DOCUMENT RESUME

ED 375 596 EC 303 436

TITLE	Trace Research and Development Center: Report of Progress, 1987-94.
INSTITUTION	Wisconsin Univ., Madison. Trace Center.
SPONS AGENCY	National Inst. on Disability and Rehabilitation Research (ED/OSERS), Washington, DC.
PUB DATE	94
NOTE	125p.
AVAILABLE FROM	Trace Center Reprint Service, University of Wisconsin-Madison, S-151 Waisman Center, 1500 Highland Ave., Madison, WI 53705 ($5).
PUB TYPE	Reports - Descriptive (141)
EDRS PRICE	MF01/PC05 Plus Postage.
DESCRIPTORS	Accessibility (for Disabled); *Assistive Devices (for Disabled); *Communication Aids (for Disabled); *Communication Disorders; Computers; Delivery Systems; Hearing Impairments; Input Output Devices; Mental Retardation; Physical Disabilities; *Severe Disabilities; *Technological Advancement; Training Methods; Visual Impairments
IDENTIFIERS	*Trace Research and Development Center WI

ABSTRACT

This report documents activities and projects from 1987 to 1994 of the Trace Research and Development Center (Wisconsin), which addresses the communication needs of nonvocal severely disabled children and adults. During this period the Center also served as a national Rehabilitation Engineering Research Center on the topic of Access to Computers and Electronic Devices. Introductory information includes an overview of the Center and a description of recently released products. The main body of the document presents 41 individual project reports. These are grouped into the following focus areas (with sample projects noted in parentheses): (1) movement impairment (development of improved headpointing computer access system); (2) sensory impairment (tactile perception and business graphics studies); (3) cognitive impairment (interface training and use by persons with cognitive disabilities); (4) cross-impairment (computer and operating system accessibility design guidelines); (5) information and training programs (databases on communication, control and computer access development and downloading); and (6) service delivery programs (communication aids and systems clinic). Two additional sections describe cooperative and consultative efforts of the Center and list Trace Center publications. (DB)

TRACE RESEARCH AND DEVELOPMENT CENTER

REPORT OF PROGRESS

1987-94

Trace Center

Trace Research and Development Center

Report of Progress 1987-94

Trace Research and Development Center
Waisman Center and Dept. of Industrial Engineering
University of Wisconsin-Madison

The activities described in this report have been funded in part by the National Institute on Disability and Rehabilitation Research, U.S. Dept. of Education.

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From the Director

Dear Friends and Colleagues:

This Report represents the culmination of many long efforts, and also marks the beginning of a new program of work at the Trace Center.

From 1987 to 1993, the Trace Center served as a Rehabilitation Engineering Research Center on the topic of "Access to Computers and Electronic Devices." The RERC program was sponsored by the National Institute on Disability and Rehabilitation Research (NIDRR), U.S. Department of Education. What we've been able to achieve in that period of time has been heartening, though much work remains to be done and new challenges are continually arising.

The attempts to build accessibility directly into computers as they are manufactured began tentatively with a meeting at the White House in 1984, but between 1987 and 1994 we saw the effort spread substantially. Today the federal government includes computer accessibility requirements in its contracts for data processing equipment. The Rehabilitation Act and the Americans with Disabilities Act now specifically require employers and public accommodations to make sure they are electronically accessible.

Most encouraging has been the response of the computer industry itself. With the encouragement and support of the Trace Center and other groups across the U.S., major computer brands now include many of the accessibility features were only experimental six years ago. Those who have not yet built them into their systems "right out the box" have developed add-on software for current systems, and are adding access features to the next generation of systems soon to be released.

This Report of Progress covers the Trace Center activities funded under the RERC program, and also projects sponsored by other funding sources. We try to maintain a balanced program at the Center, covering not only research and development but information, training and clinical service programs.

As I mentioned, this Report marks the beginning of a new challenge. In 1993 the Trace Center began a new five-year RERC program, on the topic of "Adaptive Computers and Information Systems." The computer has expanded from the desktop model we all know to a variety of information systems now found in libraries, shopping malls, government buildings, airports and banks as well as in the workplace and home. These dedicated information systems will be one of our great challenges under the new RERC.

Gregg C. Vanderheiden, PhD
Director

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Projects Covered in This Report

(Page numbers follow each project title)

Overview of the Center

THE TRACE CENTER was formed in 1971 to address the communication needs of non-vocal severely disabled children and adults. From the beginning the center worked with electronic technologies, developing one of the first microprocessor-based augmentative communication devices. Over the past twenty years the center has greatly expanded its funding base, personnel and activities. The center has also expanded its scope, to deal with new technologies.

Throughout the 1980s, computers became more of a fact of life for the average person, making the issue of accessibility for people with disabilities crucial. If barriers in the design of computers prevented people with disabilities from using them, a whole segment of our society would be denied access to education, employment and independent living—simply because the computer was not built with them in mind.

This Report of Progress covers the period of 1987-94, including the period from 1987-93 when the Trace Center served as a national Rehabilitation Engineering Research Center (RERC) on the topic of Access to Computers and Electronic Devices. The RERC was funded by the National Institute on Disability and Rehabilitation Research (NIDRR), U.S. Department of Education, to study the obstacles to computer use, and to develop strategies for providing computer accessibility—"computer curbcuts."

The Trace Center's involvement with computer access dates back to the 1970s. Among its other efforts, the center was involved in a 1984 White House meeting on computer access by people with disabilities. This meeting led to the formation of a nationwide group of industry, consumer, research and government representatives. The Trace Center coordinated this group in the task of creating guidelines for computer and operating system design. The document that resulted has been used as a basis for other guidelines, including the computer accessibility guidelines of the General Services Administration for Federal information technology managers.

Starting in 1993, the Trace Center has embarked on a new five-year RERC program, focusing on Adaptive Computers and Information Systems. In some areas, this program represents an extension of the earlier program, particularly as the center continues its work with computer companies to make computers more accessible "right out of the box." In addition, the new RERC program will expand into the growing area of information systems. With the advent of integrated audio, video and data telecommunications in the workplace, home and community, the issue of accessibility for users with disabilities becomes critical. The new RERC will address technologies such as automated teller machines, public information kiosks, and fax machines.

Other Trace Center programs

Although the RERC grant is the largest single source of funding for Trace Center activities, it comprises around half of the center's total funding base. A variety of other public and private funding sources fund other assistive technology projects at the center. Recent activities have included: specific technical assistance to computer and software companies in developing accessible systems, cooperative efforts with disability information providers to create new database technologies for information and referral, and model training programs in assistive technology for students at the University of Wisconsin-Madison. These activities funded outside the RERC core funding are also summarized in this report.

Trace Center programs

The Trace Center is located in the Waisman Center, a nationally recognized center for research on developmental disabilities at the University of Wisconsin-Madison. The Trace Center is also closely connected with the University's Department of Industrial Engineering: the center's director, Gregg Vanderheiden, is a faculty member in the department, and many of the center's research projects are based in the department's Human Disabilities Laboratory. In addition, strong ties with the Department of Kinesiology, the School of Education, and the Department of Communication Disorders have integrated Trace Center research and development activities with professional training.

Trace Center staff have diverse backgrounds, as appropriate to the interdisciplinary nature of the center's mission. The center employs people with backgrounds in electrical engineering, computer science, industrial engineering, speech and language pathology, biomedical engineering, psychology, and occupational therapy.

The center achieves its goals through seven principle types of activities:

Basic research—The center investigates basic issues in the design of devices and software, including not only products made especially for disabled consumers but also those designed for the general marketplace. The latter receive special emphasis, as the establishment of "electronic curbcuts" not only can provide disabled people with greater access to the mainstream of society, but can result in less need for wasteful retrofitting.

Research and development—Trace Center research is also directed toward the development of specific products. The center's role in development is to establish groundwork and assist private companies, who take on the responsibility for manufacturing and marketing developed products. Successful commercial transfer is integral to all development projects.

Standards—The rehabilitation field periodically establishes standards for the design and manufacture of products. The Trace Center has been involved in a number of standards projects, acting as a research and coordination center. Establishing and promoting these standards ensures greater compatibility among devices and software available to assistive technology consumers.

Commercial facilitation—The Trace Center works on cooperative projects with industries, research groups, and individuals—projects aimed at evaluating technological concepts and moving them successfully to the marketplace. Assistance that the center provides includes: technical review, design assistance, competitive analysis, identification of markets, locating of development funding sources, and assistance in the formation of alliances.

Information—The Trace Center serves as a focal point for collecting and disseminating information on technology for communication, control and computer access. In addition to answering information requests from professionals, consumers and the public, the center maintains and disseminates databases of products, services and publications, as well as distributing shared data from other information centers. Database development efforts have also addressed the need for databases to be more accessible to consumers and service providers.

Training—The center is actively involved in both preservice and inservice training. The center's workshop series provides several training opportunities around the country each year. Programs in cooperation with the University of Wisconsin-Madison Occupational Therapy Program, Department of Communication Disorders, School of Education and Industrial Engineering program allow graduate and undergraduate students to earn a technology or augmentative communication specialization with their degree.

Clinical services—A number of service delivery programs are directly connected with the Trace Center. Through these programs the center is able to use its personnel and expertise to directly benefit clients.

Center program structure

Although certain Trace Center programs are restricted as to the populations served, overall the center has as its goal to investigate factors affecting persons with all. The activities of the center during the period of this report were organized according to the type of impairment they focused on, as follows:

- movement impairment focus area
- sensory impairment focus area
- cognitive impairment focus area
- cross-impairment focus area

In addition, the center is involved in information and training programs, and service delivery programs.

The approach for each of the focus areas has been different. This is a result of the differences between the maturity of the areas. In some areas, the initial groundwork was laid and therefore the projects are of a more advanced nature. Other areas have seen less development, and therefore the nature of the center's activities has been more fundamental.

In the *movement impairment* area, a large number of specific access techniques are available, due to both the developments in the augmentative communication field and specific developments in computer access hardware and software. The major efforts in this area, therefore, have been directed toward addressing techniques for accessing newer generation computers which incorporate newer input techniques, and toward developing mechanisms for evaluating and improving the adequacy and efficiency of existing techniques for individuals with more severe motor impairments. There also continues to be a heavy need for information and technical support for standard computer manufacturers in incorporating the results of past research into their products.

The *sensory impairment* area focuses on both visual and hearing disabilities. Access problems for visually impaired individuals are at a fairly mature stage, with a wide variety of access systems available. However, the shift in computer design from character-based computer displays toward bit-mapped screen and graphic-based environments has presented additional technical challenges, requiring a new generation of screen-reading technologies. For this reason, the center's focus in the visual access area has been not only on developing access solutions, but on coordinating information and efforts between manufacturers and researchers.

Individuals with *hearing impairments* currently have little difficulty in using standard computers. The major concern for deaf and hearing impaired individuals stems from the potential for increased use of auditory output and speech control features both for computers and for other electronic devices. The focus in this area, therefore, is on identifying these potential problems as well as identifying and defining solution strategies for them.

The *cognitive impairment* area is less mature in terms of both research and product development. Although there is a large body of literature about the various cognitive disabilities, and some literature about special device use, there has been little effort directed toward the issue of access to standard devices and software by individuals with different cognitive impairments. The focus of the Trace Center's work in this area has been to gather the best knowledge and expertise of related fields as they apply to the access problem, to document this information, and to perform some basic research to quantify the difficulty of different interfaces for individuals with cognitive impairments.

Most of the projects in the *cross-impairment* area have dealt with the conversion of information obtained through the other impairment focus areas into formats which can be directly accessed by researchers, developers, and consumers in the field. Since the major focus of the center is on creating a more accessible world, the target of these activities is standard equipment and software manufacturers. Efforts in this area have also been directed toward the development of design manuals and the provision of technical and research support to manufacturers.

The *information and training* programs similarly are cross-impairment in function, being designed to move information and results on a broad range of topics to those who need them. The major focus is on disseminating information on activities and trends in the entire field, not just the specific projects of the Trace Center.

The Trace Center also works cooperatively with *service delivery* programs which serve people with specific impairments and needs. Services are provided for augmentative communication systems, writing systems and computer access.

Current Trace Center Personnel

Center Director
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John Mendenhall, MS
Molly McMahon, MS
John Schaab, BS
Bridget Powers Untersee, BS
Lucia H. Watson, MS
Natalie Weisensel, BS

Recent funding

- National Institute on Disability and Rehabilitation Research, U.S. Department of Education: Rehabilitation Engineering Center on Access to Computers and Electronic Equipment.

- National Institute on Disability and Rehabilitation Research, U.S. Department of Education: Rehabilitation Engineering Research Center on Adaptive Computers and Information Systems.

- National Institute on Disability and Rehabilitation Research, U.S. Department of Education: Feasibility Demonstration Project for a Disseminable, Directly Accessible Electronic Library of NIDRR Information Resources.

- Computers to Help People, Inc., Madison, WI: Direct Access by Persons with Disabilities to Information on Assistive Technology Services: A Model Inter-State Cooperative Database (subcontract).

- Office of Special Education Programs, U.S. Dept. of Education (Personnel Preparation): TechSpec Preservice Training Program.

- Office of Special Education Programs, U.S. Dept. of Education (Personnel Preparation): Interdisciplinary Augmentative Communication and Technology Training (InterACT) program.

- American Occupational Therapy Association: OT FACT Development.

- University of Wisconsin-Madison cost-reimbursement account: Trace Center Workshops and Reprint Service.

- University of Wisconsin-Madison cost-reimbursement account: Rehabilitation Research Services.

- University of Wisconsin Hospital and Clinics: Communication Aids and Systems Clinic.

- Division of Adult Community Services, Dane County Department of Human Services: Communication Development Program.

- Apple Computer, Inc.: Accessible database development and information programs.

- IBM Corporation: Accessible database development.

- IBM Corporation: Development of AccessDOS software.

- Ameritech Foundation: Accessibility of TDDs for Hearing Impaired Individuals With Multiple Impairments.

- Information Technology Foundation: Development of Guidelines for the Design of Software Application Programs to Increase Their Accessibility to Persons with Disabilities.

- Technology-Related Assistance Act Program, State of Maine: Development of Cooperative Service Directory software.

- Technology-Related Assistance Act Program, State of Connecticut: Development of Cooperative Service Directory software.

- Technology-Related Assistance Act Program, State of Maryland: Development of Cooperative Service Directory software.

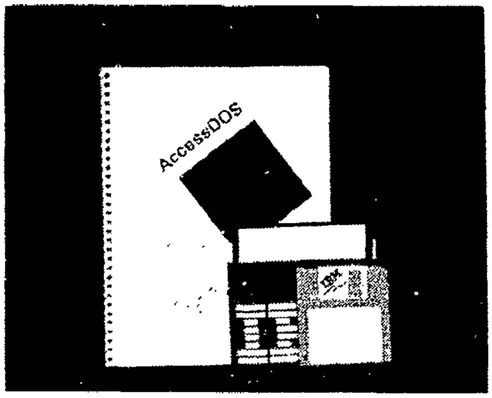
- Technology-Related Assistance Act Program, State of Utah: Development of Cooperative Service Directory software.

- Technology-Related Assistance Act Program, State of Wisconsin: Development of Cooperative Service Directory software.

- Disability and Business Technical Assistance Centers, National Institute on Disability and Rehabilitation Research: Development of Cooperative Service Directory software.

Trace Center
Recently Released Products

AccessDOS



The AccessDOS package, free from IBM

Not all adaptations for people with disabilities can be built into standard computers. However, a wide variety of accommodations can be incorporated directly into the computer design.

Working with IBM Corporation the Trace Center developed a set of accessibility features for IBM and compatible computers using DOS. The software, called AccessDOS, lets users alter the way the keyboard and mouse operate to accommodate particular physical needs.

AccessDOS allows many people with disabilities to use a computer, just by letting them alter or customize the way it operates. (See the complete list of features below.) The program is available as optional software; the goal is to eventually get the AccessDOS features integrated directly into the design of DOS.

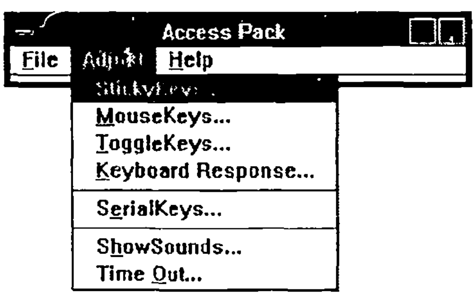
Individuals can receive AccessDOS for free, simply by calling IBM at (800) 426-7282. The software comes with documentation.

