HUMAN INTERFACE DESIGN AND THE HANDICAPPED USER

ORGANIZER:

William Buxton
Computer Systems Research Institute
University of Toronto
Toronto,Ontario
Canada M5S 1A4

PANELISTS:

Lawrence Scadden (Chairman)
Director, Rehabilitation Engineering Center
Electronic Industries Foundation
1901 Pennsilvania Ave. N.W.
Suite 700
Washington, DC 20006

Richard Foulds
Director, Rehabilitation Engineering
Tufts University School of Medicine
Tufts-New England Medical Centre
171 Harrison Ave.
Box 75K/R
Boston MASS 02111

Fraser Shein
Rehabilitation Engineer
Hugh MacMillan Medical Centre
350 Rumsey Road
Toronto, Ontario
M4G 1R8

Michael J. Rosen
Principal Research Scientist
Mechanical Engineering Dept
Room 3-137
MIT
77 Massachusetts Ave
Cambridge MASS 02139

Gregg Vanderheiden (in absentia)
Director
Trace R & D Centre
Waisman Center
1500 Highland Avenue
Madison Wisconsin

INTRODUCTION: William Buxton

The use of computers in the workplace has increased our opportunity to open new avenues of employment for handicapped people. However, the full potential of this opportunity is far from being realized. In fact, as Lawrence Scadden points out, some design decisions aimed at improving the interface for the non-disabled user are making those same systems less accessible to those that are handicapped. ("Direct Manipulation" interfaces, for example, present real problems of access for the visually impaired, compared to more traditional keyboard-based interaction.)

Our hope for this panel is to increase designers' awareness of issues pertaining to the interface of systems used by physically handicapped individuals. We have four main objectives:

1. To present a basic taxonomy of motor, sensory, and cognitive disabilities and how they affect performance.

2. To familiarize designers with what special interfacing devices are available to the handicapped user, and where these devices and information about them are available.

3. To present the case for a standard interface (hardware and software) for alternative devices on future computers, and to inform the CHI community about efforts in this direction being undertaken by the Department of Education.

4. To help designers better understand the impact of how their decisions will inhibit or facilitate the use of their systems by handicapped users.

Within the context of the panel, it is clear that these issues can only be addressed at a very general level. The best that we can hope for is to raise the general level of awareness of the issues, and provide pointers to more detailed sources. There are two main sections to the remainder of this written presentation First, we present some introductory statements of position. Second, we provide pointers to sources of additional literature and technologies.

CONTRIBUTION: Fraser Shein

Innovations in interface technology have advanced to the level where even the most severely physically disabled person can now operate a computer. A few years ago, rehabilitation professionals were asking, "How could a disabled person control a computer?", and "What could they do once they achieved control?". Today, a multitude of specialized input systems enable disabled persons to access computers, and they can potentially engage in the same activities as everyone else and a few special applications such as augmentative communication. Now the key question is, "How can someone who is disabled and uses a special input system achieve equal and independent access to any computer-based technology used by the rest of the population in a reasonable and economical manner?".

Before describing a variety of interface devices used by disabled persons, I would like to put forth the concept of a business executive as a physically disabled person to illustrate a parallel. An executive often doesn't want to use the traditional keyboard because it is slow and awkward, while a physically disabled person can't use it because of some physical limitation. Both need quick efficient access to computer systems with minimal effort. However, access problems are accentuated by a physical disability when an alternative input mode is essential rather than a feature. It may turn out that developments for helping disabled persons will have an impact upon the able-bodied population and help the business executive. These developments are ongoing in a field called rehabilitation engineering.

The key concept behind computer control for disabled persons is *transparent access* which allows them to use any commercial software application through whatever input device they employ. Custom application software for disabled persons is not a feasible solution unless a specific application does not already exist. Similarly, a custom computer is not economically practical.

