROP (IBM Compatible), Personic's Headmaster (Macintosh) and Freewheel (IBM, Macintosh). The ACS EvalPac optical pointer shines a red light onto the selection display. This system is one of the easiest to use with an optical pointer due to the visual feedback provided by the red light. The red light activates a matrix of sensors that correspond to choices. Other optical pointers rely on the feedback from the selection display. The selection display is usually a separate computer monitor from the one being used for an application (e.g., Words + LROP) or the selection display is positioned on a section of the monitor used for the application software (e.g., Headmaster, Freeweel). When it is on the same monitor, the selection display is usually on the bottom of the screen or can be moved into other positions. The selection display can also be a matrix of lights that indicate where the optical pointer is directed (e.g., Prentke Romich Company LightTalker). The Prentke Romich Company LightTalker can be used by individuals that have difficulty maintaining the position of the optical pointer. The positions that are being pointed at with the optical pointer can be averaged over a set period of time and a likely selection made.

Optical pointers can facilitate fast speeds using direct selection. Some people who use a headwand or a mouthstick effectively can improve their ability to access a computer by using an optical pointer. Persons unable to use a headwand or mouthstick may be able to use an optical pointer to facilitate direct selection. Optical pointers have proven to have greater application than previously suspected. The primary disadvantage in using an optical pointer is the increase in equipment expense.

Quantitative Evaluation

The third step in identifying an input device is a comparative analysis of the potential combinations of anatomic sites and movements with input devices. This analysis is used to determine a ranked list of the most effective combinations of anatomic sites and input devices. Following this analysis, the possible selection and acceleration strategies should be considered and evaluated to determine what the person should actually use with a computer application. The ranked list is needed because it is often the case that, based on an application or the use of strategies, the best input device will not necessarily be the one that is at the top of the list during the evaluation period.

Evaluate at least three combinations of anatomic site, movement and input device. For each combination, it is absolutely essential that the input device be stabilized on a stationary surface. If someone holds the device or if the device can be moved out of the desired position, the results of the quantitative evaluation will not be valid.

The evaluation should consist of qualitative as well as quantitative components. The quantitative evaluation includes measuring frequency or rate and accuracy. To determine initial scanning characteristics, reaction times are measured. The qualitative evaluation includes monitoring of fatigue and learning to use the device. If a person has not used an input device on a regular basis, learning to use the device will affect performance. The quantitative measures will often improve after a period of use. For example, optical pointers are initially very difficult to use. When first evaluated, a person may be very slow and make many errors. With practice, however, this tool can facilitate fast direct selection. If the student is interested and motivated to develop the skills required to use an optical pointer, he/she should be given the opportunity to practice for several days or weeks and then be reevaluated.

Potential Direct Selection

If a person is able to use his or her hands and type on a standard, mini or expanded keyboard, use the quantitative evaluation strategies described in Chapter 2. During the evaluation process, consider rearranging the keyboard in alphabetical order, in a layout of keys around a center point, or as a Dvorak keyboard. The typing rates and errors should be compared to those attainable with other input devices and strategies, such as those using switches (e.g., Morse Code) or those controlled with the head (e.g., optical pointer).

Single Switch Evaluation

The successful use of a single switch is dependent on the selection of an appropriate input device and selection strategies. Performance measures should be used to develop a rank ordered list of switches. This list of switches must be completed before selection strategies are identified.

Evaluate at least three switches from Table 3.1

based on the matching of CAS to input device strategies. Usually more switches will need to be evaluated. For each of the switches, measure average activation, reaction and duration times. Use the single switch quantitative evaluation form (Figure 3.13) to record performance.

Activation Time. To measure activation time, ask the student to press the switch five times and stop. The time should be recorded from the time the switch is first pressed to the fifth time it is pressed. The rhythm of the switch activations is noted as either even or uneven. This is an indicator of the degree of control the person has with a switch. It is important to note whether the student is able to stop pressing the switch after the fifth press. If the student is not able to stop, this may lead to problems when using a selection strategy. Other anatomic sites or movements should be considered or reconsidered if this occurs. This test is used to screen the switches. If a student cannot press the switch five times in less than 20 seconds, the single switch system is not a likely candidate.