Access Pack for Microsoft Windows

Computers can be made accessible to many people with disabilities by including the necessary features or adjustments in the operating system—the program that controls the internal functions of the computer. In recent years, a popular operating system for IBM and compatible computers has been Microsoft Windows.

Working with Microsoft Corporation, the Trace Center developed a set of accessibility features for computers using Windows. The software, known as the Windows Access Pack, provides adjustments to accommodate the needs of many users with disabilities. (See the complete list of features below.) The program is now available as optional software; the goal is to eventually get the AccessDOS features integrated directly into the design of DOS.

The Access Pack is currently being distributed by Microsoft Corporation. The program can be downloaded from CompuServe, GEnie, Microsoft Online and other computer bulletin boards, or disks can be obtained by calling Microsoft at (206) 637-7098; TDD (206) 635-4948.



Main menu of the Access Pack software

Features of AccessDOS and Windows Access Pack:

StickyKeys: Multiple key operations (such as Shift-key) with a single finger.

MouseKeys: Control of mouse functions from the keyboard.

RepeatKeys: Control over auto-repeat of keys, preventing accidental repeated keys.

SlowKeys: Adjusts amount of time a key must be pressed before the computer accepts it.

BounceKeys: Prevents "bouncing" on keys (tremor related).

SerialKeys: Control of keyboard and mouse functions from an external assistive device.

ToggleKeys: Audible tones to indicate the status of Caps Lock, Num Lock and Scroll Lock keys.

ShowSounds: Visual indication for audible warnings (beeps).

TimeOut: Turns off AccessDOS when the computer is unused for a certain time.

Trace Transparent Access Module (T-TAM)

Certain people with physical disabilities cannot operate standard input devices for commercially available computers. Many of these individuals can, however, operate a special communication or computer access aid, using a control system such as an optical headpointer or single switch. This special aid can then be interfaced to the computer and used as an input device.

The T-TAM allows control of all keyboard and mouse functions on Apple Macintosh, Apple IIGS and IBM PS/2 computers. The user can input to the T-TAM from any communication or computer access aid that has a serial port. The T-TAM provides assisted keyboard features for the standard computer keyboard.

The device has been transferred to two companies for commercial production: Prentke Romich Company of Wooster, OH and Words+, Inc. of Lancaster, CA.

Hyper-ABLEDATA

The Trace Center has created Hyper-ABLEDATA, a microcomputer version of the on-line database ABLEDATA, supported by the National Institute on Disability and Rehabilitation Research. The database lists all the commercial assistive technology products available to consumers in the U.S.—currently over 19,000 items.

Hyper-ABLEDATA & DOS-ABLEDATA display pictures of products

The program runs on the user's own microcomputer. The very easy to use interface does not require the user to be trained in how the system works. Hyper-ABLEDATA currently contains pictures of about 2,500 products, plus sound samples of products such as speech synthesizers. A "blind access mode" built into the software allows users who cannot see the screen to operate the program completely independently. In this mode, control functions are executed from the keypad on the keyboard and all screen information is conveyed in synthesized voice.

Hyper-ABLEDATA is now available on CD-ROM and floppy disk, through the Trace Center's Reprint Service. It will also be available for downloading from the Internet.

DOS-ABLEDATA

The Trace Center has created DOS-ABLEDATA, a microcomputer version of the on-line database ABLEDATA, supported by the National Institute on Disability and Rehabilitation Research. The database lists all the commercial assistive technology products available to consumers in the U.S.—currently over 19,000 items.

The DOS-ABLEDATA software was developed at a cooperative effort between the Trace Center, Learning Express, the University of Arkansas, and the ICAN project. The program runs on IBM PCs and compatibles, including older, lower-powered machines (80086-class) with just 640K of RAM. DOS-ABLEDATA has been specifically designed and tested to be compatible with screen reading programs used by blind computer users.

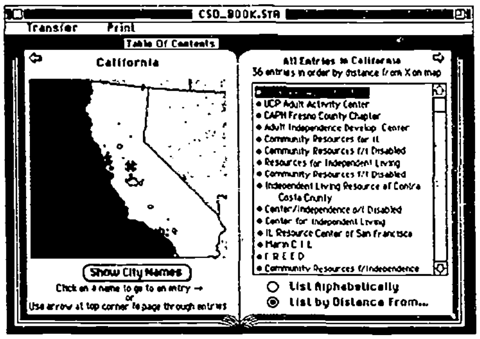
DOS-ABLEDATA is now available on CD-ROM and floppy disk, through the Trace Center's Reprint Service. It is also available for downloading from the Internet, and on several computer bulletin boards.

NOTE: The information in Hyper-ABLEDATA and DOS-ABLEDATA is currently maintained through the ABLEDATA project at Macro International in Silver Spring, Md., who make it available on-line and on CD-ROM.

Cooperative Service Directory

New computer technologies allow large databases to be located directly at the point of inquiry. Such direct access lets information seekers browse through the information to locate that which best meets their needs at very low or no cost. Direct access also allows for databases that are extremely user-friendly, so the novice user can locate information.

Using the Cooperative Service Directory software, information and referral (I&R) program can create electronic "directories" of disability-related services. The directories can be distributed and shared. The development of the CSD software has been a cooperative effort between the Trace Center and over 30 different information centers around the country. The software takes advantage of fast searching software, graphical screens and hypertext techniques to make locating information fast and easy.



Pointing and clicking on a map lists services by their distance from a location

The CSD software runs on Macintosh computers and IBM PCs with DOS or Microsoft Windows. Organizations participating in the development have received software that lets them create CSD databases. In January of 1994, CSD databases began to be distributed publicly, with the release of 11 CSDs on the Trace Center's *Co-Net* CD-ROM.

Trace Voice Sampler

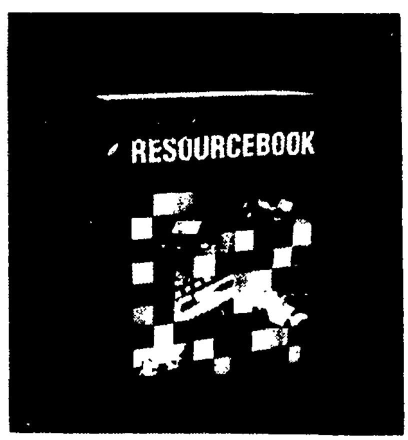
Speech synthesizers are commonly used for conversation by nonspeaking people, or for reading of text or computer screens by blind people. The Trace Voice Sampler is computer software that contains digitally recorded voice samples from the major types of speech synthesizers. This allows comparison of voice qualities without the need to obtain the actual devices.

The Trace Voice Sampler is distributed as a set of disks, and is also included in the Hyper-ABLEDATA product database. Both are distributed through the Trace Center's Reprint Service.

Trace ResourceBook

The *Trace ResourceBook* lists all assistive technology products for communication, control and computer access that are currently available in the U.S. and Canada. The book provides descriptions of each product, pictures where relevant, and information on availability. The 1993-94 Edition lists dozens of types of products, including: augmentative communication devices, environmental controls, adaptive switches, screen enlarging software, and braille printers.

The *Trace ResourceBook* is available through the Trace Center's Reprint Service, both in print and in alternative formats for people with disabilities who cannot read print.



Trace ResourceBook

Design Guidelines for Computers

For several years the Trace Center has served as a coordinating center for the Industry/Government Task Force on Computer Accessibility. The current working document of this group is titled "Considerations in the Design of Computers and Operating Systems to Increase their Accessibility to Persons with Disabilities." Version 4.2 is being disseminated to the field for review. It is being used by many computer manufacturers; it is known to have been adapted and adopted as an internal reference document by two major manufacturers. It was also used by the General Services Administration in the preparation of their computer accessibility guidelines.

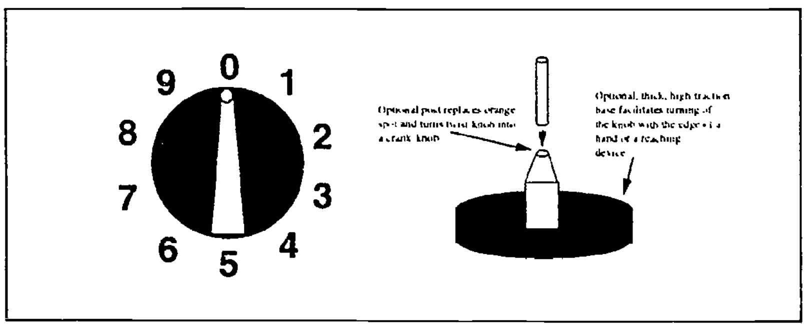
The document is available through the Trace Center's Reprint Service. The full text also on the Trace Center's *Co-Net* CD-ROM and on the Trace Center's Gopher server (on the Internet).

Design Guidelines Consumer Products

Consumer electronic products can present many obstacles to people with disabilities. The Trace Center has produced a set of guidelines for designers of products such as televisions, radios, tape players, and microwave ovens to accommodate the needs of consumers with disabilities. These guidelines discuss the full range of needs of persons with physical, sensory and cognitive disabilities and discuss possible solutions. Most solutions suggested are low- or no-cost. The usefulness of certain modifications to non-disabled consumers is stressed—such as location and ease of use for controls.

The guidelines are treated as a working document, sent out to consumers, researchers and manufacturers for comment. This effort is carried out in cooperation with the Assistive Devices Division of the Electronic Industries Foundation and the Consumer Products Technical Group of the Human Factors Society.

Accessible Design of Consumer Products is available from the Trace Center's Reprint Service, on the Trace Center's *Co-Net* CD-ROM, and via Internet on the Trace Center's Gopher server.



Design for a more accessible control knob, from the Guidelines

Design Guidelines for Standard Application Software

Although many special adaptations for computers are available, in some cases, a feature of standard commercial software (word processor, spreadsheet, etc.) causes a problem, clashing with the adaptation. Software developers need to be aware of these conflicts, and to consider including ease-of-use features for people with disabilities.

The Trace Center is now working with the Information Technology Association (formerly ADAPSO) to develop a support document on the design of standard software to maximize its accessibility. A preliminary "White Paper" for the software guidelines is now being distributed. ITA and Microsoft Corporation have provided the document to their affiliated software developers, and the Trace Center distributes it through its Reprint Service.

Campus Computer Laboratory Accessibility Manual

Many institutions of higher education are recognizing a need to make their computing facilities accessible to students and staff with disabilities. In response to this need, the Trace Center has developed a document titled "Checklists for Implementing Accessibility in Computer Laboratories at Colleges and Universities." It covers generic implementations of equipment—with steps delineated by time and money required to carry them out—and also procedures for assisting individuals who require more specialized equipment. An actual set of checklist forms is provided, on which staff can mark steps as they are implemented.

The Trace Center distributes the document through its Reprint Service, on the *Co-Net* CD-ROM, and via Internet on a Gopher server.

Library Information Systems Accessibility Manual

Libraries are more likely now than ever to find themselves serving a significant number of patrons with disabilities. In addition, library services have changed to incorporate more electronic information systems, including microcomputers, computerized card catalog systems, and on-line and CD-ROM information databases. To comply with federal legislation mandating equity of access to public accommodations for disabled and non-disabled persons—and to ensure that patrons with disabilities need not regard computers as barriers instead of aids to their successful library use—libraries need to plan for and implement accessibility measures.

The Trace Center has created a set of checklists to serve as a tool for libraries trying to make sure they are electronically accessible. Titled "Checklists for Making Library Automation Accessible to Patrons with Disabilities," the document covers generic implementations of equipment—with steps delineated by time and money required to carry them out—and also procedures for assisting individuals who require more specialized equipment. The Trace Center distributes the document through its Reprint Service, on the *Co-Net* CD-ROM, and via Internet on a Gopher server.

General Input Device Emulating Interface (GIDEI) Standard

Certain people with physical disabilities cannot operate standard input devices for commercially available computers. Many of these individuals can, however, operate a special communication or computer access device, using a control system such as an optical headpointer or a single switch. The special device in turn can be interfaced to the computer and used to perform keyboard and mouse functions.

A *general input device emulating interface* (either hardware or software) is used to convert the serial output from the special input device to the standard (keyboard and mouse) input signals for the computer. The Trace Center has developed an input/output standard for GIDEIs, so that any GIDEI can be used with any special input device. This standard also paves the way for GIDEIs to be built into standard, off-the-shelf computers.

The GIDEI Standard is now part of the three commercial products: the Trace Transparent Access Module (T-TAM) the Ke:nx and Darci Too computer interfaces. The GIDEI is also a part of the "SerialKeys" feature in the Windows Access Pack and AccessDOS, two recently developed disability access software packages for IBM PC and PS/2 computers.

Simple Electrical Transducer (SET) Standard

The Trace Center first became involved in the standardization area in order to deal with the problems surrounding user interfaces to communication, control, and computer access aids. At the time, there were approximately 65 specialized switch-type interfaces (single switches, multiple switches, matrix keyboards) commercially available. Unfortunately, no two manufacturers, chose the same connectors or connector pin assignments for their controls. As a result, clinicians were restricted to the use of only a small number of these interfaces, since the interfaces were not interchangeable across aids without rewiring either the interface or the aid.

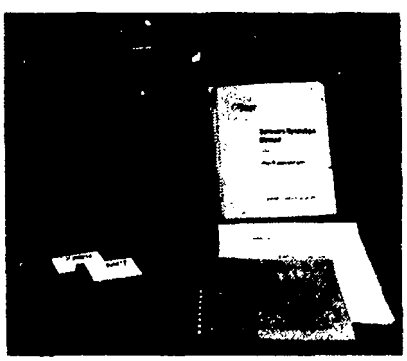
The Trace Center initiated an effort and, working with manufacturers and researchers from North America, Europe and Japan, developed a Simple Electrical Transducer Interconnection Standard (SET standard). Since its introduction, about 80% to 90% of controls and devices addressed by the SET have conformed to most or all of the specifications.

TechSpec Curriculum Packages

Advances in assistive and rehabilitation technology have challenged professional training curricula to keep up. Many professional training programs in fields such as occupational therapy need to modify or add courses to their programs in order to include topics such as augmentative communication, selection and positioning of device interfaces, or high-technology seating and mobility systems.

As part of a model technology curriculum project known as TechSpec, the Trace Center has created curriculum packages for teaching technology skills in postsecondary professional training programs. Descriptions of the overall program are part of the packages, as are curriculum guides for specific courses. The TechSpec curriculum packages are available at cost through the Trace Center's Reprint Service. Educational programs are free to use and adapt any Trace Center material in the packages for their specific professional technology training needs.

OT FACT



The OT FACT software package

Although there are many sophisticated systems for assessing specific aspects of human functional performance, there has been a need for some way to integrate and report the results of assessment across the full range of human function. In 1985 the Standardized Assessment Committee of the American Occupational Therapy Association initiated development of a profession-wide standardized assessment. The Trace Center has led a set of projects in this effort. The result is a system known as OT FACT (Occupational Therapy Functional Assessment Compilation Tool).

OT FACT has been designed as microcomputer software, for IBM PCs, PS/2s and compatibles. The software uses a technique called Tailored Sub-branching Scoring. It steps the user through the stages of the assessment, following the nodes of a decision tree. The program solicits scores from the user, tabulates and totals scores automatically, keeps records, and automatically charts results graphically. The resulting *functional performance profile* of a client can be used to summarize functional performance, justify therapy plans, and document the client's change in status over time.

The AOTA is disseminating OT FACT. Version 1.0 for IBM PCs was released in 1990; Version 1.1 in 1992. Version 2.0, for Macintosh and Microsoft Windows, is currently being developed.

Project Reports

Movement Impairment Focus Area

Movement impairments have a wide range of causes. These different causes result in different types and degrees of impairment. Head injury, spinal cord injury, loss of or dysfunctional limbs, cerebral palsy, poliomyelitis, muscular dystrophy, multiple sclerosis, amyotrophic lateral sclerosis, Parkinson's disease, and severe arthritis are some of the causes. In general, an individual's impairment could be characterized by one or more of the following categories:

Reduced control: the individual's motor control or range of movements has been reduced. Arthritis, poliomyelitis, and mid-level spinal cord injuries commonly result in this type of impairment.