Keyboards may be modified to compensate for poor finger control through: attachment of keyboard guards; replacement of keys such as SHIFT and CONTROL with latching-type keys; disengagement of the autorepeat function of keys; and the inclusion of a key delay such that the key must be held for some time before being accepted to reduce accidental selections. Furthermore, keyboards may be redefined and multiple keystrokes reduced to a single macro through background software to facilitate access with a single finger and head-mounted or mouth-held pointers. Expanded and miniature keyboards and touch panels are now available for persons with poor targetting ability or restricted ranges of movements. One-handed chordic keyboards may be used effectively by persons having one functional hand or by blind persons since the fingers never have to leave the keys.

When a person does not have the ability to make direct selections required by keyboards, then a method that emulates keyboard action can be employed with an indirect selection scheme using the limited movements available. As little as a single-input may be used although arrays of inputs (usually up to five) provide greater control. Here, some keyboard-like arrangement of letters, words, pictures, or symbols are presented to the user. A cursor scans these items automatically or under manual control of the user's input device, and a selection is made by some intentional input action. A large number of input devices are available including: a variety of microswitches, lever and leaf switches, pneumatic switches, joysticks, EMG switches, capacitive touch plates, and membrane switches. Almost any intentional movement of the body may be tapped with an appropriate device.

It is important to note that the user's input shouldn't be considered as just a switch. Rather, it is comprised of four key components that have been termed MSIP - body (M)ovement, body contact (S)ite, (I)nput device, and (P)osition of the input device (Shein, Lee and Milner, 1983).

Presentation of information for scanning selection may be done on a separate hardware device such as an array of LEDs or a second computer terminal. Alternatively, with a single computer a pop-up window may be displayed on the screen in which items are scanned. In all cases, selected items are interpreted by the host computer as if entered from the standard keyboard.

One very powerful, yet inexpensive front-end system is the MOD Keyboard System developed by the National Research Council of Canada (Nelson et al, 1983; Lee et al, 1985). An inexpensive home computer is used as a front-end to display items that are scanned, selected, and transmitted to the host computer. The user interacts with two monitors where one monitor is a visual keyboard and the other monitor displays the host application. Customized software modules are available that plug into this home computer that incorporate a variety of input methods and display features to adapt to a wide range of different user characteristics. The end result is that most physically disabled persons can access any commercial software on the major computer systems available today without any modifications to the software.

We (Shein et al, 1984) have developed another dual-computer system where one screen displays items in Blissymbols, a visual-graphic communication system for non-speaking persons. Selected items are translated and sent to the host computer as conventional ASCII strings. In a recently-completed research project a number of severely disabled students were taught to program in Logo entirely through Blissymbols using this method.

The use of pop-up windows gained prominence through the use of a device called the Adaptive Firmware Card (Schwejda and Vanderheiden, 1982). This plug-in card for the Apple *//e* has a number of desirable features including: several single-input scanning strategies (both automatic and manual); morse code input; facilities for redefining external keyboards; an adjustable program slow-down mode; and single-input analog paddle emulation. The disadvantages of this card are a limited single-line display window for scanning and its hardware dependency.

Voice input is becoming more widely used and offers great potential for disabled persons who have virtually no limb movements. An interesting development in the rehabilitation field is the idea of poor voice in and good voice out. A speech recognition unit may be used to recognize dysarthric speech which is processed and output through a good quality speech synthesizer. Another technology that is still in its infancy but having great potential is eye-gaze control. While a number of systems are available, they are prohibitively expensive and are prone to loss of calibration when the head moves. A number of clinical issues such as using the eye as both a receiver and selector of information, and positioning still remain to be resolved.

Of all the interface technologies mentioned, there is not one approach that will meet the needs of all disabled persons since everyone's needs and abilities are so different. Choosing or designing interface systems for disabled persons is a multi-objective task. There are three main aspects that must be considered, each with a number of objectives that must be achieved within certain constraints.