Reaction Time. To measure reaction time, use a visual stimulus such as a flashlight or a computer. Ask the student to press or activate the switch when the flashlight turns on or when a character appears on the monitor. The time, from the tester providing the stimuli until the switch is pressed by the student, should be recorded in seconds. If the student presses the switch much faster than the tester is able to time, the student's reaction time is considered good and and should be recorded as less than one second. Some students are not able to see the visual stimulus and, in that case, an auditory stimulus such as a bell should

	Description	T	Activation time (sec)	Stop (Y or N)	Rhythm (even or uneven)	Reaction time	Duration
#1		1					
		2					
		3					
		4					
		5					
#2		1					
		2					
		3					
		4					
		5					
#3		1					
		2					
		3					
		4					
		5					
#4		1					
		2					
		3					
		4					
		5					

Figure 3.13 Single switch quantitative evaluation form

be used. If a person has good reaction times using the auditory stimulus, rather than with the visual simulus, auditory scanning should be evaluated.

Duration Time. To measure duration time, ask the student to maintain activation of the switch for 10 seconds. Count to 10 for the student. If the student is not able to maintain switch activation, selection techniques using maintained activation (e.g., directed scanning) should not be used.

Evaluating Selection Strategies

When using a single switch for the first time, the students should first be introduced to a linear auto scan. The student needs to learn to stop the scan at a designated choice. Initially, it is recommended that an

array size of nine or 10 be used. It is important to instruct the student not to follow the scan with the eyes, but to watch only the choice, and wait to activate the switch only when that choice is highlighted by the evaluation device.

If the user is able to use linear auto scanning easily, row-column scanning should be evaluated. When introducing row-column scanning, use a selection dis play with a matrix of at least 30 potential choices. Place three to five targets or choices on the selection display. If the student is able to accurately select the targets, introduce the letters of the alphabet as choices. It is desirable to position the letters according to frequency of use (Figure 3.8) and then allow the user to practice and learn the positions. After a training period, speed and accuracy can be measured. If row-column scanning is effective, consider group-row-column scanning.

If visual scanning strategies are not useful, auditory scanning should be attempted as well as Morse code. Each of these strategies should be tried and, if they have potential, the alphabet should be introduced. The student should be given a practice period of several days before speed and accuracy is measured.

Best Results of the Evaluation Process

The best input device, enhancement tools, selection and acceleration strategies should facilitate input to a computer by the user at a rate which is comparable to that of an able-bodied peer for creative writing (production of approximimently two to four pages per hour). Desirable typing speeds are approximately 30 to 60 characters per minute with an error rate of less than one error per 100 characters selected. A person should be able to work at the computer for at least an hour at a time for a total of five to six hours per day.

Janie: A Case Study

Students with profound orthopedic disabilities present a unique challenge to educators. In order to fully participate in the academic environment, these students often require many special services including personal attendants, tutors and on-campus transportation. Even with such services available, the nature of many profound orthopedic disabilities limits oral communication and greatly increases the time required to produce written work. These difficulties have been the ultimate barriers which no legislative action or heroic effort on the part of program administrators or student services personnel have been able to remove. And yet, the need among severely disabled persons for post-secondary education is critical. Disabled persons who lack college degrees are almost totally unemployed. After subtracting the substantial, and frequently ongoing, cost of medical expenses from the modest income provided through Supplemental Security checks, most severely disabled persons who lack college degrees find themselves in an economic category below that of inner-city Blacks.

Although computers have always held great promise for disabled students, until recently effective use of microcomputers by students with profound dis abilities has been virtually impossible. The difficulty arises from a fundamental design characteristic of microcomputers: their users must be able to see the screen and manipulate the keyboard. Severely disabled individuals may be unable to accomplish either of these
3.42 tasks.

Recent refinements in the field of adapted computer technology have been particularly significant for profoundly disabled students. In many instances, it is now possible to dramatically improve the speed and efficiency with which such persons can produce written material.

The process of providing access to adapted computer technology for a profoundly disabled college student is well illustrated by Janie, a young woman se verely disabled by athetoid and spastic cerebral palsy who is not able to use speech conversation and has no functional use of her hands, arms, feet or legs.

Limited facilities and services available to Janie in her native state seriously reduced her educational opportunities prior to moving to California. In 1982, her family came to California so that she could attend a school which specialized in working with the severely disabled. Janie had used an ETRAN (a clear, plexiglass sheet covered with numbers and the letters of the alphabet used to spell out sentences one letter at a time) as her primary means of communication since she was very young. She had mastered the eye gaze strategy with her family but the system was ineffective with people who did not know her well. In addition to the ETRAN, Janie used a Prentke Romich Company Express III (a sophisticated, computerized device which provides communication by voice output through synthetic speech and a small printer) which she accessed through use of an optical pointing system to enhance her communication options.