Restricted control: the individual has normal motor control but only over part of their body. High spinal cord injuries (normal control of head but no control below the neck) and loss of limbs could cause this type of impairment.

Interference with control: other uncontrolled movements interfere with the individual's motor control. Cerebral Palsy and Parkinsonism are two causes of this type of impairment.

Weakness: the individual has fine motor control but has no strength or endurance. The individual may also be unable to move major limbs easily or at all. Multiple sclerosis, muscular dystrophy, amyotrophic lateral sclerosis, and poliomyelitis are causes.

For individuals with movement disabilities, it is the input mechanisms (keyboards, mice, touchpads, etc.) that present the greatest problems. Other controls (such as on/off switches, contrast knob on monitor, buttons to eject floppy diskettes) may also prove difficult. Many disabled individuals can use a standard keyboard but have difficulty with multiple-key operations. Others are unable to use the standard keyboard, and must rely on special mechanisms for connecting alternate input systems to the computer. Many such specialized interfaces have been developed for the popular computers, along with adaptations to facilitate handling of disks, adjustment of screen control, etc.

However, advancing computer technologies are creating new and more difficult problems. Individuals who are able to use standard or adapted keyboards are often unable to use newer mouse-, touchpad-, or touchscreen-based systems. Furthermore, attachment points (both physical and software-based) that have been used to connect these specialized interfaces in the past are not necessarily present in the newer generations of computers. In fact, for various technical reasons unrelated to the disability market, many new computer designs have restricted or blocked the connection points which are currently used by disability access aids. Thus, existing solution strategies no longer work. Computer companies are now aware of the problem, but the technical reasons for the changes remain.

In the area of movement impairment, the Trace Center has two major areas of activity:

1) Quantification and comparison testing of alternate input techniques and devices.
2) Development of extensions for standard computers and operating systems to allow access by motor impaired users.

Quantification and comparison testing of alternate input techniques and devices

Since input devices such as the mouse have become standard on many computers, a number of alternative input devices for users with physical impairments have been developed. Before an alternative input device for a person with a motor impairment can be selected and evaluated by a therapist working with such an individual, it is necessary to have an objective measure of performance. Since each disability is a personal issue, to determine which strategy out of a number of potential interventions is most appropriate for a specific individual with special capabilities it is necessary to have a quantitative measure for comparing performance using devices. Furthermore, determining the optimum settings for a particular individual requires an objective measure that is reliable and has predictive properties.

The center's activities therefore have been directed toward developing mechanisms for quantifying and then carrying out quantitative cross-comparisons of the various alternative input devices and approaches.

In this activity area, technical and methodological groundwork has been laid for a series of headpointing studies, and several studies have been carried out. Although quantification of input device performance is of primary interest to researchers and developers, the measurement instrument and protocols have potential direct positive impacts for people with physical disabilities:

- improved methods for evaluating the efficacy of special input devices, ultimately benefiting consumers through improved device design;
- ability to objectively compare different input strategies to determine which work best in which circumstances; and
- potential use of the research tool as a clinical evaluation tool, allowing clinicians to more accurately judge what input devices and interventions will work best for a particular client.

Development of extensions for standard computers and operating systems

Important features providing access for many users with movement impairments can often be implemented in standard products. The Trace Center's movement impairment program plan seeks to develop demonstration versions of such features, and to encourage their implementation by computer companies.

Some of the problems that people with movement impairments can have with standard input devices are:

- difficulty pressing and releasing keys quickly enough;
- difficulty pressing desired keys without accidently pressing others;
- motoric or other problems the preclude operation of the mouse;
- inability to press two keys at the same time, making it impossible to operate "modifier" keys such as Shift;
- inability to use communication aids or other alternate interfaces in place of the standard computer keyboard and mouse.

One way the Trace Center is addressing the need for extensions for standard computers and operating systems is by creating special adaptations. These have taken the form of software programs designed to adapt the operation of common operating systems (the software on a computer that controls its operation). The center has also developed external hardware devices which connect to the computer. These are more complex, but have the advantage of not being tied to particular operating system software.

The second strategy of the Trace Center for creating extensions to standard computers is to encourage computer companies themselves to adopt simple adaptations as standard parts of their operating systems. Some companies have already taken steps in this direction, incorporating simple adaptations—such as one finger operation of modifier keys—into their products. The Trace Center has assisted computer companies by creating model versions of such adaptations, by evaluating adaptations created by computer companies, and by providing information about what accessibility features are most needed. At present, Apple Computer ships many of the adaptations modelled by the Trace Center as a standard part of the operating systems of their computers (Macintosh and IIgs). IBM and Microsoft Corporation also now provide extensions to their operating systems (DOS and Windows) which incorporate similar features. These extensions were developed by the Trace Center for Microsoft and IBM.

The Trace Center's efforts to encourage the adoption of accessibility features in standard computers is discussed further in the "Cross-Impairment" section of this report (see the project report on "Computer and Operating System Accessibility Design Guidelines").

Development and Testing of an Instrument for Studying Efficiency of Standard and Alternative Input Devices

Project Team: Robert G. Radwin, PhD; Gregg C. Vanderheiden, PhD; Mei Li Lin, MS

Background

Pointing-based input devices such as the mouse have become standard components of major new computer systems over the past several years, necessitating the development of alternatives for people with movement impairments. In order to provide quantitative data by which particular alternative input devices or strategies can be evaluated, a microcomputer-based research instrument has been developed. The instrument is designed to measure the operation of both standard and alternative input devices, automatically logging performance data for analysis.

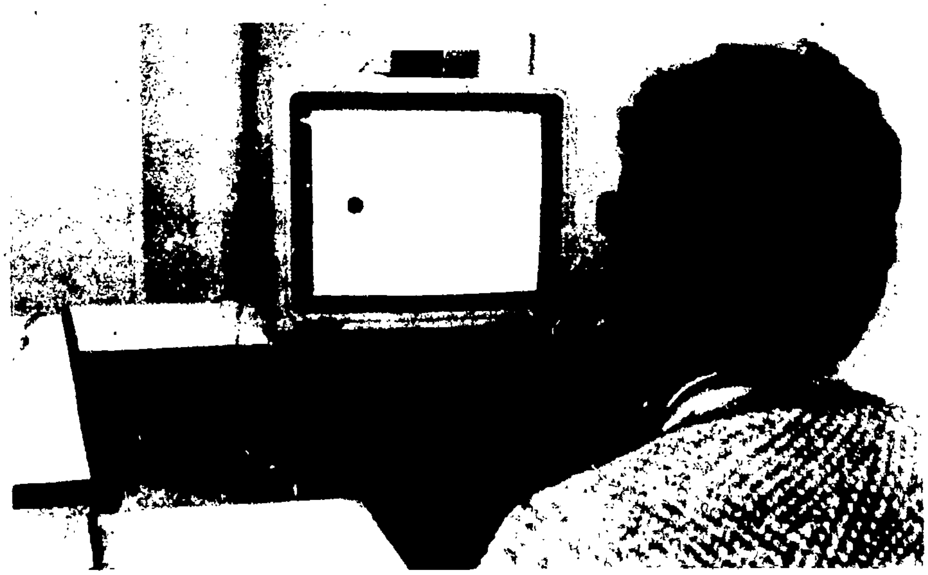
Approach

An instrument for testing performance in pointing tasks was designed for the initial phases of input device research. The instrument was designed to test standard mouse input devices and also special headpointing input devices designed for users with disabilities. The capabilities of the instrument are being improved upon as other forms of input devices are tested.

The headpointer is a relative displacement device similar to a mouse. It is designed for emulating a mouse pointer by tracking head rotation for horizontal cursor displacement and head extension-flexion for vertical cursor displacement.

Effective evaluative and normative procedures for the instrument were developed, and the instrument was tested and its capabilities to effectively measure pointing performance determined. It is currently being used for headpointing comparison studies.

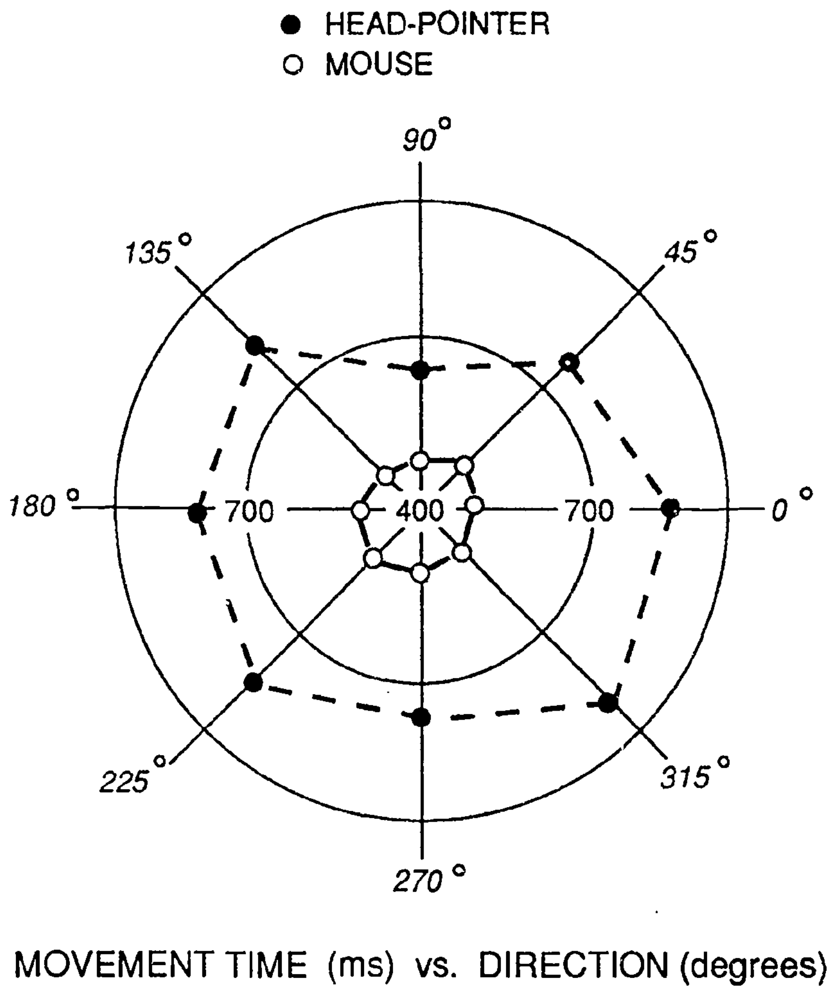
The instrument has been tested to determine if a Fitt's Law discrete target acquisition task can be used for evaluating and comparing computer input devices—in this case, a standard mouse and a remote headpointing device. Performances using a conventional mouse and an ultrasonic head-pointing device intended for individuals lacking normal movement ability were studied. The discrete movement task consisted of moving a cursor from the center of a computer display screen to a target of varying size and radial displacement.



Instrument used to test headpointing performance

Ten normal subjects performed this task using both devices. Fitt's Law adequately described movement behavior for both types of pointing devices. The instrument was also tested with two subjects with cerebral palsy. The instrument was able to measure significant differences between a disabled and an able-bodied subject, as well as between the supported and unsupported condition for a subject with cerebral palsy.

Marked improvements in performance were ob-



Average movement time plotted against direction, in polar coordinates, for both the mouse and the head-controlled pointer (10 subjects). Note that the center of the plot represents 400 ms.

served in one subject with cerebral palsy after lateral trunk support was provided. This demonstrated that the task would be useful as an evaluative instrument for selection and comparison of alternative pointing devices for individuals with movement impairments, as well as for evaluating modifications in the workplace for such individuals.

Status

Design and testing of the instrument have been completed. The instrument is being used for the pointing device comparison studies (see next report).

Selected publications

Radwin, R. G., Vanderheiden, G. C., & Lin, M. L. (1990). A method for evaluating head-controlled computer input devices using Fitt's Law. *Human Factors, 32*(4), 423-438.

Effects of Gain on Pointing Device Performance

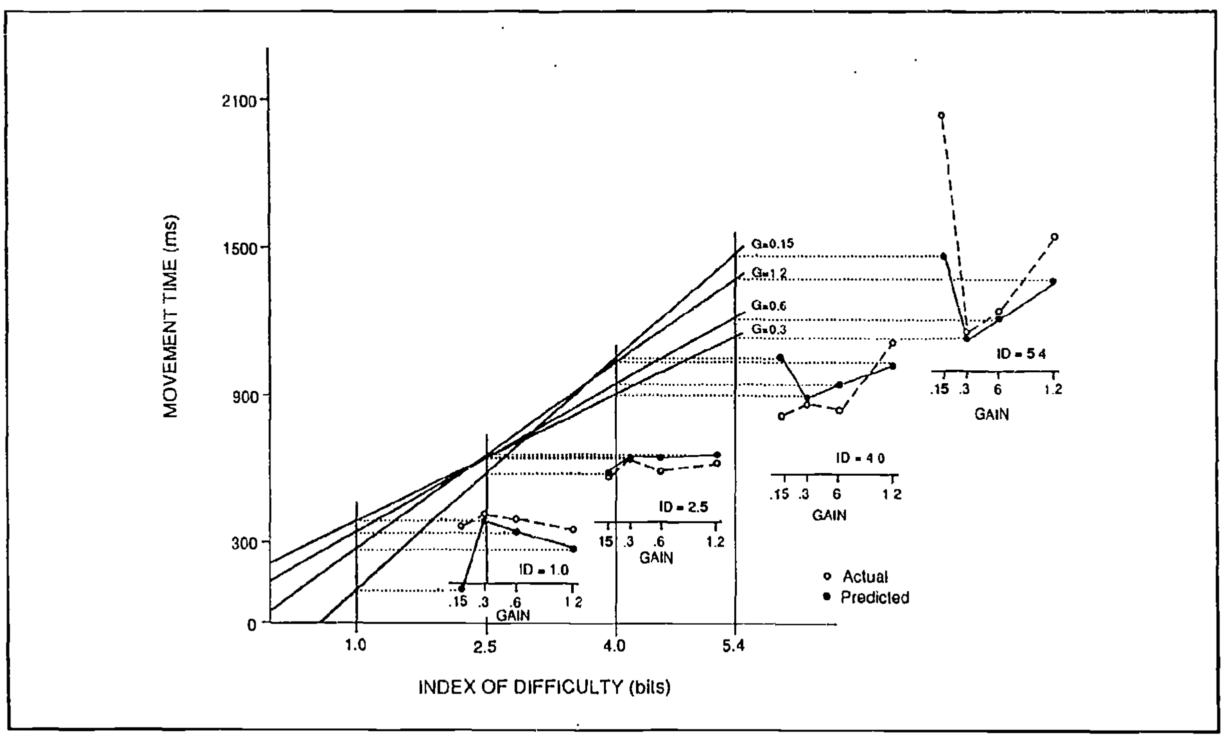
Project Team: Robert G. Radwin, PhD; Gregg C. Vanderheiden, PhD; Mei Li Lin, MS.

Background

One of the most powerful new techniques for access to computers is the use of remote headpointers. These headpointers can be a replacement for the mouthstick for persons with spinal cord injuries, and, as a new input technique for some individuals with cerebral palsy, can provide rapid, low-fatigue interface methods for computers. Because of their relatively simple hardware designs, they can also be efficiently and economically manufactured. As a result, a number of different headpointing systems have come out or are under development at the present time.

Until now, there have been no cross-comparisons of these various devices. In addition, many individuals who can use a headpointer can also use other pointing systems. A comparative evaluation between headpointing techniques and other approaches is therefore also required.

A research instrument has been developed for collecting data on input device operation performance (see previous project report). The instrument was put through evaluative and normative testing. These initial studies showed that a discrete movement target acquisition task based on Fitt's Law can be useful for evaluating and comparing headpointing performance. The instrument is now being used for the pointing device study series.



Data showing the effects of varying gain on the relationship between index of difficulty and movement time for a remote headpointer

27

Approach

The first studies in the series concerned the effects of gain on subjects' performance using headpointing and standard mouse devices. A Fitt's Law pointing task (like the one used in testing the research instrument) was used to measure subjects' performance.

The studies approached the question of gain effects from three angles:

1) To determine how control-display gain influences performance using a head-controlled computer input device.

2) To compare relative sensitivity to gain between head-controlled pointers and standard hand-arm controlled mice, and also to examine optimal gain across the two types of systems.