First to be considered is how one physically accesses some input device. Physical performance of the user is to be maximized by taking advantage of efficient movements which may be defined as those that a person can reliably initiate, control, and return to a resting position. Generally, a larger number of efficient movements is desirable. Negative physical factors must be minimized such as fatigue, overflow from one movement to another, stimulation of abnormal movement patterns that interfere with control movement, and poor posture. Performance characteristics of the input device must be maximized through consideration of arrangement of keys or switches; physical properties of the device such as overall size, key/switch dimensions, and feedback (tactile, auditory, proprioceptive). Also to be maximized is the transfer of information through some selection strategy appropriate to the user's input device and cognitive level. Other factors to be optimized include comfort, cost, reliability and durability given the consideration that the user may be using the input device for prolonged periods of time and may carry the device at all times. Further, efforts must be made to ensure that the user can independently use the input device. Often an able-bodied person is required to set up the input device and this reduces independence.

Second, the ergonomics of the physical configuration of computer system components with respect to the user must be considered. Efficient access and interaction with all peripherals must be maximized. Positioning of monitors or displays is especially important for persons in a wheelchair who may sit further back from a table than what is considered normal. Any dual displays must be positioned such that the user readily sees both screens and that switching gaze from one to the other does not interfere with the input. The user may not need to sit at a table if the standard keyboard is not employed. A remote keyboard placed on a wheelchair tray may be a better and less expensive solution than an adjustable table. Placement of the main processor is less important since the user generally doesn't interact with it except to insert/remove disks and to switch power on and off. A power switch may be brought forward and made accessible, but the disks present a major stumbling block. Some aids have been designed to guide the disks and to grasp them, but the only solution for severely disabled persons is to use a hard disk or have someone else perform disk insertion/removal. Other peripherals such as printers must be positioned such that they may be operated. The environment in which the person uses the computer must provide sufficent room for manouvering by the user who may be in a wheelchair, a stretcher, or a bed, or who may be ambulatory but require support while walking.

The third may aspect to be considered is the access to the computer and to standard software. Some means, whether software or hardware, is required to ensure emulation of required input commands. Efforts are underway at the Trace Center at the University of Wisconsin and the Hugh MacMillan Medical Centre/University of Toronto to develop a universal means of accessing computer-based systems. Here, two main problems are faced - the lack of standard and accessible 'entry' points into operating systems, and the lack of a standard software user interface. Some point is required into which an alternative input device can be patched and subsequently interpreted as if it was a standard device (ie. keyboard or mouse). Widely varying software user interfaces pose difficulties for average users and are even more frustrating for disabled persons who must then customize their special input devices for every application For example, sequences of commands for one program may be reduced by a macro definition but this definition will likely not work in another application.

These comments should be considered as only a very brief overview of present state of affairs with regard to computers for disabled persons. Much work remains before disabled persons can truly use computer technology with the same ease as the rest of the population. It is hoped that combined efforts by both rehabilitation professionals and human factors specialists in industry will benefit all persons to interact with computers in the future.

Acknowledgements

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CONTRIBUTION: Lawrence Scadden

FACILITATING ACCESS OF FUTURE GENERATIONS OF COMPUTERS

A cursory review of both engineering and rehabilitation literature would suggest that the future for people with physical or sensory disabilities is being made bright through the application of computer technology. People with vocal impairments are communicating; those who are blind are reading printed materials independently; and people with severe motor impairments are beginning to interact with, and even control, their environments. Computers are providing many disabled people with the highest level of independence and productivity hitherto experienced. A closer analysis of the evolution of computers and their application and utilization by the public at large indicates, however, that these changes are advancing at a rate which may endanger strides already made, and, more importantly, create new barriers for disabled people living in a highly technological world.

In the past decade, the vast majority of the progress made in the fields of rehabilitation and special education through the use of computers has been based upon retrofitting existing computers by adding alternative input or output access technology. The process has always been a "game of catchup." The accelerating evolution rate of computer technology increases the strain upon engineers seeking solutions to problems of access. In fact, ***the gap between computer accessibility by disabled and nondisabled*** *populations appears to be widening rather than narrowing.* Examples of new problems of accessibility can be drawn from the applications side of computers and from the technology design laboratory.