Janie came to Monterey Peninsula College after receiving a diploma from a local high school. She was 23 years old, highly motivated and eager to learn. As a result of limited educational opportunities, Janie had serious deficits in many basic skills areas. To be a successful college student, her basic skills level, and the ability to communicate effectively and produce written materials would all need to be dramatically improved.

After extensive consultation with Janie, a speech pathologist, a physical therapist, the college's Director of Supportive Services for the Disabled and Janie's family, decided upon a course of action: Janie would be provided with access technology which gave her maximum use of personal computers. The primary focus would be on word processing with extensive computer-assisted instruction programs used to upgrade her skill levels in the areas of reading, spelling and writing. With the possible exception of assistance required to turn on the computer, the system would be designed to allow Janie to use all of its options independently.

To accomplish these computer access goals, several major questions would need to be answered:

1. How to access the computer keyboard given the limited control of head movement Janie possessed (enough to operate the Express III with the infrared optical pointer but not nearly enough to allow her to use a standard PC keyboard with a headstick or other pointing device)
2. How to design a "user friendly" computer interface which would provide full access to all programs and resources while continuing to make sense to someone with no previous exposure to computers
3. How to reduce the sheer volume of time Janie required to complete written assignments, carry on conversations and answer classroom questions
4. How to generate the funding with which to buy the equipment to solve the first three problems

The funding issue was solved decisively and dramatically by a group of businessmen who became aware of the project and promptly raised $27,000 to provide Janie with whatever technology might be needed.

Selecting Appropriate Access Systems

Several keyboard access alternatives were considered (scanning systems, direct visual selection and special keyboards) before a decision was made. Ex treme spasticity and rapid fatigue precluded the use of any kind of physical pointing system to access the keyboard. Eye gaze systems were impractical due to spasticity and pronounced nystagmus. Although she was capable of using a scanning, single switch system, Janie had a strong dislike of this approach and would not consider it as a possibility. Scanning would also have been much slower than Janie's present communication speed with the Express III. We determined to use Janie's Express III for computer access since it could also be made to function as a remote keyboard for the PC computer through use of the model K-II Keyboard Emulating Interface for the IBM PC from the Prentke Romich Company.

Since Janie was already proficient at using the Express III, it represented one less obstacle to overcome along the way to providing her with computer access. The reduction in speed of text production brought on by Janie's limited key selection accuracy and the mechanics of using the communication device could be offset through use of "smart" word processing software.

Designing Friendly Environments 3.45

With ease of use and timely production of accurate, written communication as primary goals, we began the second phase of the project: selection of software and design of the interface between Janie and the computer. For many profoundly disabled persons, the use of a computer is a "necessary evil." When designing special access methods for use by such individuals, it is vital to remember that the person using the system may or may not have any special interest in computers per se. Simplicity is absolutely essential. Janie was not inherently fascinated by computers nor particularly interested in the technology; she simply wanted a tool she could use independently which would allow her to write effectively and learn at her own pace.

Using an IBM PC XT with a 10 megabyte hard disk, we designed and programed (using simple commands in the IBM PC DOS batch file language) a sophisticated and yet easy-to-use, menu-driven interface which could be operated with single keystrokes. The main menu, which appeared automatically after the computer was turned on, provided three main options: word processing, word exercises and games. Selecting the word processing option displayed a secondary menu of word processing categories which Janie agreed seemed to cover most possibilities: homework, business, personal letters, communication or return to main menu. Selecting the word exercises option displayed a secondary menu of choices: Word Attack, Spell It, Speed Reader II (Davidson Associates software) or return to main menu. Selecting one of the word exercises options would display a third menu offering various grade levels at which to work. Choosing a grade level started the selected program using materials appropriate to that grade level. Each of the

programs from Davidson Associates were similar in design and operation, thus reducing the learning time and simplifying the overall use of the computer assisted instruction programs. Upon exiting any of the selected programs (word processing, word exercises or games,) Janie was automatically returned to the previous menu. In this way, Janie would have independent access to all programs available on the computer system.

Selection of appropriate software is a critical process. It must meet the student's needs without becoming overwhelmingly complex and, in the case of se verely disabled students, it must function harmoniously and concurrently with one or more hardware and/or software adaptations operating in the "background."