3) To investigate control-display gain interactions with other task factors including target width, movement amplitude and direction.

Status

Ten subjects participated in the studies. The results indicated that gain had a significant effect on movement time for both types of pointing devices and exhibited local minimums. Use of optimal gain levels with the head-controlled pointer improved subjects' performance by more than 21%. The results indicated that optimal gain was more important for the head-controlled pointer than for the conventional mouse in terms of movement time.

Little data has been available previously concerning performance at sub-optimal gain, or specifying optimal gain for head-pointing controlled computer input devices. This data is important for designing computer interfaces that enhance performance for computer users who have upper-extremity movement impairments and thus must depend on head-pointing devices.

Future possible areas of inquiry include: (1) varying acceptance time (the amount of time subjects must stay on the target before they are considered to have acquired it); (2) clicking operations (activation of a switch to signal target acquisition) and (3) dragging operations (continuous activation of a switch from the home position to the target). Acceptance time, clicking and dragging are all control methods used with remote headpointers. All three also have analogs in the operation of input devices designed for non-disabled computer users. These experiments will also measure performance across different pointing devices (mouse, trackball, headpointer, keyboard-controlled mouse) and across disabling conditions (cerebral palsy, spinal cord injury, multiple sclerosis, non-disabled subjects).

Selected publications

Lin, M. L., Radwin, R. G., & Vanderheiden, G. C. (1992). Gain effects on performance using a head-controlled computer input device. *Ergonomics, 35*(2).

Evaluation of Two Control-Display Gain Methods for a Head-Controlled Computer Input Device

Project Team: Robert G. Radwin, PhD; Gregg C. Vanderheiden, PhD; John A. Schaab, MS

Background

Remote head-controlled computer input devices (i.e. headpointers) are a frequently-used computer access adaptation for individuals who have limited ability to press keys on a keyboard, but who have an adequate range of head motion. Individuals who can use this technology include some people with spinal cord injuries, cerebral palsy, or degenerative muscular conditions. There are several commercial remote headpointers on the market.

Through the Pointing Device Study Series, the Trace Center is identifying methods for evaluating headpointer performance. The ultimate goals of this work include: the ability to compare remote headpointers to other input techniques, the ability to compare remote headpointer designs, and the ability to determine appropriate control settings for headpointers.

A research instrument has been developed for collecting data on user performance of input devices. The device was used to test the reliability of a Fitts' Law model for evaluating and comparing headpointer performance (see previous project reports). The Fitts' Law model was used to analyze the relationship of gain to performance, and it was shown that the optimal adjustment of gain was significant to performance.

One of the key issues raised with gain control was whether user performance would be dependent on the distance from the headpointer's transmitter. Users typically place a headpointer's transmitter in a fixed location (e.g. on top of the monitor) although users may not always position themselves at the same viewing distance. If the control system of the device is dependent on the distance from the transmitter users may become confused when selecting a preferred control setting because the device will respond differently at different viewing distances for a selected setting.

It was hypothesized that a system which maintained a fixed amount of cursor displacement per degree of head movement would be independent of the transmitter's distance and thus be a preferred method for controlling this computer interface. This method will be referred to as D/A gain.

Approach

Two methods of controlling a headpointer's control-display gain were examined in this study. One method, defined as A/A (angle/angle) gain, is the ratio of the angle subtended by the displacement of the cursor back to the viewing position, and the angle of head extension/flexion or rotation. This method of controlling headpointer gain was examined in a previous study. The second method, defined as D/A (displacement/angle) gain, is the ratio of the linear displacement of the cursor on the screen and the angle of head extension/flexion or rotation. The focus of this study is to determine whether user performance will change with viewing distance for predetermined settings of each type of control system. In addition, the study will attempt to determine the optimal settings for each type of control system.

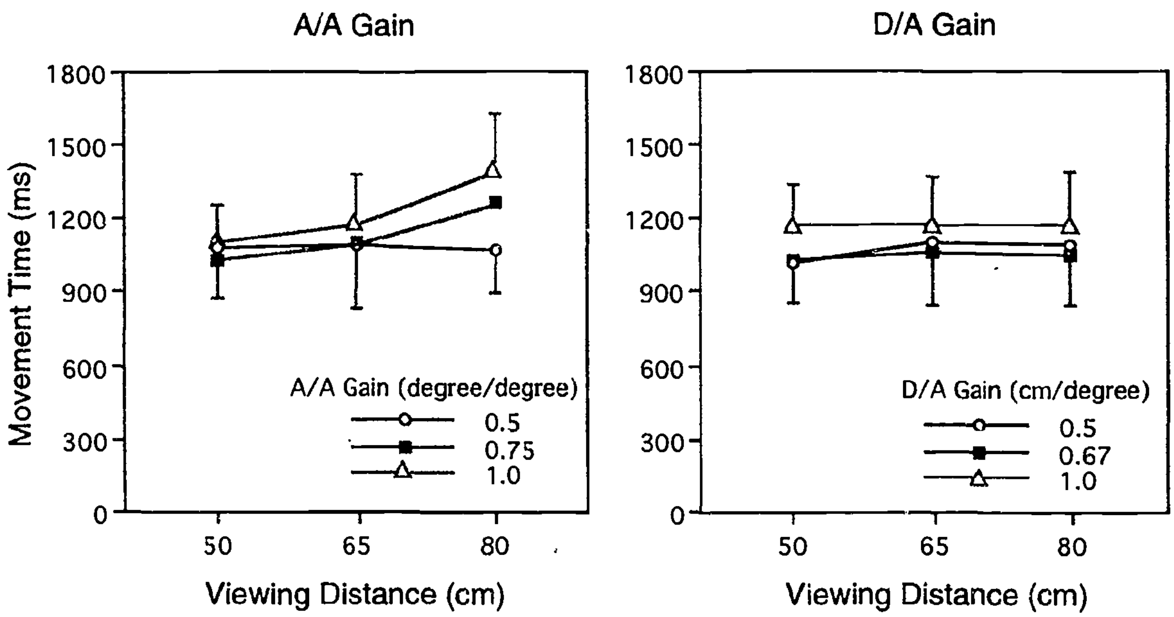
The comparison study of A/A gain versus D/A gain was performed using a single head-controlled computer input device. The device was made to simulate each type of control device using the software of the Fitts' Law program.

Status

A comparison study was designed to analyze the effect of viewing distance on user performance for each control device defined. The target acquisition task based on Fitts' Law as described by Radwin et al. (1990) was used to measure subject performance. Twelve subjects participated in this comparison study. The three viewing distances studied were 50 cm, 65 cm, and 80 cm. At each distance subjects performed the task for each A/A gain level of 0.5, 0.75, and 1.0. Subjects also performed the task for each D/A gain level of 0.5, 0.67, and 1.0 cm/degree.

Preliminary results of the study are summarized in the accompanying figure. The results indicate that there is an interaction between viewing distance and A/A gain. This data supports the conclusion that an operator's optimal A/A gain setting will depend on the distance from the transmitter. The drawback of a constant A/A gain system for a headpointer, therefore, would be that users may need to select a new A/A gain setting each time they use their computer. This method of controlling gain is very different from other computer interfaces such as mice or trackballs.

The results of the D/A gain data did not detect a significant interaction between viewing distance and D/A gain. The benefit of a control device which is independent of viewing distance is that it allows a user to maintain consistent performance at a predetermined setting regardless of where they are positioned from the transmitter. This study is continuing.



Average movement time (ms) plotted against subject viewing distance (cm) for both an A/A gain and a D/A gain controlled head-pointer. Data is summarized for twelve subjects.

Development of Improved Headpointing Computer Access System

Project Team: Jon R. Gunderson, PhD; Joseph M. Schauer, BS; Gregg C. Vanderheiden, PhD

Background

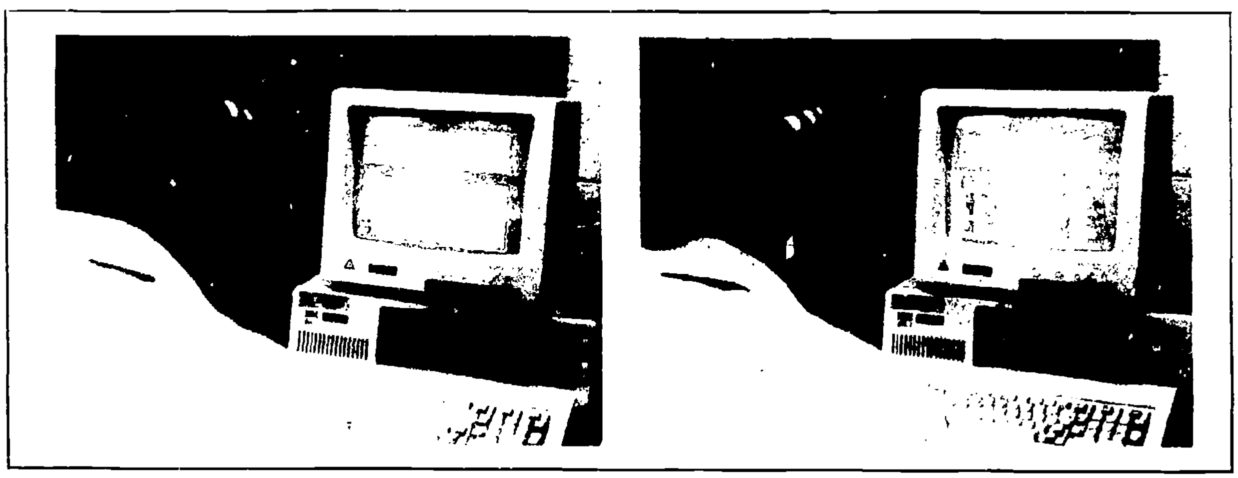
In 1981, the Trace Center began development of an optical headpointing input system for computers. The system was designed for use by persons who can easily aim at a target by moving their head, but who cannot effectively or quickly type keys using a finger, headstick or mouthstick. The user would point a small, lightweight optical detector towards an image of a keyboard displayed on a computer monitor. Pointing at the keys on the image would be equivalent to typing them on the standard keyboard. In this way the user could operate standard commercially available software on the computer.

The prototype system used one microcomputer and monitor for the input system and another for the application program (the word processor, spreadsheet, etc. that the user wanted to operate). Before transfer to a manufacturer for production and distribution, the Long Range Optical Pointer (LROP) system was modified so that only one computer was required. However, two monitor screens were still required: one to display the keyboard image and one to display the application program.

Feedback from users and from the manufacturer indicated that some people could operate the system better if it was implemented on one screen instead of two. For these reasons, a "One Screen" version of the original LROP software was developed.

Approach

The One Screen version of the LROP is designed for IBM Personal Computers, using standard CGA graphics. To type keys, the user points the optical headpointer at the screen. The application program is then temporarily interrupted while an image of the keyboard appears on the screen. The user can type a string of text or other characters on the keyboard screen, and edit this string before sending it to the application program (this feature also was not present on the two-monitor system). From the keyboard screen, the user can: (i) switch to the application program for viewing, without sending the characters currently typed on the keyboard



The software displays the on-screen keyboard (left) and the application program on the same monitor screen; (2) switch to the application program and send the typed characters to the program; or (3) move the pointer off the screen while retaining the keyboard image (in order to rest or think).

The One Screen version of the LROP also provides a typing acceleration system. In the ordinary keyboard image, a list of common words appears at the top of the screen. The user can type any of these words by selecting it with the optical pointer. If the desired word is not on the list, the user can enter the initial letters of the desired word. As letters are entered the word list changes, displaying words that begin with the letters typed so far. The user can type any of these words at any time by selecting it from the list with the optical pointer. The word lists are drawn from a 4000-word vocabulary.

Status

The One Screen software was designed for use with several different pointing systems. It was transferred to Words+ or Lancaster, Calif., who sold it with the Long Range Optical Pointer device. The program was sold with the LROP until the LROP was discontinued in 1991 due to changes in computer display technology.

Selected Publications

Gunderson, J. R. & Vanderheiden, G. C. (1988, June). One screen multiplexed keyboard for transparent access to standard IBM PC software. *Proceedings of the International Conference of the Association for the Advancement of Rehabilitation Technology (ICAART).*

Development of Extensions for Standard Computers and Operating Systems to Allow Access by Users with Motor Impairments

Project Team: Mark Novak, BS, BS, PE; Joseph Schauer, BSEE; Jay Hinkens, BS; Gregg C. Vanderheiden, PhD; Peter A. Borden, MA

Background

The most effective technique for providing access to computers for persons with disabilities is to have the computer designed in such a way that it is already accessible when manufactured. When accessibility features can be built directly into the design of the computer, the cost for these modifications drops to zero or close to zero, and their availability to persons with disabilities is universal. Of particular interest is the ability of individuals with disabilities to access computers in public settings, where it is difficult to modify a computer for a particular individual.

Not all adaptations for persons with disabilities can be built into standard computers. However, a wide variety of accommodations can be incorporated directly into the computer design. The purpose of this program is to develop simulations, demonstrations, or actual functioning extensions to operating systems which can be used to demonstrate to computer and operating system manufacturers how their systems could be modified to make them more accessible.

Approach

The ultimate goal of this program is to encourage the computer companies to take on the task of making their computers accessible. In some cases, the computer company has had its own programmers implement the accessibility features. In other cases the Trace Center has actually written the software or developed the hardware for transfer to the company.

The purpose of this project is to encourage the implementation of features needed by single-finger, headstick and mouthstick typists, people with physical disabilities who must drive the computer using an external communication or computer access device, and users with hearing & vision impairments. Eight features have been identified as extensions:

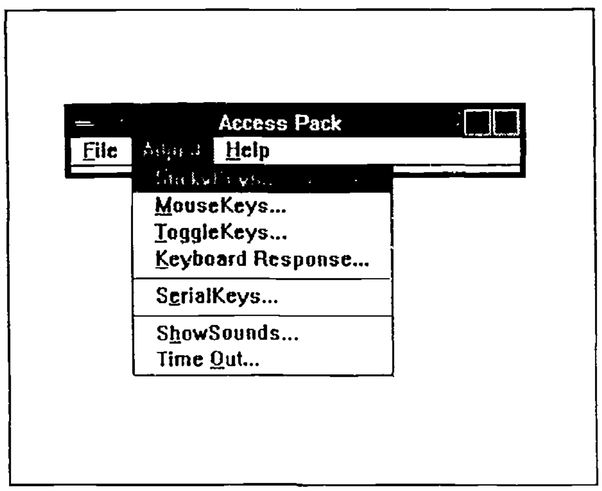
1) *StickyKeys*: The capability to execute multiple key operation (such as Shift-key) with a single finger, headstick or mouthstick.

2) *MouseKeys*: Option of using the numeric keypad on the keyboard to perform all mouse functions on the computer.

3) *RepeatKeys*: Control over auto-repeat of keys, including the rate at which keys repeat and the duration for which a key must be pressed before the auto-repeat commences.

4) *SlowKeys*: Control over the amount of time a key must be pressed before the computer accepts it as input.

5) *BounceKeys*: Elimination of "bouncing" on keys, sometimes caused by tremors. A key cannot be activated more then once within a certain time frame.



Menu from Windows Access Pack, showing the set of extensions

6) *SerialKeys*: Capability to perform all keyboard and mouse functions from an external assistive device (such as communication aid) connected to the computer's serial port.

7) *ToggleKeys*: For individuals who cannot see toggle key status lights, this feature provides audible tones to indicate the status of the caps lock, num lock and scroll lock keys.

8) *ShowSounds*: Visual indicator for sounds coming

from the system, for users who are deaf or have hearing impairments.

At present there are many operating systems which are either in common use or headed for common adoption. The Trace Center is currently developing (or assisting in the development of) modifications for the following systems:

- Macintosh (Apple Computer)
- Microsoft Windows (Microsoft Corporation, for IBM PC and PS/2)
- MS DOS (Microsoft, IBM PC and PS/2)
- OS/2 (IBM)
- X Windows (Unix-based systems)

Status

Macintosh Environment: The Trace Center has been working in conjunction with Apple Computer over the past seven years, assisting them in their efforts to implement the guidelines of the Industry/Government Cooperative Initiative on Computer Accessibility and later of the GSA. These efforts have resulted in the incorporation of several changes and additions to the Macintosh to increase its accessibility by persons with disabilities. These modifications include StickyKeys, RepeatKeys, SlowKeys and MouseKeys. These modifications are now shipped as a standard part of every Macintosh and Apple IIGS sold.