Computer-based directories found ubiquitously in shopping malls and airports, for example, are replacing the almost universally accessible human being. Without special adaptations, these systems will not be useable either by motor impaired or blind individuals. As speech displays proliferate in the future, people with hearing impairments will be added to the list of people for whom these systems are inaccessible.

Job stations that require the use of a computer appeared, for several years, to offer expanded employment opportunities for disabled people because computers could be made accessible. But, as employers update equipment with state-of-the-art technology, questions of accessibility again emerge. Previously used solutions are not automatically appropriate. Revamping an accessible solution is costly.

Hardware and software innovations under development in design laboratories are also producing concern relating to the ability in the future to interface them with existing access technology or with systems currently also in the development phase. The proliferation of interactive screens and "direct manipulation" systems in the past few years presents new problems. These relate to the accessibility of these systems by blind individuals using speech or braille displays which do not adapt well to this style of interface. Similarly, evolving input protocols in other systems limit the effectiveness of existing keyboard emulators used by motor impaired individuals.

A government/industry initiative on computer accessibility for people with disabilities was launched in 1983 by staff of the U.S. Department of Education. The Electronic Industries Foundation and the Trace Research and Development Center assumed leadership of the initiative. To date, two meetings have been held bringing together senior level personnel from leading computer manufacturers to discuss current and future problems with rehabilitation technology specialists and with disabled computer users. These discussions have led to the design and early implementation of planning activities which should increase the likelihood that future generations of computer technology will be accessible *at the time of its introduction into the marketplace*. Four major tasks have been delineated for immediate action.

1. *Development of Design Guidelines.*

Participants at the most recent computer initiative planning meeting agreed that solutions to accessibility problems should be left primarily to the creativity of those individuals given responsibility for computer design rather than from those outside of the industry. These individuals, however, expressed a desire to have a prioritized list of recommended design guidelines developed to highlight specific access needs. For instance, redundancy of information display options is needed to insure that both blind and deaf users can access error menu messages. Auditory tones or synthetic speech messages should be supplemented with simultaneous, or optional, visual information. Also, provision of industry-accepted interface connectors and operating system "hooks" to facilitate the attachment of alternative input and output access technology would permit future use of flexible, intelligent devices with a wide variety of computers.

A working group has been established for the purpose of developing a list of design guidelines. All sectors are represented on this working group. The development process will be an interactive one.

2. *Development of Mechanisms to Facilitate the Dissemination of the Guidelines.*

Each manufacturer representative will be responsible for taking the lead on the development of recommendations to be made to the computer initiative steering committee of techniques which will be most appropriate for that firm to enable the dissemination of the guidelines and other relevant information to the decision makers. A multi-media approach is anticipated. Video tapes, written materials, and live demonstrations will be prepared.

3. *Development of Rehabilitation Technology Resources for Industry Personnel.*

Industry representatives have expressed a need for materials and reliable resources upon which they can rely for obtaining current information regarding access technology and accessibility needs. The Project on the Handicapped in Science in the American Association for the Advancement of Science (AAAS) will serve as the focal point for the development of these materials and for the central clearinghouse in an operational informational network.

4. *Accessing Industry Technical Information.*

Rehabilitation engineers and access technology manufacturers have expressed a recurring need to be able to obtain extensive technical documentation on computers not incorporated in user manuals. At the same time, industries must be sheltered from an overwhelming number of requests for assistance for unqualified or inappropriate individuals. A working group is being formed which will prepare a list of commonly needed information which then may be packaged by manufacturers in manuals or other releases. In addition, efforts are underway to identify other means by which direct contact can be established between qualified rehabilitation technologists and authorized industry personnel for the purpose of facilitating computer access for disabled people.

The activities of the government/industry initiative on computer accessibility will continue as an ongoing process. The support of manufacturer corporate officers and the interest and commitment of line personnel have produced a strong foundation upon which cautious optimism can be built.