In order to enhance and extend Janie's ability to produce written and "spoken" text, we employed a new software technology which may hold tremendous potential for profoundly disabled students. "Smart" word processors such as MindReader from Brown Bag Software use techniques of artificial intelligence to examine the context of a sentence being written and "guess"-with amazing accuracy-the word or phrase about to be typed based on its initial one or two letters. For profoundly disabled individuals, such programs provide a significant increase in the speed at which text can be produced. Such programs also have the ability to learn the writer's style and selection of vocabulary so that as time goes by, a very real partnership is established between writer and software resulting in greatly increased productivity.

In order to expand Janie's ability to produce "spoken" communication, we included Freedom 1, a program often employed by blind computer users to read any or all of the screen display. Speech output was produced through DECtalk, a state-of-the-art speech synthesizer from Digital Equipment Corporation. In combination, these two components provided an easy method for Janie to "say" as much or as little of what she had written as she wished. Using a sophisticated speech synthesizer like DECtalk also made it possible to create a distinctly female, non-robotic, young woman's voice. Janie's ability to identify with her artificial voice greatly enhanced her willingness to communicate verbally and thus improve both her written and "spoken" communications skills.

Slight modifications (with the publisher's permission) were made to the computer assisted instruction programs (Word Attack, Spell It and Speed Reader 11) from Davidson Associates so that they would function smoothly within the design interface.

Training was the final, and most important step in the process. Although Janie had been involved in every phase of the project's development, ultimately, its success would depend on her ability to learn and use it.

We divided Janie's training into small chunks of information which could be easily mastered. Initial trainings focused on accessing and using the word pro cessor in simple and practical ways. Additional lessons included methods for reading the screen, printing, using the instructional software and games. With each training, she gained a sense of increasing competency and success. Several months were required to complete the entire process and advance Janie to the point at which she could begin to function independently. Training was also provided to Janie's parents and aides who would also operate and maintain the computer system.

The system works well. Janie uses it daily to complete class assignments, write letters to friends and communicate with people in her home environment. She has learned to operate all of the basic features of the computer and continues to develop and refine her skills and abilities. Although Janie can now function much more competitively in the academic environment, it is only a beginning. Much remains to be done as unexpected and sometimes humorous problems continue to arise. Janie's enthusiasm for writing and learning have been such that her extended periods of using the Light Talker/computer interface have resulted in serious neck strain. Having acquired access to a device which greatly expanded her freedom of communication, Janie began to produce text in a volume sufficient to clearly demonstrate the extensive scope and range of her learning deficits. Adapted computer technology has provided an opportunity for a bright, highly motivated and remarkable young woman to reach beyond her disability and take a firm grip on the future.

We asked Janie to write about her life as a way of sharing her remarkable spirit with others. What she wrote seems a fitting conclusion to this study and ample justification for the importance of providing profoundly disabled students with access to adapted computer technology.

janie

My name is Janie and i was born in Phoenix, Arizona the youngest of eight girls. But i got picked to have C.P. but somehow we did live thru it. For eight days the mds told my mom and dad that I would not live ut boy I did and people who knew me well just look and say Why me God. But I am happy that I did live because I have seven good sisters who would not let me think I have C.P. Where they went I went. When I was little I would be home plate for the ball games or I would be out fielder. They would tie my chair to their bikes and take me to the store with them. One time they were going on camp out to the Grand Canyon and I was on the floor watching them pack and my mom said no you cannot go. So they put my bag and clothes in car and said by mom and picked me up and I did go. I went on a river trip with my dad and y sister Kayla and Marilyn and her man. My dad did not go on trip but he did drive us up to the river. I rode on horses with my sister Kayla and we did jump barrels but my mom almost had a heart attack and said no no no. So we said ok mom and gave each other the wink and go ride some more.

My mom went to schools every year and asked if I could just sit in on class but they would say no we can not handle her so when I was four years old my mom took me to a cp school and they put me in room with just old lady and babies and pens and paper and gave me mush to eat. So I cried and after half day the school called my mom and said come and get this kid.

Every year when it was time for school to start my mom would go to the school near us and try to get them to just let me sit in the class when they were teaching reading but they would always say that I am retarded and they did not take retarded kids. So one day a Nun come to visit and she said if you do not think this kid is etarded I don't think she is so we will d out. So the sister andmy mom and dad took me to L.A. to Rancho LosAmigos and they tested me for two days and sent their report to us. It said I am little retarded. So my mom and jump up and down and took me back the next year for them to test me again. So they brought an "expert" up from SanDiego to test me. His report said this kid is of normal intelligence. So my mom took it back to the school and they said but it is a law that kids have to be potty trained to go to school. My mom sat on the floor and cried and my sister Cynde was going to Europe the next day and
3.50 she said "Janie, if you can tell us when all your soaps come on and what number they are on you can tell us when you have to go so I will give you 25 cents for every time you go to the john while I am gone. She still owes me money but the next time my mom went to school I was potty trained. I will do anything for money. Well; almost anything.