Windows Environment: The emergence of PCs with more memory and more powerful processors, together with the increased popularity of graphics-based operating systems, has led IBM and Microsoft to develop new operating systems for these computers. One such system is Windows, an operating system shell developed by Microsoft. None of the existing MS-DOS adaptations will work with software that is running under Windows. In addition, Windows uses a mouse as a standard input device. The Trace Center has developed a set of extensions to Windows—known as the Windows Access Pack—which includes the eight features discussed above. There is also a "TimeOut" feature, allowing the access features to automatically turn off after a certain length of time. The access pack is currently being distributed by Microsoft Corporation. The program can be downloaded from CompuServe, GEnie, Microsoft Online and other computer bulletin boards, or disks can be obtained by calling Microsoft at (206) 637-7098 (TDD 635-4948). The Trace Center will continue to update the features for future versions of Windows as appropriate, and will also assist Microsoft Corporation in any attempts they may make to incorporate these features permanently into the Windows operating system.

PC-DOS/MS-DOS Environment: For several years the Trace Center has been involved in programming model access software for PC-DOS and MS-DOS, the operating system software used in IBM PC computers and in the large number of IBM-compatible computer models on the market. The StickyKeys and RepeatKeys features have been available for several years in a program called 1-Finger, developed and distributed by the Trace Center. In addition, the Trace Center agreed to work with IBM on the development of a more complete package of access features for IBM computers using DOS. The package, known as AccessDOS, is available from IBM free of charge as of May, 1991. It includes all of the eight key features discussed above. Individuals can receive a free copy of AccessDOS, simply by calling IBM at (800) 426-7282.

OS/2 Environment: At the present time, the OS/2 operating system is gaining momentum in the business world. IBM included StickyKeys, RepeatKeys and SlowKeys in Version 2 of OS/2. The Trace Center will assist them in the development of these and other features for future versions of OS/2.

X Windows Environment: The X Windows interface is a graphical interface commonly used with the Unix operating system, widely used in government, education and industry. By providing accessibility to X Windows, many Unix systems can be made accessible. The Trace Center is part of the Disability Access Committee on X (DACX). The Trace Center serves as coordinator for the group and is also in charge of initiatives for physical access issues. This work has involved developing a basic access package for X Windows similar to those developed for DOS. This package was recently included in Version X11,R6 of X Windows.

Selected publications

Lee, C. C., Novak, M. E., Schauer, J. M., & Vanderheiden, G. C. (1990, Oct.). Providing access in Windows 3.0. In *Proceedings of the Eighth Annual Closing the Gap Conference*. Minneapolis, MN.

Novak, M. E., Schauer, J. M., Hinkens, J. D., & Vanderheiden, G. C. (1991). Providing computer access features under DOS. *Proceedings of the Fourteenth Annual RESNA Conference*.

Novak, M. E., & Vanderheiden, G. C. (1993). Extending the user interface for X Windows to include persons with disabilities. *Proceedings of the Sixteenth Annual Conference* (RESNA). Las Vegas, NV.

Trace Transparent Access Module (T-TAM) for Apple and IBM Computers

Project Team: Mark Novak, BS, BS, PE; Joseph Schauer, BSEE; David P. Kelso, MS; Gregg C. Vanderheiden, PhD

Background

Certain people with physical disabilities cannot operate standard input devices for commercially available computers. Many of these individuals can, however, operate a special communication or computer access aid, using a control system such as an optical headpointer or single switch. This special aid in turn can be interfaced to the computer and used as an input device.

In the past, Keyboard Emulating Interfaces (KEIs) have been used to connect an aid to a computer. However, newer models of computer require the use of other standard input devices, in particular a "mouse" pointing device. Thus the computer user must be able to use the mouse (or an equivalent) to operate the computer. This requires a General Input Device Emulating Interface (GIDEI), not just a KEI.

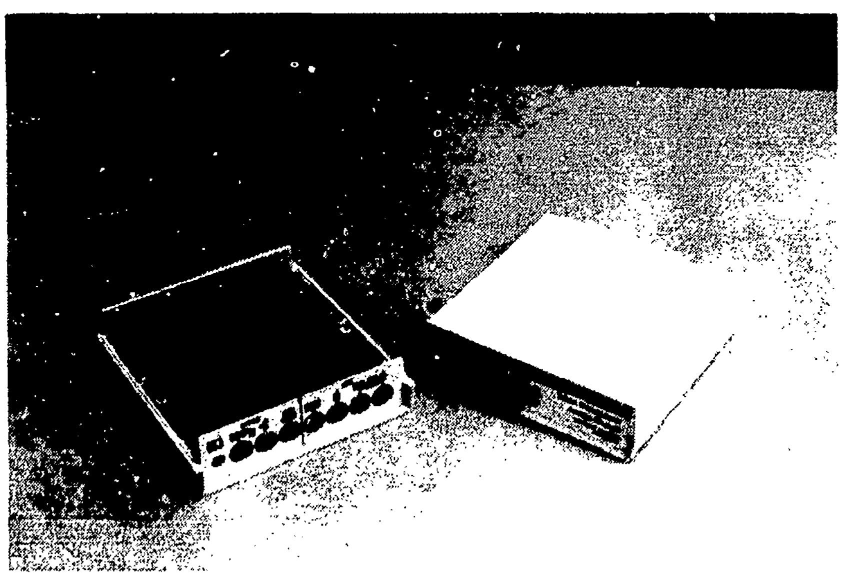
Approach

The goal of this development effort has been to create a commercially viable design for a GIDEI for Apple Macintosh, Apple IIGS and IBM PS/2 computers—all of which use a mouse as a standard input device. This particular GIDEI has been named the Trace Transparent Access Module (T-TAM), since it provides "transparent" access to standard commercially available computer systems.

The T-TAM is a hardware module that translates standard serial ASCII code output from a communication or computer access aid into the keyboard and mouse input signals required by the computer. Serial ASCII code was selected as the form of output from the aid, since it is by far the most common output interface on computer-independent aids. Serial ASCII is also the interface used in older KEIs.

In order to accomplish the function of a key or a mouse movement, the user sends a single ASCII character or string of characters to the T-TAM. According to the definitions set down in the GIDEI standard, the T-TAM converts the ASCII string to the correct keyboard or mouse input signal. Since most aids also provide the capability to store strings of characters under a single selection, the user can program longer command strings (such as moving the mouse 20 pixels or pressing the "Print Screen" key) to correspond to single selections. This effectively allows the user the most direct access possible to a particular action.

The T-TAM provides connections for both Apple and IBM computers—that is, the same T-TAM can be connected to an Apple Macintosh SE and to an IBM PS/2 Model 50 (though not at the same time). Because the input devices comply with the same standard in Apple IIGS, Macintosh SE and Macintosh II computers (the Apple Desktop Bus), the T-TAM can easily be used with any of the three. Since an adaptor is available for connecting IBM PS/2 keyboards to the older IBM



The T-TAM unit: back panel and inside (left), and front panel

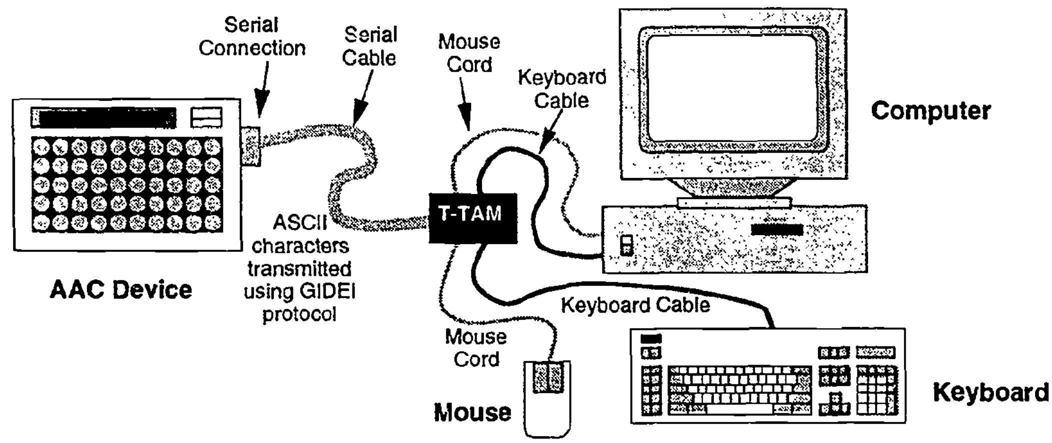


Diagram of computer access system showing connection of T-TAM and standard input devices

PC-AT computers, the T-TAM can also be made to work with the ATs.

In addition to providing access through special input devices, the T-TAM provides assisted keyboard features for the standard computer keyboard. Among these are StickyKeys (the ability to type key combinations like shift-key with one finger), RepeatKeys (the ability to control the keyboard's auto-repeat feature), and MouseKeys (control of mouse functions from the keyboard).

Status

The device has been transferred to two companies for commercial production: Prentke Romich Company of Wooster, OH and Words+, Inc. of Lancaster, CA. Both companies are long-standing manufacturers of communication and computer access devices. Prentke Romich Company started shipping T-TAMs to customers in Sept., 1990; Words+ in Dec., 1990.

Selected publications

Schauer, J. M., Novak, M., & Vanderheiden, G. C. (1990). Transparent access interface for Apple and IBM computers: The T-TAM. *Proceedings of the 13th Annual Conference of the Association for the Advancement of Rehabilitation and Assistive Technology (RESNA).*

Kelso, D. P., Lee, C. C., Novak, M., Schauer, J. M., & Vanderheiden, G. C. (1990, Oct.). Transparent access interface for Apple and IBM computers: The T-TAM. In *Proceedings of the Eighth Annual Closing the Gap Conference.* Minneapolis, MN.

Sensory Impairment Focus Area

Individuals with sensory impairments, either visual or auditory, can experience difficulty in using standard commercially available computers and other electronic devices. Since the types of needs and the degree of severity of current access problems are different for users with visual impairments than for users with hearing impairments, the two groups are addressed by separate research and development programs.

Visual Impairments

Individuals with visual impairments primarily need to be provided with some mechanism to perceive the contents of visual displays such as computer monitors. Because most computer software relies almost exclusively on the visual display of information, the barriers faced by persons with visual impairments—particularly individuals who are severely visually impaired or blind—are quite large. Moreover, the recent trend toward increased detail in visual displays, in the form of text formatting and graphic images, is greatly complicating the process of providing alternate access to this information. Although a wide variety of different solutions are currently available for providing access to the character-based screen displays used by computers in the past, there is currently only one software program designed to provide blind users with access to a graphics-based operating system.

A key reason that access systems have not been developed for the new graphics-based displays is the extreme technical difficulty of deriving screen information in a form that can be easily accessed and interpreted by special Braille, voice, or tactile display systems. With older, character-based screen displays, it was possible simply to tap into the area of the computer's memory where the text to be displayed on the screen was stored. A special braille, tactile or voice output system could then display this information, character for character. Newer graphics-based computers, however, do not use character-based screens, and do not store the textual information from the screen in a convenient location where a special device can tap into it.

A further difficulty lies in the *kind* of information displayed by newer computer systems. A significant portion of the information on the screen may be presented through the text's formatting, arrangement and location with respect to graphical elements, or directly in pictorial or graphic form. This problem is compounded by the fact that some of the major new operating systems by Apple, Microsoft, and IBM use overlapping images, which makes interpretation by external devices extremely difficult if not impossible without some cooperation from the computer and operating system composing the image. Operating system "hooks" are needed to ensure that adaptive hardware and software for blind users can function successfully.

In addition to the difficulties in getting access to the screen image, there aren't good strategies for presenting this information to a blind individual. Better techniques are needed for handling the diverse formatting of text (style, font, size, and spatial arrangement) if these new screens are to be properly interpreted. In addition, there is a need to identify and develop specific strategies for allowing blind individuals to directly explore charts, diagrams, and other business and program graphics that are being used at a rapidly increasing rate in standard business and educational software.

The primary needs in the area of visual impairment at the present time are:

1) the identification of techniques for tapping the display image in the new generation computers and operating systems;
2) the identification of strategies for securing the information displayed on the screen before it is turned into a visual image (in order to provide screen access techniques and to develop direct interpretation strategies for blind individuals);
3) research into the optimum techniques and strate-

gies for blind individuals to work with formatted text displays;

4) research into the best formats and techniques for allowing blind individuals to perceive and manipulate graphic images (in order to allow them to operate the new generation programs and operating systems).

Hearing Impairments

Individuals with hearing impairments do not currently experience much difficulty in dealing with current computer and software designs. They will face increasing barriers, however, if the use of sound (tones or voice) to transmit information is increased. The primary need in the area of hearing impairments is therefore in identifying where these barriers are likely to arise, and in identification of alternatives for presenting this auditory information. The primary approach currently being developed and advocated in that of a "ShowSounds" feature at the level of the computer operating system. This feature would allow the user to indicate to the operating system or application software that he or she needs visual indications of sounds or captions for spoken text.

Program Plan

The Trace Center has three major areas of activity within the Sensory Impairment Focus Area:

1) *Development of Blind User Interfaces for Graphic-Based Computer Systems.* The chief activity is this area has been the development of the experimental prototype "Systems 3" device for combined auditory-tactile access to screen information.
2) *Identification and Development of System Hooks to Allow Access by Blind Individuals.* This effort includes development of operating system hooks (software connection points) for access devices such as the "Systems 3" device. The Trace Center is also assisting and advising computer companies in their efforts to design such hooks directly into their computers and operating system software.
3) *Development of Auditory Access Techniques for Deaf and Hearing Impaired Users.* In this area, the Trace Center has been exploring the development of a "ShowSounds flag" which would allow software to be alerted to the need to present information in both auditory and visual form.

In addition to these three areas of activity, the Trace Center has carried out several other projects that directly address the needs of people with sensory impairments. These projects are described in the "Cross-Impairment Focus-Area" section of this report. They include: accessibility manuals for computers and consumer electronic devices, informational efforts on providing computer access in higher education settings, and an effort to increase accessibility of TDDs to people with multiple impairments.

State-of-the-Art Planning Workshop on Access to Graphics-Based Computers by Blind Users

Project Team: Charles C. Lee, M.S.; Gregg C. Vanderheiden, Ph.D.; Christine Thompson, B.S.

Background

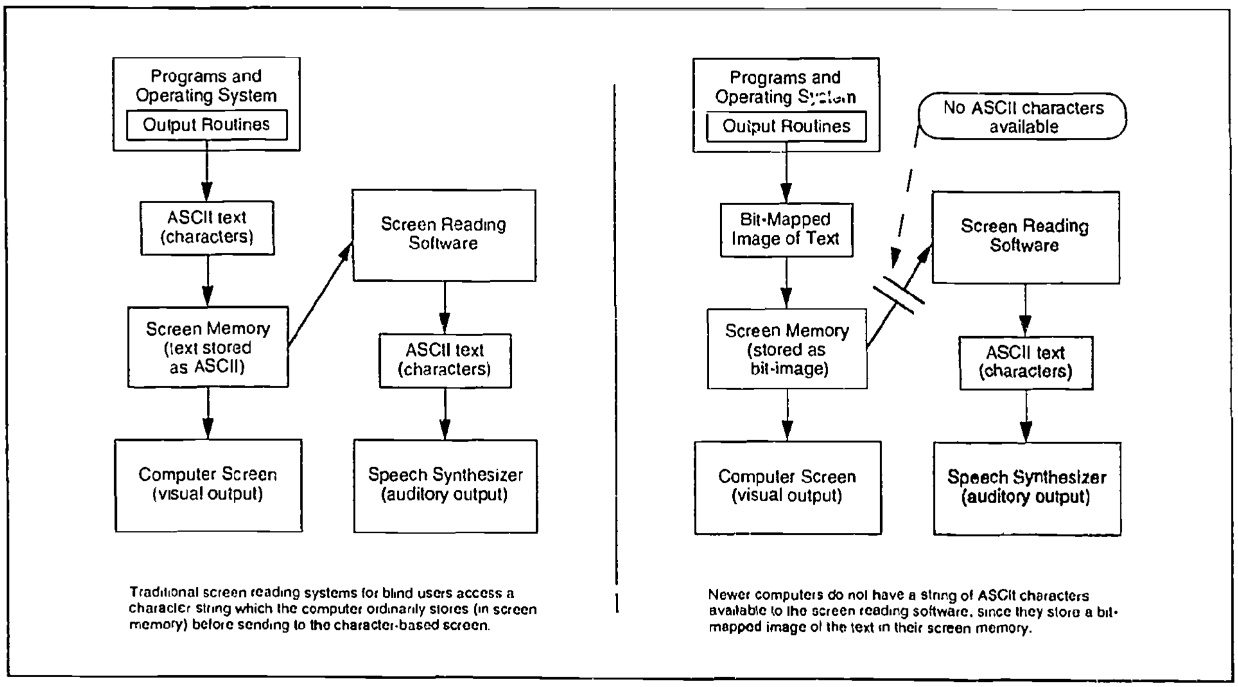
The greatest single technical obstacle to computer access for blind individuals to arise in the past five years is the emergence of computers which use graphical displays as a standard part of their operating systems. The existing computer access systems for blind users (both braille-output and voice-output) rely upon a character-based display: one consisting primarily of alphanumeric characters which are stored in memory as characters rather than as pixel images. Current access systems rely on the ability to recognize characters and determine their position by directly reading the screen memory. This information can be sent directly to a speech synthesizer or braille display and there translated into an intelligible form.