CONTRIBUTION: Michael Rosen

This section introduces some of the goals, factors, methods, and potential impact of interface optimization for the handicapped user.

A conceptual framework for optimization of control interfaces for motor-impaired users has three major components. These are:

1. definition of the performance criteria to be maximized or minimized;

2. identification of design variables which determine how well a system meets these criteria; and

3. development of methods and databases for arriving at an "optimal" interface for a particular user.

The operative question for any clinical or R&D effort devoted to selection or design of an adaptive interface is "How great is the payoff?, *i.e.* how sensitive are the performance outcomes to the variation of design variables and, ultimately, to the effort devoted to choosing the best values." While this question is far from having been answered, except in limited ways, some present research by this author and colleagues is being focused on it. The purpose of this presentation is to add some detail and illustrative examples to the conceptual outline presented above and to offer some preliminary but hopeful results which suggest that attempts at optimization may have profound effects on functional performance. While much of what follows could as easily be applied to interface optimization for able-bodied users, disabled users are distinguished by the diversity of motor abilities they present, and by the *critical dependence* of their vocational, educational, and social success and satisfaction on availability of optimal control interfaces.

The measures of success when evaluating a user-interface system must be related to objective and subjective indices of performance. While most are obvious, techniques for their assessment must be carefully defined to take into account the realities of function in motor disability. In addition, it is important to keep in mind that significant effort may be required to design an interface which allows any performance at all. Keys which are too small, given the amplitude of pathological tremor or key-to-key movements which set off postural reactions that require minutes to correct, can make an interface completely unusable. In this presentation, the assumption is made that performance greater than zero has been achieved, and ways are sought to improve it.

Speed and accuracy are, of course, the primary criterion variables in designing an adaptive interface. This is true whether the computer is being used for computing, for non-vocal communication, for playing games, or for environmental control. The experimental or clinical measures of these quantities must be based on evaluation of performance over an extended period, since a tendency toward muscular fatigue or attentional deficits, for example, may make brief performance measures poor predictors of functional success.

In addition to the trade-off relationship which is likely to exist between speed and accuracy, improvements in both of these indices are likely to be bought at the expense of increased learning time and ongoing mental load. In other words, these are criterion variables which a design may seek to minimize. The importance assigned to learning time, *i.e.* the period of use required to reduce mental load to a minimum, will depend on both the user's prognosis (does the user have a neurological disease such as ALS which implies a severely limited life span) and on their motivational state. Additional subjective variables which may be defined as components of performance are particularly related to the presence of disability. For example, in a mainstream environment, some handicapped users may be particularly concerned with obtaining an interface which looks "ordinary", *i.e.* as much as possible like what able-bodied colleagues are using. While this may be nearly impossible for some users, where it is possible a user may choose to work with a conventional keyboard, even at considerable expense in rate or accuracy.

The interfaces which are being proposed, tried, or marketed for the disabled are physically quite diverse. Nevertheless, a relatively small set of design variables and qualitative descriptors may be defined which have meaning for most interface designs, and thereby provide a consistent framework for distinguishing among interfaces. While this presentation is orders of magnitude too brief to cover these in detail, the following annotated list will serve to present the most important design factors and to suggest their significance for optimization:

Mode: This categorical variable defines the strategy by which a user selects from a language menu. The standard approaches, at present, allow selection either by direct indication of a menu item, by use of a code which specifies the key sequences that map to each item, or by single switch interruption of an automatic menu scan.

Menu: The set of language elements offered by an interface is critical to rate of communication (with computer, person, or hardware). The possibilities include letters, words, phrases, syllables, and phonemes. Other things being equal, a menu which requires the fewest selections per word is desirable.

Menu Size: The number of items in the menu may have a major influence on rate since it (and other variables) determines how far a disabled keyboard user must move between keystrikes. (Multiple finger typing is virtually always ruled out for motor-impaired users.)