Now the school did not have any more excuses to not let me go so they sent me to a school name Gomper's Rehab. It was a ok school but it was not for me. I was not getting time to be taught and when the teacher sent home a good picture and said Janie did it all by herself and I can not use my hands my sister Kayla made me a sign and I did picket the teacher. Boy she was mad. But I did go to summer school and one day some teachers who were there to observe while working to get their masters and they did pick me to watch. When the day was ended they told my dad and me about Washington school because it had special classes for me. So I went there for the next three years. They were very happy years.I had the same aide for three years and she is one of my best friends today. At that school I learned to TYPE with my head and to use the Bliss symbol board which I did not like. Each year in May we went on a three day camp out. Half of the kids had never been away from home at night. It was a blast. My dad and Kayla went my sister worked with the kids but my Dad was food man My sister is now a Special ed. teacher.

To get money for our camp outs the kids sold tickets for a raffle. I got my bus driver to make an afghan and my sister Anne Marie took me all over our streets selling tickets. **I did sell over $200.00 in tickets** the most in the school and all people were shocked but not Pat the aide in my room, who is one of my good good friends today. She said thats my Janie. I did graduate and then I went to high school. It was o.k. but I had a man teacher and he did read the news paper for two years. He did talk the school to buy Express 2 but he got put in a new room. My sister Tricia was T. at a school in L.A. for handicapped kids and the school had summer school so my sister asked the speech teacher for books on communication and she said no bring Janie to summer school. So I went for six weeks and that lady really knows her stuff. That is when I got my E-Trap. And she is still my friend today. One day my sister Marilyn called me from Phoenix and said Guess what Janie, you are going to have a new teacher and you met her when I worked with her at the Grand Canyon that summer. She did hurt me and that is all I want to say about her.

My mom and dad said they would find me a new school so that summer we went to see schools in south Ca. but we did not like it there so we came up here to see my sister Tricia who lives here now. We could not find any school here so we packed our bags to go home and give up. My mom is into old things so talked my dad into one more day so she could go to an auction.

I am not in to old things so why I did go I do not know. I was talking to my mom and my sister Tricia with my E-tran and a lady setting behind us was watching me for a long time. She asked us about the board and said I was a speech teacher at A.B. Ingham school and I know kids who could use a board like that. We went home and called the school and they were having summer school so we could come out to see it. My mom and dad and Tricia fell in love with the O.T. She showed us things she was making for the kids. I did wonder about her she just was too good to be true. I cannot spell too well and her name is Georgette so I just called Nuts. That is short for Nuts and Bolts because she always ran around with a little box of nuts and bolts fixing things. But in my book she will always be "My O.T."

And there was Verjean my speech therapist who I call Red. She is my eyes and ears and always looked for new things for me.It would be a book for me to tell about Jim and the staff and how much they did do for me and how much they mean to me.

Now I do believe in miracles and I did get mine when I went to that auction and ran into that lady. Because I did meet Nita, my teacher. I cannot I cannot say what she means to me. I was hurting in my ego really bad when I went to A.B. Inghamand I really did not want to go and Nita knew it because I did not want to live over here away from my other sisters. But I heard my dad say for 23 years Get high school diploma and I only had one more year in Arizona. But I did know I could not make it without going nuts so `I did make up my mind to come over here. But Nita worked with my ego and, Boy, she did get it back in shape. It is running over now. She worked me really hard and told me you are coming to summer school so I said o.k. If I did say no she would say I am sorry Janie but you are. So I did. We did bring my grade level up in two years and six weeks.And I did graduate. Now i am going to M.P.C. and I got a B in my first class, Child Development. So I do think I will make it.

References

Barker, M.R. and A. M. Cook. (1981). A Systematic Approach to Evaluating Physical Ability for Control of Assistive Devices. Proceedings of the Fourth Annual Conference on Rehabilitation Engineering. Washington, D.C.

Brandenburg, S.A. and G.C. Vanderheiden. (1987). Rehab/Education Technology ResourceBook Series: Communication, Control, and Computer Access for Disabled and Elderly Individuals. Boston: College-Hill Press.

Weiss, L. (1983). "An Improved Row/Column Scanning System, TETRAscan II." Zygo Industries, Inc., PO Box 1008, Portland, OR 97207.