In graphical operating systems, screen memory stores pixel images, providing no source of text to send to a synthesizer or braille display. Furthermore, information about text position is not stored in the absolute form in which it is stored in character-based systems. The result of this situation is that there is currently no commercially available system for voice output access to graphic operating systems; and only one tactile system, displaying images of letters rather than true braille

There are many researchers and developers who have tackled these access problems, and many users with a wealth of experience in using current systems. However, information sharing has primarily occurred only through individual contact and publications.

Approach

In order to ascertain the state of the art in access to graphic operating systems for blind users, it was de-



Traditional screen reading systems for blind users access a character string which the computer ordinarily stores (in screen memory) before sending to the character-based screen.

Newer computers do not have a string of ASCII characters available to the screen reading software, since they store a bit-mapped image of the text in their screen memory.

Diagrammatic explanation of one current computer access problem for blind users

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cided to host a planning workshop. This session would bring together those with a great deal of knowledge and experience to discuss the problem, to share information, and to determine research and development priorities.

The workshop was scheduled to last three and a half days, to ensure that enough time was provided for sharing information and for discussion of issues. The four principle objectives were: 1) to acquaint all of the key individuals in the field with state-of-the-art information and ideas; 2) to identify promising access strategies; 3) to develop a recommended plan of action for addressing access problems of blind and visually impaired individuals; and 4) to identify and form collaborative links among individuals working in various areas.

Status

The state-of-the-art planning workshop was held in Madison on October 4-7, 1988. Thirty-seven participants were invited, including representatives from computer companies, special access equipment manufacturers, consumers, and researchers. Eleven of the 32 participants were blind or deaf-blind.

Results of this workshop were used to guide the GUI access work of the Trace Center and helped in securing better linkages between the organizations and individuals participating in the meeting.

Selected Publications

Lee, C. C., & Vanderheiden, G. C. (1989, June). Access to graphical computers by blind users: Results of a planning workshop. In Proceedings of the 12th Annual Conference of the Association for the Advancement of Rehabilitation and Assistive Technology (RESNA). New Orleans, LA.

Lee, C. C., & Vanderheiden, G. C. (1988, June). Accessibility of graphically based user interface computer systems for individuals with visual impairments. In Proceedings of the International Conference of the Association for the Advancement of Rehabilitation Technology (ICAART). Canada: Montreal.

List of participants

Adams, Frank R. (Special Needs System Development, IBM Entry Systems Division)
Bach-y-Rita, Paul, MD (Dept. of Rehab. Medicine, University of Wisconsin-Madison)
Barello, Larry (Microsoft Corporation)
Blazie, Deane (Blazie Engineering)
Boyd, Larry H. (Berkeley System Design, Inc.)
Brabyn, John (Smith-Kettlewell Institute)
Chong, Curtis (Minneapolis, MN)
Cranmer, Tim (Frankfort, KY)
de l'Aune, William (Rehabilitation R&D Center, Veterans Administration Medical Center)
Durre, Karl P. (Computer Science Department, Colorado State University)
Ewers, Neal (St. Paul, MN)
Foulke, Emerson (Perceptual Alternatives Laboratory, University of Louisville, KY)
Fowle, Tom (Smith-Kettlewell Institute)
Gabias, Paul (Pueblo, CO)
Goodrich, Gregory (Western Blind Rehabilitation Center, Veterans Administration Medical Center, Palo Alto, CA)
Gunderson, Jon (Trace R&D Center)
Holladay, David (Raised Dot Computing)
Kasday, Leonard R. (AT&T Bell Laboratories)
Milewski, Allen (AT&T Bell Laboratories)
Lauer, Harvey (Blind Center)
Lee, Charles C. (Trace R&D Center)
Lewis, Paul (Telesensory Systems, Inc.)
Mansoir, David (Sight Center, Cleveland Society for the Blind)
McKinley, Jan (Western Blind Rehabilitation Center, Veterans Administration Medical Center, Palo Alto, CA)
Melrose, Sue (New Berlin, WI)
Millar, Susanna (Department of Experimental Psychology, University of Oxford, England)
Navy, Caryn (Raised Dot Computing)
Orman, Steve (Dept. of Rehab. Medicine, University of Wisconsin-Madison)
Parreno, Antonio (Hospital Ramony Cajal, Madrid, Spain)
Runyon, Noel (Campbell, CA)
Schreier, Elliot (National Technology Center, American Foundation for the Blind)
Thompson, Wayne (Kentucky Department for the Blind, Technical Services Unit)
van den Meiracker, Maud, PhD (COI/ECC, The Netherlands)
Vanderheiden, Gregg C., PhD (Trace R&D Center)

Access to Graphics-Based Operating Systems for Blind Individuals: "Systems 3" Model

Project Team: Gregg C. Vanderheiden, PhD; John Mendenhall, MS; Kelly L. Ford, BA; Wesley L. Boyd

Background

Graphics-based operating systems pose severe obstacles to computer users with blindness and certain other visual impairments. Such systems require the user to visually recognize and locate words, boxes, on-screen "buttons," and icons. Pointing to these images (usually with a pointing-based input device like a mouse) instructs the system to carry out commands. A user unable to visually orient themselves is thus unable to operate the system.

The first challenge in allowing transparent access to such systems for blind users is to locate operating system "access hooks": points at which screen information can be accessed in order to be sent to some alternative output system such as a braille display or speech synthesizer. A second and equally important challenge, however, is to provide a structured interface for presentation of the screen information so that blind users can interact with the computer in an effective and timely way.

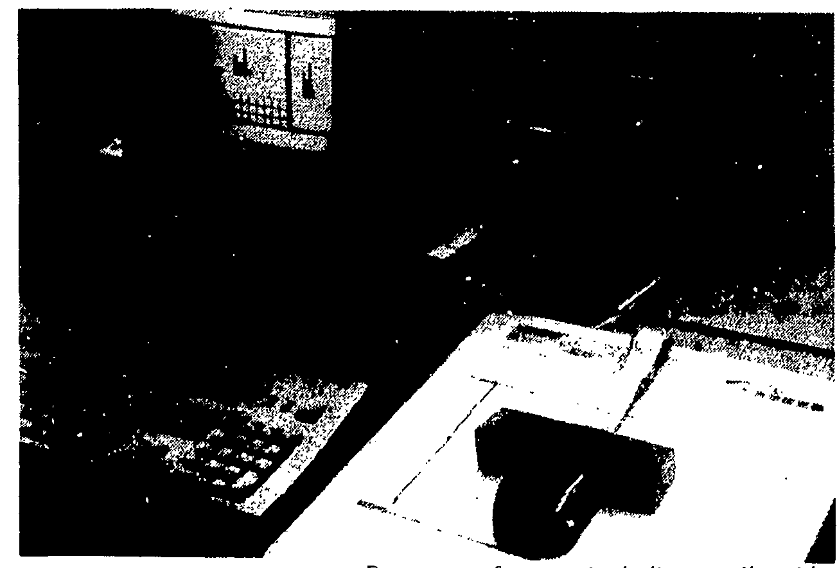
Approach

The first challenge in providing access (outputting screen information) is being addressed as part of other Trace Center projects and through cooperative links to other researchers and developers. The second challenge (structuring the user interface) is being studied in terms of a "Systems 3" model. This model allows for three different approaches to screen access, which could coexist in eventual commercial implementations.

In System 1, no additional special hardware component is used for navigating the screen. All commands and requests for information are issued using the keyboard. In System 2, a touch tablet is used. The user can touch on "speed lists"—areas of the tablet that correspond to menus and messages—in order to specify what information is to be read back. System 2 does not provide any additional access to the computer, but does provide faster access. Neither System 1 nor System 2 can deal directly with graphics information. In System 3, a "virtual tactile tablet" is added to the system. This tactile tablet allows the user to "feel" the image on the screen by using a mouse-like puck which contains a tactile array of 100 vibrating pins.

A working prototype of the Systems 3 model is being used for five purposes:

1. To solve technical problems involved in making Systems 3 workable. Most of the major hurdles in getting the system operational have been cleared. However, the system will have to be fine-tuned as new features are added.
2. To determine if the design of Systems 3 will work



Prototype of system including tactile tablet in actual application by blind users. Several prototypes have been given to knowledgeable blind computer users for evaluation. The prototype has also been presented at rehabilitation conferences in order to obtain professional and consumer feedback.

3. To refine the design to serve the purposes of blind users and to make the system more "user-friendly" to them. Suggestions from blind testers of the system, and others, have resulted in design changes to make it more useful and easier to use.

4. To study how blind people can best obtain information from a graphics-based screen. This objective is discussed in the "Tactile Perception and Business Graphics Study Series" report. Results of these studies will be considered in making modifications to the system.

5. To study the feasibility of creating commercial production models. This objective is currently in its infancy. Feedback from users indicates that the system could be very useful as a commercial product, but many ergonomic issues—and production cost issues, especially for the tactile tablet—must still be resolved.

Status

An initial prototype of Systems 3 has been developed in conjunction with Berkeley Systems, Inc., and with the cooperation of Telesensory Corporation, Kurta, Inc., Apple Computer and Articulate Systems, Inc. Four copies of the prototype have been created and are being used in field testing and experiments (see report on "Tactile Perception and Business Graphics Study Series"). Initial field tests have been successful, but also point out some of the limitations of this type of approach.

One of the results has been the development and exploration of an alternate but complimentary approach which uses slower but higher-resolution techniques for access (see report on "Access to Graphical User Interfaces Through Dynamic Screen Snapshots").

Selected publications

Vanderheiden, G. C. (1989). Nonvisual alternative display techniques for output from graphics based computers. *Journal of Visual Impairment and Blindness*, *83*(8), 383-390.

Boyd, L. H., Boyd, W. L., & Vanderheiden, G. C. (1990). Graphical user interface: Crisis, danger and opportunity. *Journal of Visual Impairment and Blindness*, *84*(10), 496-502.

Vanderheiden, G. C. (1990). Graphic user interfaces: A tough problem with a net gain for users who are blind. *Technology and Disability*, *1*(1), 93-99.

Vanderheiden, G. C., Boyd, W. L., Mendenhall, J. H., & Ford, K. (1991). Development of a multisensory nonvisual interface to computers for blind users. *Proceedings of the Human Factors Society 35th Annual Meeting*. San Francisco, CA.

Tactile Perception Studies: Factors in Perception of Simple Shapes

Project Team: Steven Wiker, PhD; Gregg C. Vanderheiden, PhD; Seongil Lee, MS

Background

Access to computers for individuals who are blind depends increasingly upon the user's ability to recognize and interpret non-verbal or graphic information. The need for a nonvisual mode for presenting graphic information led to the inclusion of a vibrotactile array in the prototype Systems 3 device. (See Systems 3 project report for more thorough discussion and illustrations of the hardware.)

The vibrotactile array of the Systems 3 device allows individuals who are blind to feel shapes of graphics appearing on the computer screen. There are several aspects of this type of tactile presentation which can be varied, however, and the effects of these variations in optimizing the user's ability to derive information are not known. The purpose of this study series is to examine different tactile presentation modes and compare their relative efficacy.

Approach

The first experiment in this series dealt with the recognition of elemental shapes, or tactemes. Subjects perceived the shapes using the Systems 3 computer configuration: a computer connected to a graphics tablet, with a hand-held puck for navigation and a vibrotactile array for tactual interpretation of shapes. The tablet area corresponds to the computer screen. The user moves the puck around the tablet, in the process feeling whatever image is on the computer screen.

Subjects were timed in their identification of tactemes. A basic set consisting of vertex, cross, gap and arc was used, with each of the shapes being presented at three different angles—90°, 60° and 120° (see Figure 1).

Experiments compared three variables in the operation of the system:

1) *Same-hand vs. cross-hand perception*—that is, whether the vibrotactile information was presented on the same hand with which the user moved the puck around the shape or on the other hand. This involved testing using two versions of the system: one with the tactile display mounted on the mouse, and one with a moving mouse for one hand and a stationary tactile display for the other hand.

2) *Large vs. small stimulus size*—that is, the absolute size of the image being perceived, as it appears on the computer screen. Two different sizes were compared: objects the size of the display and objects 2.25 times the size.

3) *High vs. low mapping ratio*—that is, the ratio of the number of pixels on the screen to the pins on the vibrotactile array that correspond to those pixels. Two different mapping ratios were used: 32 pixels to one pin and 8 pixels to one pin.

Each subject experienced all 24 experimental conditions (see Figure 2). Amount of information transmitted and subject response time were examined for effects of display mode, object size and display resolution, using repeated-measures analysis of variance (ANOVA).

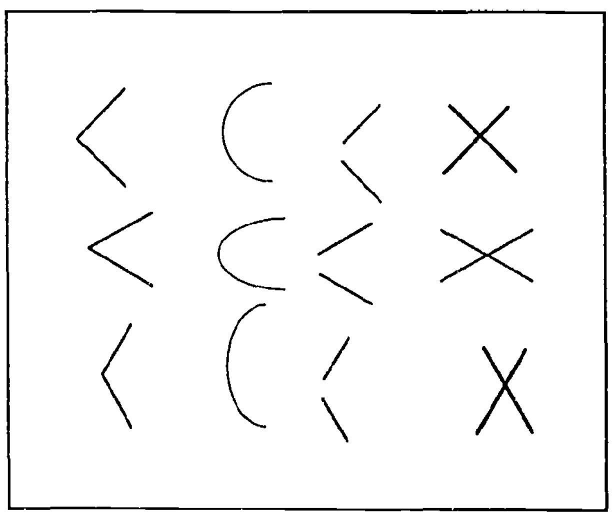


Fig. 1: Set of tactile primitives, with angle variations

Status

This study has been completed and the data analyzed. Results consistently showed that tactile image size does have a significant effect upon individuals' ability to correctly recognize shapes and shape elements, with the larger size being easier to identify. Similarly, the lower pixel-to-pin mapping ratio produced better recognition.

No significant performance difference, however, was found with ipsilateral (same-hand) versus contralateral (opposite hand) tactile feedback. This would indicate that there would not be any significant performance difference between a system with the tactile array mounted on the movable puck and one with the puck held in one hand and the array felt with the other. If this finding holds true with more complex shapes, it could mean a lower-cost approach for the development of the System 3 product by a commercial vendor.

Selected publications

Wiker, S. F., Vanderheiden, G. C., & Lee, S. (1991). Development of tactile mice for blind access to computers: Importance of stimulation locus, object size, and vibrotactile display resolution. *Proceedings of the Human Factors Society 35th Annual Meeting*. San Francisco, CA.