Menu Layout or Keyboard Layout: The frequency of occurrence (in language or computer use) of pairs of menu items determines the frequency of the movements required to select or encode those pairs. Optimization for rate can be strongly influenced by adjusting the layout of menu items or code entries on keyboards (or on scanned menu displays) so as to assign the least time-consuming movements to the most frequent key pairs.

Key Size, Force, and Travel: These physical variables may be relevant to speed and accuracy, and the extent to which they are degraded by fatigue. For some users, greater switch closure force is desirable if avoiding accidental closures is a problem.

Fixed vs. Predictive Menu Displays: Some interface designs seek to increase the linguistic efficiency of system use by predicting the most likely next menu units and making these particularly accessible for selection. While rate gains may be realized by this approach, they may be at the cost of considerable mental load since a dynamically changing interface cannot be overlearned and requires greater visual attention.

For a number of years, development in adaptive interfaces have been driven by technologists motivated by the urgency of a particular disabled user's needs and by designers' zeal for novel hardware. Increasingly, attention is turning to development of methodologies whereby designs may be refined to optimize person- interface system performance. This must happen in two places -- at the designer's drawing board (or CAD terminal), and in the clinic. For language rate, in particular, efficient and thorough investigation of alternatives requires prediction on the basis of an appropriate model. The author and colleagues, (in particular Dr. Cheryl Goodenough-Trepagnier at Tufts-New England Medical Center) are presently involved in the development of a battery of computer- based clinical techniques for deriving a closed-form heuristic motor performance model from instrumented user-assessment data. The underlying assumption is that rate in the use of a communication device will be limited by motor performance once the learning phase is complete. An assessment which measures the dependence of movement time on the task variables which apparently characterize "keyboard" use has been developed. Device use rate predictions are presently being tested against actual measured rates of communication. While the

methodology depends on the availability of frequency data for communicative use of English, a technique appropriate for rate estimation in other computer uses is an essential (and probably reachable) research goal.

To the extent that identifiable clinical groups of disabled users have in common major aspects of their motor performance, it should be possible -- given a sufficiently large base of experimental data -- to derive "standard user models". These would provide the designer with a well-defined dependence of movement time on task variables (distance, direction, key size, etc.) on which to base improvements in language menu layout. A particular touch panel might optimize rate based on a model which is approximately valid for cognitively intact spastic cerebral-palsied users, for example. The extent to which a Fitts Law can be found for members of each of several disability categories is presently untested.

The line between designer and clinician is blurred somewhat by the availability of low cost and touch panels as input interfaces. Work is presently underway (Goodenough-Trepagnier and colleagues) to develop a system in which the touch panel serves in the clinic as assessment instrumentation and as a functional interface device. The attached computer operates on assessment data to derive an "optimal" layout for a language menu selected on other grounds. This approach too should be able to be extended beyond the current interest in non- vocal communication.

A small number of present data suggests the extent to which rate may be improved by optimization of interface design. Reports of improvements in speed which may be achieved for able-bodied users of alphabetic keyboards which improve upon the QWERTY layout indicate gain of 50%. Local efforts at minimizing distance moved in *one finger typing* have yielded optimization algorithms which generate comparable improvements. Application of these and newer algorithms to models arising from motor performance data from disabled subjects are underway. Trial use of our rate prediction technique has also demonstrated a strong dependence of estimated rate on the *angular* variation of movement speed accounted for in our model. For other subjects for whom both measured and predicted communication rates are available, the correlation degrades substantially when the body of data contributing to the model is intentionally pruned. In short, there is preliminary but suggestive evidence that effort committed to optimization of interfaces will yield major objective gains in functional performance. In addition, it is important to note that the subjective and functional acceptability of various levels of performance may follow a distinctly non-linear curve. In other words, disproportionate gain may be realized by means of a small objective improvement of rate, accuracy, learning time or mental load, if a critical threshold is exceeded.

CONTRIBUTION: Gregg Vanderheiden

Note: Contrary to convention, we have chosen to include a written presentation from a "panelist" who is not able to attend the conference. The Trace Center, which Gregg Vanderheiden directs, is one of the world's leading centers for research into computer aids for the handicapped. We present this overview of their work as being representative of current research. W. B.

Introduction

For a large number of individuals with disabilities, the most serious barrier to any meaningful opportunity, personal development, creativity or employment is the lack of an effective means of communication. This communication barrier is not limited to conversation, but also extends to writing, access to data processing and information systems, and control of essential devices and materials in the home, school, and employment environments. The recent application of affordable high technology solutions to these problems has produced an explosion of interest and activity in the field of rehabilitation engineering.

The Trace Center's research program is directed toward individuals with language and physical disabilities caused by stroke, head trauma, cerebral palsy, multiple scleroisis, muscular dystrophy, and other disorders. It is estimated that there are currently more than 2 1/2 million nonvocal or nonwriting people in the United States. Technologies capable of meeting many of the needs of these individuals are theoretically available now, and a large number of communicative aids, ranging from the relatively simple to the extremely sophisticated, have been developed and are being used by persons with disabilities. However, there has been little systematic effort to evaluate the effectiveness of these aids, or to develop a detailed understanding of the needs and constraints of the persons using them.

As a result, there are currently three barriers to more normal functioning for individuals with severe communicative disorders: the inability to communicate at an effective rate; the difficulty of access to standard equipment or control systems; and the lack of methods to compensate for language disorders. The Trace Center conducts research in all three areas, specializing in the use of microcomputer and communication aids.

The Inability to Communicate at an Effective Rate

Most aids are capable of assisting an individual to converse at the rate of only 2 to 3 words per minute (compared with 180 words per minute for a nondisabled individual). Rate is not the only barrier to effective communication, but it is at present the most dominant factor, and probably accounts for most of the functional disability faced by individuals who are nonvocal.

Limited conversational ability imposes many restrictions. The large difference in communication rates between disabled and nondisabled individuals makes it extremely difficult if not impossible for individuals using augmentative aids to participate in interactive communication in education, employment, or even daily living. One of the current Trace Center projects addressing the rate question involves utilizing off-the-shelf technology in the creation of a portable writing device. Techniques originally developed on another stationary writing aid utilizing the Apple II computer will be transferred to this smaller, less expensive computer to produce a portable, battery-operated aid providing both writing and conversation abilities at an accelerated rate.

Another project involves developing interfaces that allow the individual with limited physical control sites to maximize the amount of information that can be transferred during a period of time. This empirical study compares the long-range optical pointer and the SPA-SYN-COM (TM) pointing device with children who have cerebral palsy or other disorders and adults with high spinal cord injuries. Another project, QuicKey, involves the implementation of abbreviation expansion concepts, providing access to whole words and phrases with only a few keystrokes. QuicKey is also being developed for use on several microcomputers and other communication aids.

Lack of Access to Standard Equipment

A wide range of modified programs have been designed so that individuals with disabilities can operate them using very minimal control. However, the same program that allows the individual "access" to the computer also ties up the same computer so that the disabled user cannot use any standard software. The programs do not, therefore, address the greater need for individuals with handicaps to be able to use standard systems.

Individuals with disabilities will need to acquire greater access to computers if they are to carry out the activities required in school or on the job. In order to do this, however, the individual will need to be able to control the computer without modifying the software programs. "Transparent access", defined as the ability of a disabled person to control the computer through some special technique or device without the computer being in any way able to 'see' that it was not being controlled in the standard fashion (e.g., through the standard keyboard), is the only way that disabled computer users will be able to use the computers and run the same programs as their non-handicapped peers.

The Trace Center REC has begun several projects to provide completely transparent access to the most widely used microcomputers or computer systems. The simplest example of a transparent modification is a weight on a hinge, that can be tipped to hold down the shift key on a computer keyboard. This mechanical modification can allow a one-handed or one-fingered (or headstick) typist to enter shift or control keys on the keyboard. A more powerful approach is the use of keyboard emulating interfaces. Currently, the Trace Center has developed keyboard emulating interfaces for the DEC VT-100, the Apple IIe, and the IBM PC. Other emulators are planned for similar small microcomputers.