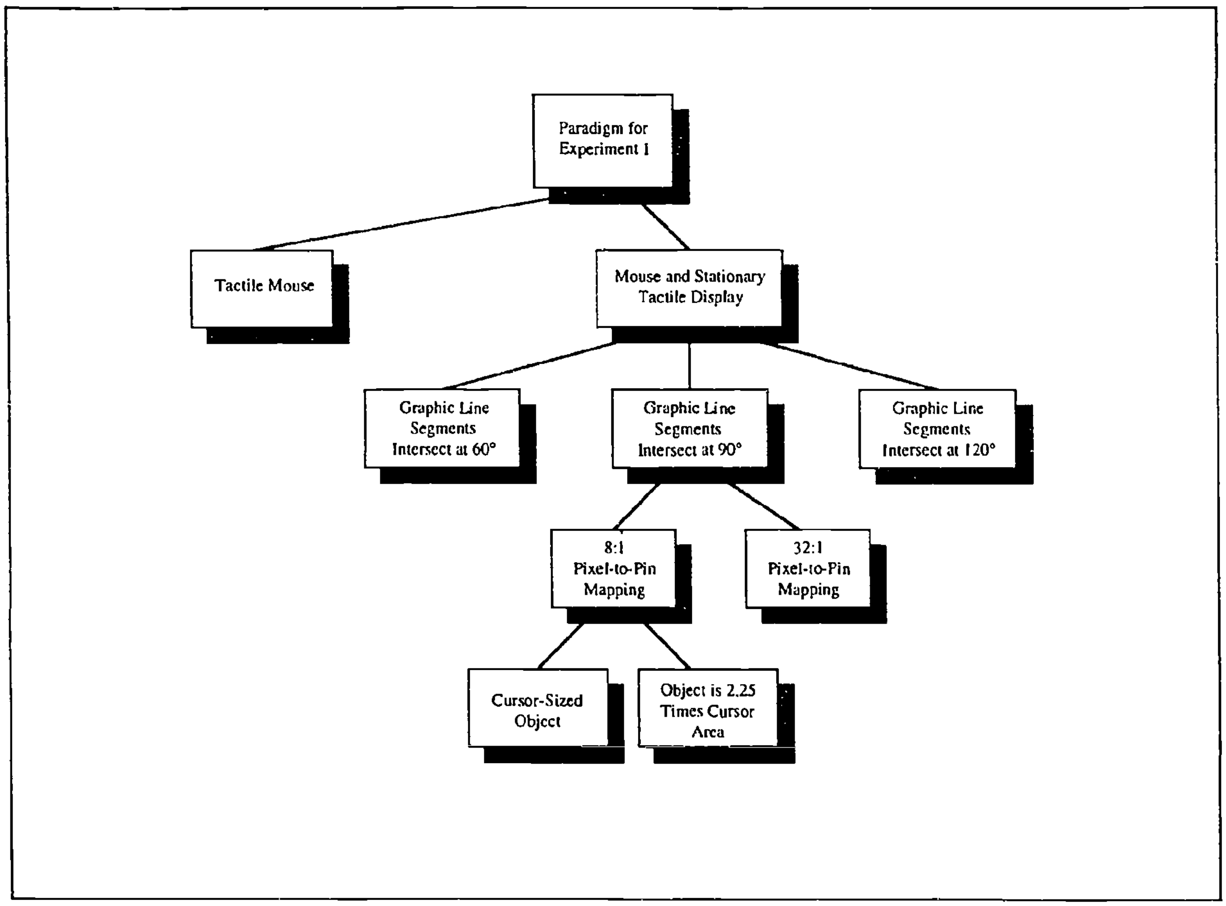


Fig. 2: Paradigm of experiment

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Tactile Perception Studies: Factors in Perception of Compound Shapes

Project Team: Steven Wiker, PhD; Gregg C. Vanderheiden, PhD; Seongil Lee, MS

Background

Access to computers for individuals who are blind depends increasingly upon the user's ability to recognize and interpret non-verbal or graphic information. The need for a nonvisual mode for presenting graphic information led to the inclusion of a vibrotactile array in the prototype Systems 3 device. (See Systems 3 project report for more thorough discussion and illustrations of the hardware.)

The vibrotactile array of the Systems 3 device allows individuals who are blind to feel shapes of graphics appearing on the computer screen. There are several aspects of this type of tactile presentation which can be varied, however, and the effects of these variations in optimizing the user's ability to derive information are not known. The purpose of this study series is to examine different tactile presentation modes and compare their relative efficacy.

Approach

The first experiment in this series dealt with the recognition of elemental shapes, or tactemes (see previous project report). This second experiment dealt with the use of compound shapes, consisting of combinations of the tactemes used in the first experiment (see Figure 1).

As in the first experiment, subjects perceived the shapes using the Systems 3 computer configuration: a computer connected to a graphics tablet, with a hand-held puck for navigation and a vibrotactile array for tactual interpretation of shapes. The tablet area corresponds to the computer screen. The user moves the puck around the tablet, in the process feeling whatever image is on the computer screen.

Subjects were timed in their identification of the compound shapes. A set of ten shapes was used (see Figure 1).

As in the first experiment, three variables in the operation of the system were compared:

1) *Same-hand vs. cross-hand perception*—that is, whether the vibrotactile information was presented on the same hand with which the user moved the puck around the shape or on the other hand. This involved testing using two versions of the system: one with the tactile display mounted on the mouse, and one with a moving mouse for one hand and a stationary tactile display for the other hand.

2) *Large vs. small stimulus size*—that is, the absolute size of the image being perceived, as it appears on the computer screen. Two different sizes were compared: objects the size of the display and objects 2.25 times the size.

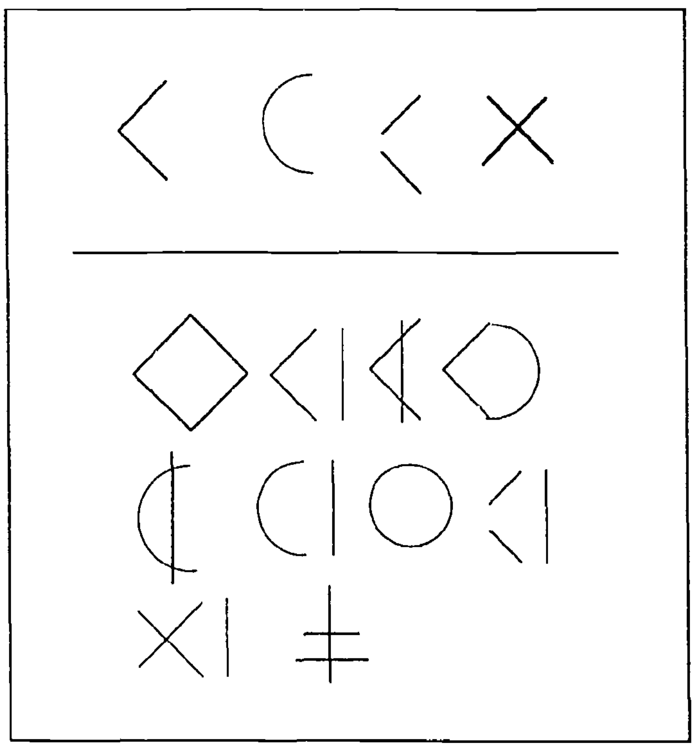


Fig. 1: Shape primitives (top); compound shapes (bottom)

3) *High vs. low mapping ratio*—that is, the ratio of the number of pixels on the screen to the pins on the vibrotactile array that correspond to those pixels. Two different mapping ratios were used: 32 pixels to one pin and 8 pixels to one pin.

Procedures and experimental paradigm were similar to the first experiment, but using the 10 compound shapes, presented in three serial blocks for a total of 30 presentations. Unlike the experiment involving tactemes, no angular deviations of shapes were included in the stimulus set.

Status

This study has been completed and the data analyzed. Results reflected the findings of the first study, showing that the effects of the three examined variables were similar for the compound shapes as for the elemental shapes (tactemes). Results consistently showed that tactile image size does have a significant effect upon individuals' ability to correctly recognize shapes, with the larger size being easier to identify. Similarly, the lower pixel-to-pin mapping ratio produced better recognition.

As in the first experiment, no significant performance difference was found with ipsilateral (same-hand) versus contralateral (opposite hand) tactile feedback (see Figure 2). This would indicate that there would not be any significant performance difference between a system with the tactile array mounted on the movable puck and one with the puck held in one hand and the array felt with the other. This could mean a lower-cost approach for the development of the System 3 product by a commercial vendor. It also would allow for use of tactile displays too large to mount on a mouse, should such displays become feasible from technological and cost standpoints.

Selected publications

Wiker, S. F., Vanderheiden, G. C., & Lee, S. (1991). Development of tactile mice for blind access to computers: Importance of stimulation locus, object size, and vibrotactile display resolution. *Proceedings of the Human Factors Society 35th Annual Meeting*. San Francisco, CA.

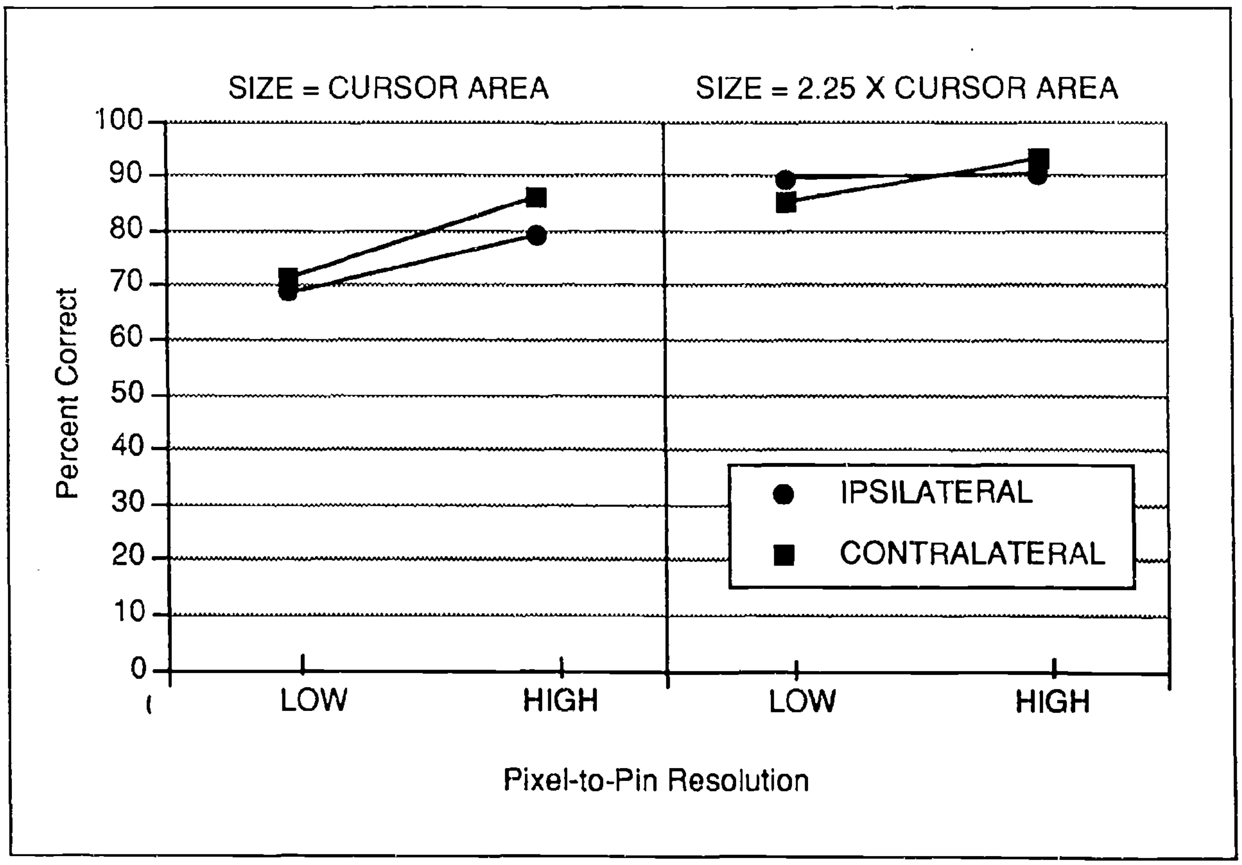


Fig. 2: Data on response accuracy show the similarity of ipsi- and contralateral approaches

Tactile Perception Studies: Impact on Tactile Perception of Combining Tactile Primitives

Project Team: Steven Wiker, PhD; Gregg C. Vanderheiden, PhD; Seongil Lee, MS

Background

Access to computers for individuals who are blind depends increasingly upon the user's ability to recognize and interpret non-verbal or graphic information.The need for a nonvisual mode for presenting graphic information led to the inclusion of a vibrotactile array in the prototype Systems 3 device. (See Systems 3 project report for more thorough discussion and illustrations of the hardware.)

The vibrotactile array of the Systems 3 device allows individuals who are blind to feel shapes of graphics appearing on the computer screen. Experiments have been conducted to examine the effects of several variables in how information is presented (see previous project reports). However, additional information useful in the development of user interfaces can be derived by studying the relationship of the geometry of target shapes to rates of recognition. This information is potentially very useful in determining how blind users can effectively access a graphical user interface. For example, are there certain shapes or shape combinations that are more recognizable tactually? Could these shapes or shape combinations be used in the design of on-screen symbols and icons?

Approach

This study used the subject data from the first two experiments in the study series (see previous project reports), but examined the impact of combining particular tactile primitives upon accurate recognition of non-sense two-dimensional graphic images that are of comparable complexity to those found in tactile maps currently produced for blind users.

Four simple two-dimensional shape patterns—vertex, cross, gap, and arc—were used as hypothetical tactile primitives (tactemes). These primitives were then concatenated in a factorial fashion to create ten stimulus forms: vertex-vertex, vertex-arc, gap-arc, etc. The shapes were drawn on a computer display, and subjects perceived the shapes using the Systems 3 computer configuration: a computer connected to a graphics tablet, with a hand-held puck containing a vibrotactile array. Data were examined regarding rates at which subjects identified and misidentified the primitive shapes and the compound shapes.

Status

The data have been compiled and analyzed. Results showed that the tactile primitives and the more complex shapes were both identified very accurately. *Cross* and *arc* primitives were identified more accurately than vertex and gap primitives. No significant differences in correct identification rate among the ten complex shapes could be found.

Examination of the confusion matrices revealed that recognition factors in the primitives were not additive in recognition of the compound shapes. While the *gap*

Tactile Primitive	Vertex	Cross	Gap	Arc	Stimuli Total
Vertex	121	2	7	14	144
Cross	4	138	.	2	144
Gap	16	5	118	5	144
Arc	6	.	3	135	144
Responses Total	147	145	128	156	576

Fig. 1: Confusion matrix for the tactile primitive set. Responses are shown in columns for the stimulus presented in rows.

proved to be the most often confused among the single primitives, the presence of an *arc* proved to be the most troublesome when combined with other primitives in the formation of the compound shapes (see Figures 1 & 2).

The data point to some potential difficulties for users attempting to distinguish certain types of shapes or shape elements with the configuration of vibrotactile array used in the experiment. Future design of arrays for reading of graphic computer information may need to allow for even higher resolution, greater enlargement of features, audio cues, or other accommodations for exploration of complex shapes.

Selected publications

Lee, S., Wiker, S. F., & Vanderheiden, G. C. (1993). Interactive haptic interface: Two-dimensional form perception for blind access to computers. *Proceedings of the Conference on Human-Computer Interaction.*

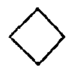
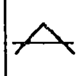
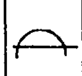
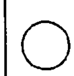
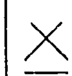
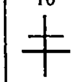
Shape	1 	2 	3 	4 	5 	6 	7 	8 	9 	10 	Stimuli Total
1	45	.	.	2	.	.	1	.	.	.	48
2	.	46	.	1	.	1	.	.	.	.	48
3	.	.	45	.	2	.	1	.	.	.	48
4	3	1	.	42	.	.	2	.	.	.	48
5	.	1	2	.	40	3	.	1	.	1	48
6	.	2	.	.	.	42	3	.	.	1	48
7	1	.	.	3	1	.	43	.	.	.	48
8	.	1	.	.	.	1	.	46	.	.	48
9	1	1	.	.	.	.	.	.	46	.	48
10	.	.	1	.	.	.	.	.	2	45	48
Response Total	50	52	48	48	43	47	50	47	48	47	480

Fig. 2: Confusion matrix for the more complex stimulus set. Responses are shown in columns for the stimulus presented in rows.

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Access to Graphical User Interfaces Through Audio/Tactile Screen "Snapshots"

Project Team: Rafael Arce, MS; Gregg C. Vanderheiden, PhD; John Mendenhall, MS

Background

As computers rely more and more on Graphical User Interfaces (GUI) to present information, computer access for blind users gets more complicated. Information contained in Graphical User Interfaces can be divided into two classes. Class I information is anything that can be completely described using words. Class II information is the type of information that cannot be completely described with words, for example complex line drawings or pictorial charts.