The Lack of Methods to Compensate for Language Disorders

People who have language disorders such as aphasia have different type of difficulty in communicating because the actual language process are primarily involved. The problem goes beyond provision of an alternate channel, and involves technical augmentation or assistance to the message formulation process itself.

A current project in this area, in cooperation with the Veterans' Administration Hospital in Madison, includes testing a number of special interfaces for use by aphasics, such as touch-sensitive screens, light pens, and touchtone telephone pads. Another project involves programming a computer to provide feedback on typical adaptive and maladaptive behaviors such as perservation and self-correction.

The problems in developing effective treatment and 'prosthetic' aids for this population are considerable. Most of the aids developed to date are for adults with mild or moderate language impairment who are able to read and spell accurately. However, it is also important to consider the communication needs of more severely affected individuals whose deficits make functional verbal communication impossible.

Other Trace Center Objectives

In addition to its research activities, the Trace Center REC has developed a program to ensure that information on new techniques and devices is readily available to the consumers and professionals who need it. This is an especially acute problem in rehabilitation engineering since there is not yet an established system for service delivery. Very few of the professionals currently attempting to apply the developments in this field have had any training in these techniques as part of their formal education. This problem is aggravated by the fact that many of the developments and aids in the field have come from small firms that cannot afford to advertise in trade journals or place exhibits at conferences.

To address this problem, the Trace Center will be feeding existing data bases with information on new aids and techniques in the field of rehabilitation engineering. The Center will explore ways to provide for the replication of techniques and technical systems by consumer advocates hobbyists. In addition, the Center has provided continuing updates to its resource book series. Books in this series cover nonvocal communication and writing aids; telecommunication aids, aids for the deaf, environmental controls, and special interfaces; and available software and hardware modifications that have been developed specifically for individuals with disabilities. To promote the commercial availability of communication aids developed in rehabilitation engineering facilities like Trace, the Center has established a commercial facilitation program, which works with individuals, groups and manufacturers to help transform research concepts into commercially available tools and aids.

DIRECTORY OF SOURCES

Comprehensive Source Books

International Software/Hardware Registry (second Edition), by G. Vanderheiden, D. Bengston, M. Brady, & L. Walstead, 1984 (236 pages). Available from the Trace research and Development Centre, Waisman Center, 1500 Highland Ave., Madison Wisconsin 53705-2280. Price: $25.00.

Directory of Services and Specialized Equipment for the Physically Imaired, Published by IBM Corp., Dept. 63C/028, Kingston New York 12401.

Major Conference/Clearing House

The *Proceedings of the Annual Conference of the Rehabilitation Engineering Society of North America.* Available from the Rehabilitation Engineering Society, Suite 700, 1101 Conneticut Ave. N.W., Washington DC 20036. (202)-857-1199.

Selected Newsletters

Closing the Gap. Bimonthly, $15.00 annually. P.O. Box 68, Henderson MN 56044. (612)-341-8299.

Computer Disability News. Quarterly, free of charge. National Easter Seal Society, 2023 W. Ogden Ave., Chicago IL 60612. (312)-243-8400.

Communication Outlook. Quarterly, $12.00 U.S., $15.00 outside North America. Michigan State University, 405 Computer Center, East Lansing MI 48824-1042. (517)-353-0870.

Sources of I/O Peripherals

Prentke Romich Co.
1022 Heyl Road
Wooster, Ohio 44691

TASH Inc.
70 Gibson Drive, Unit 1
Markham, Ontario
Canada L3R 2Z3

Telesensory Systems, Inc.
455 North Bernardo Ave.
P.O. Box 7455
Mountain View, CA 94039-7455

Zygo Industries, Inc.
P.O. Box 1008
Portland, OR 97207