A fully effective nonvisual interface needs to be able to present both types of information. The ideal solution to this problem would be a dynamic full-page tactile display, but such a system is not currently practical. The Trace Center has investigated the use of a tactile mouse for sensing of graphical screens, through the development of the "System 3" model. The vibrotactile array used in System 3 is fairly small, so that only a small area around where the cursor is on the screen is represented in the array at a time. Users explore the screen by moving the tactile mouse around and feeling the limited tactile display under their finger. As users move around the screen, any text encountered is read aloud using speech synthesis.

One difficulty users of this system have encountered is that the amount of the screen presented at any time is small compared to the complete screen image. Two particular observations with the System 3 device were:

1) Class II information interpreted with the system was commonly static information, often an overview of the layout of the screen. Changing material tended to be Class I information, which the user would find easier to access with a keyboard-based verbal interface. Although some sort of presentation of Class II information is essential, the continuously changeable, dynamic tactile presentation was not crucial to all users.

2) Some users had difficulty visualizing the tactile image because of the resolution of the tactile display. In most cases, an image was easier to interpret using a full-page raised-line drawing than with the vibro-tactile display.

These user observations support the idea that a good raised line drawing could be more effective than a dynamically changing vibrotactile display, even if the raised line drawing does not immediately reflect every change in the display (which may or may not be verbal in nature).

Approach

To test a different approach to accessing both Class I and Class II information, a "Dynamic SnapShot" access system was developed. The basic operation of the system is as follows:

1. The user comes across an image that he or she wants to explore.
2. The user employs the SnapShot software to "grab" the part of the screen to be explored.
3. The image is sent to a raised-line printer where a tactile raised-line picture is created.
4. The raised line image is placed precisely on a touch tablet.
5. The user feels the image on the picture while his or her finger movement is tracked by the tablet and the position of the finger is mapped to the screen.
6. When the user comes across any text, it is read as the user moves over it. Text can be presented using a speech synthesizer or a Braille code display.

The Dynamic SnapShot system runs in Microsoft Windows. Its software routines for accessing screen information for speech output are based on the GUI Access toolkit created by Berkeley Systems of Berkeley, California.

The Dynamic SnapShot approach addresses two basic problems encountered with the low resolution vibrotactile display: (1) difficulty with image interpretation, and (2) small amount of information presented at a time. It presents a full screen, high resolution tactile picture of the display with full access to Class I information and created ease of recognition for Class II images. Any part of the screen can be specified to occupy the whole tablet, so that the user can zoom into any desired graphic.

The Dynamic Snapshot software also presents "virtual buttons," areas of the touch tablet which the user can press to activate certain program options. This reduces the need for the user to memorize a variety of keystrokes, each invoking a different function. When the user's finger passes over a button area, the program announces the function of that button and the user can elect to activate it by pressing on the touch tablet. Functions of the virtual buttons include various options for screen image capture, text reading mode (line, word or character), saving screen image to disk, and zoom in/out.

The system also allows the user to store and recall screen images from particular applications, so that previously created tactile printouts can be used with their appropriate screen contexts.

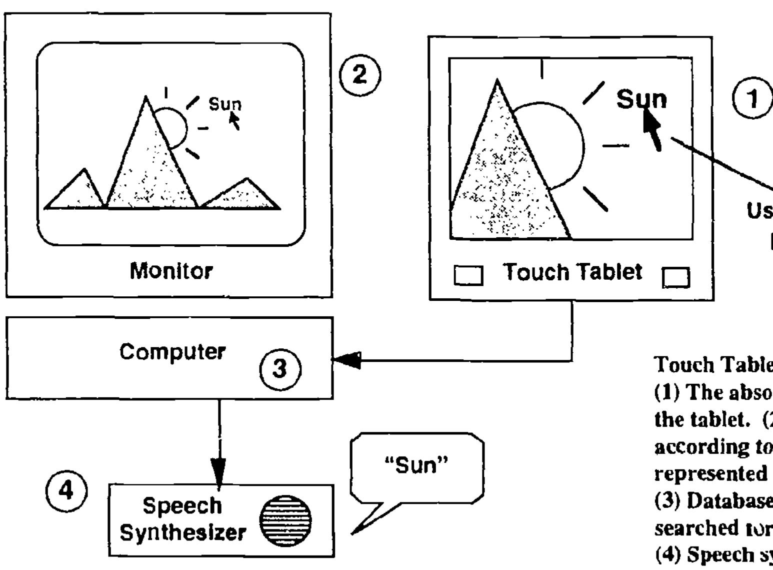
Status

A functioning prototype of the Dynamic SnapShot system has been created, working under Microsoft Windows 3.1. A variety of technical problems have been resolved, allowing the system to function effectively so that its basic design can be tested.

Several persons who are blind have experimented with the Dynamic SnapShot prototype. The tests were mostly qualitative, aimed at comparing the system with previous interfaces the users had experimented with. They were asked to explore several images that contain a certain level of Class I and II information, such as floor plans, maps, and charts.

Feedback from testers indicated that the system did have some advantages over the smaller vibrotactile display used in System 3. Users appreciated the overall resolution and bandwidth presented by the whole-page tactile image. The users felt more active in the exploration (both hands may be used) and had a better idea at all times of where they were located in relation to the complete picture. All this resulted in their being able to gain a broader view of the image more quickly.

As well as providing a platform for testing the SnapShot approach to accessing the GUI, the system may have educational applications. Testers suggested that the system would be a very effective way of providing tactile maps quickly and accurately. The major disadvantage at this point is speed: it can take three to six minutes to create the tactile image.



Touch Tablet Tracking Mechanism. **(1) The absolute position is read from the tablet. (2) This position is changed according to the screen area represented in the raised line image. (3) Database of screen information is searched for any text on this position. (4) Speech synthesizer speaks text.**

The Dynamic SnapShot system tracks the user's finger movement and reads text accordingly.

Effects of Control on Text Presentation

Project Team: Jon R. Gunderson, PhD

Background

Many research and development efforts directed toward computer access for blind individuals have concentrated on providing access to standard computers and operating systems. However, relatively few have concentrated on isolating the factors involved in optimizing the interface for the blind user. In order to create the most effective access systems, more needs to be understood about how different variables in text presentation interact in actual situations of use. As the newer systems evolve to include ever-increasing sound capabilities and built-in speech, it will be important to have information in hand as to the appropriate characteristics of a speech synthesizer for use by individuals who are blind.

There are many speech synthesizers and "screen reading" software programs on the market, designed to provide this kind of access. Many of these systems provide control over variables such as speech rate. However, there are questions that remain unanswered regarding which speech rates are useful for different types of tasks. Furthermore, there are questions regarding how the comprehension of accelerated synthesized speech differs from the comprehension of other forms of accelerated speech, including fast human speech. The answers to these questions will enable developers to optimize their hardware and software, and should also encourage the development of types of control that currently do not exist or are too rudimentary.

Approach

The main medium for people with visual impairments to access computer systems is through electronic speech synthesizers. Visually impaired computer users frequently increase the rate (words per minute) of their synthesizers in order to be able to read screen information more rapidly. They may double or even triple the speed of ordinary speech. To the casual listener, the increased-rate speech sounds unintelligible. This research program is attempting to evaluate the factors in how this accelerated is successfully understood.

Current acceleration algorithms for speech synthesizers are simply linear—that is, the duration of each phoneme is shortened. This research program will also examine how people compress their verbal speech when speaking quickly, and attempt to develop models for a human-based compression algorithm they may (1) make accelerated synthesized speech easier to understand and (2) make it possible to accelerate to greater rates with full intelligibility. Speech samples of compressed human and synthesized speech are being compared and their characteristics analyzed.

Synthesized speech is analyzed to evaluate compression techniques

Status

One explanation regarding visually impaired computer users' ability to understand high-speed synthesized speech is a general improvement in their speech perception system, allowing them to recognize speech at faster rates. The results of the experiments in this project area have validated this hypothesis. There was a significant difference in the percentage of correct words identified and word confusions between inexperienced and experienced listeners of accelerated synthesized speech. The distribution of scores for percentage of correct words for the experienced group was bimodal, indicating a number of factors which need to be identified for the understanding of the perception of accelerated synthesized speech. Results of these studies have been published in the journal of the Human Factors Society.

Selected publications

Gunderson, J. (1991). Limits of intelligibility of accelerated synthesized speech by inexperienced sighted listeners. *Proceedings of the Human Factors Society 35th Annual Meeting.* San Francisco, CA.

Auditory Redundancy for Hearing Impaired Individuals

Project Team: Gregg C. Vanderheiden, PhD; Mark Novak, BS, BS, PE

Background

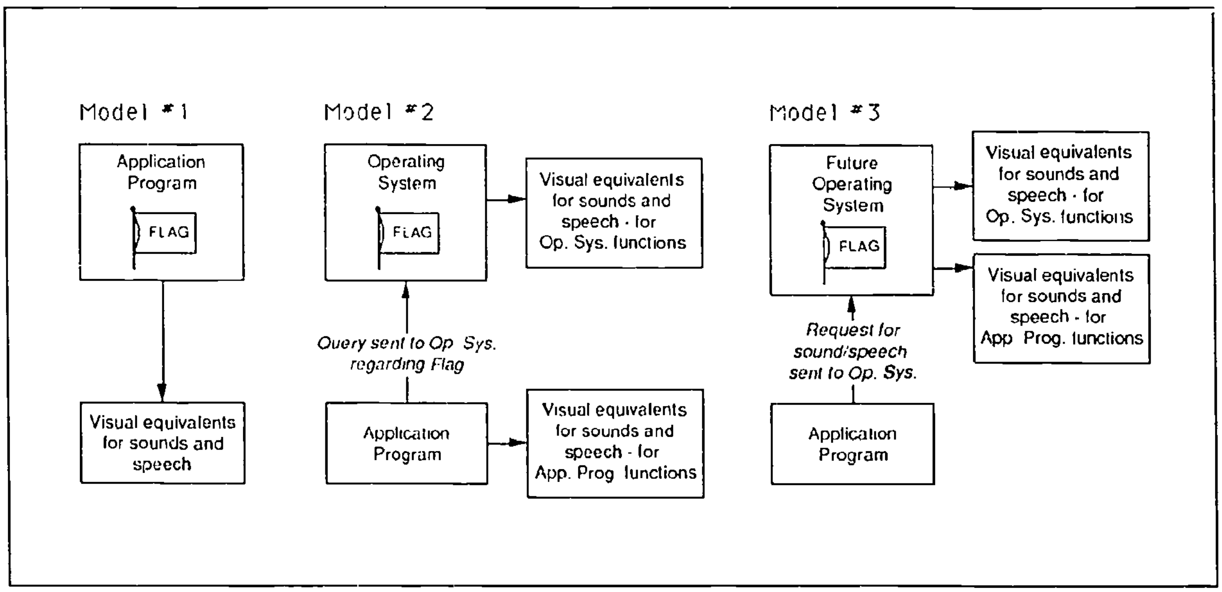
Currently, people with hearing impairments have little or no difficulties in using computers. The use of sound as a standard feature has been minimal, usually no more than a "beep." If the beep is accompanied by some visual event, no problem is encountered. If the beep is not accompanied by a visual event, the deaf person may miss the cue, may deduce what change or error has occurred, or may use a simple sound alert device with a flashing light to detect the sound.

However, the increasing sophistication of synthetic and digital speech technologies has made it easier and more desirable for computer companies to consider incorporating voice output into their products. This would probably take the form of standard voice features in the operating system (such as voice output of error messages) or available voice features that could be "called" from the operating system by application programs.

Approach

As a first step in addressing these problems, a proposal has been made for the incorporation of a "ShowSounds" flag in standard computer operating systems. Such a flag would appear along with other control settings for the operating system. The flag would provide a means for the user to signal cooperating software and operating systems that the user cannot hear any sounds emitted by the computer. Programs and operating systems could then accompany any beeps with some type of visual event on the computer screen. Simple beeps might correspond to a flashing of the menu bar or screen border. More complex tonal output could be presented to the user in some type of graphic that would appear on the screen.

The ShowSounds flag also presents the possibility of "closed captioning" for computer programs. This could work in two ways. First, cooperating programs that used speech output could check the ShowSounds flag



Three models for the implementation of a ShowSounds flag through the operating system. If the flag were set, then the program could display a caption along with any voice output. The second closed captioning method will be possible once computers have standard text-to-speech capabilities (in which case application programs can simply send a string of text to the operating system in order to have it spoken). In this scenario, an application program would simply tell the operating system to say something; the operating system itself would check the ShowSounds flag and automatically provide closed captioning. This would eliminate the need for programs to be individually equipped for closed captioning (but would not preclude this option).

The implementation of the recommendations could be carried out in stages—in fact they would need to be, since later stages require built-in text-to-speech capabilities which are not yet a standard part of any computer operating system. The stages for implementation would be:

1) Inclusion of a ShowSounds flag in the control settings of the operating system;
2) Implementation of visual events to correspond to beeps triggered by the operating system;
3) Provision of closed captions for any voice or complex sound events necessary for use of the operating system;
4) Provision of closed captioning tools for use by third party developers;
5) Provision of auto-captioning capability.

In addition, application programs can begin to check for the ShowSounds flag and provide visual cues to any auditory events. The application programs most likely to make use of such a flag would be programs designed for education or specifically for the disability field. However, government legislation regarding computer access may encourage the use of the ShowSounds flag by business software vendors as they incorporate sound into their products.

Status

The proposed ShowSounds flag has so far been moved forward in five ways. First, the Trace Center has had discussions with Apple computer regarding the inclusion of a ShowSounds flag as a part of their standard control panel for sounds in future versions of their operating system.

Second, a ShowSounds feature was incorporated into the AccessDOS software package developed at the Trace Center. AccessDOS provides several important disability access features to IBM PC and PS/2 computers running DOS. The program is distributed free of charge by IBM.

Third, the Trace Center has created a set of software application program design guidelines. One of the guidelines deals specifically with the support of a ShowSounds flag by application programs. Several thousand copies of the guideline document have been distributed to application and operating system developers.

Fourth, the Trace Center has added the ShowSounds capability to the most recent version of its "Windows Access Pack," a collection of keyboard and mouse accessibility features for IBM and compatible computers using Microsoft Windows.

Fifth, the ShowSounds concept is being incorporated into the Seamless Human Interface Protocol being developed by the Trace Center. This protocol is intended to apply not only to the design of computers but also to the design of public information systems such as automated teller machines and information kiosks.

Selected publications

Novak, M. E., Schauer, J. M., Hinkens, J. D., & Vanderheiden, G. C. AccessDOS version 1.00 [computer program]. Boca Raton, FL: IBM Corporation.

Novak, M. E., Schauer, J. M., Hinkens, J. D., & Vanderheiden, G. C. Access Pack for Microsoft Windows [computer program]. Redmond, WA: Microsoft Corporation.

Trace Research and Development Center. (1991). *White Paper on the Design of Software Application Programs to Increase Their Accessibility for Persons with Disabilities.* University of Wisconsin-Madison: Trace Research and Development Center.

Vanderheiden, G. C., & Lee, C. C. (1988). *Considerations 4.2: Results of the Industry/Government Cooperative Effort on Computer Accessibility for Disabled Persons.* Madison: University of Wisconsin, Trace Research and Development Center.

Cognitive Impairment Focus Area

Operating a computer or other electronic device is an extremely complex task, often taken for granted by experienced users. To operate a device accurately, and to respond appropriately to system variations or errors, novices must learn to concentrate on the overall goal of the device operation—rather than the minute steps involved in achieving it. Expertise in device operation depends on the individual's ability to develop certain skills: comparing what is known to what is experienced; adapting a solution to fit the problem; learning from an experience to help solve future problems. Unfortunately for many cognitively disabled users, it is these skills of memory, problem solving, visual-motor integration, and generalization that are most often impaired.

Since persons with cognitive disabilities vary tremendously both between and within diagnostic populations, it is difficult and often fruitless to try to devise a single solution strategy for any given population. For example, a person classified as having "moderate receptive aphasia" may have a wide assortment of cognitive and perceptual deficits, all of which would differentially affect computer use. Thus, while this research is motivated by the concerns of four target populations (language delay, learning disabilities, brain injury, and mental retardation), access issues and strategies focus on the specific skill deficits present in different patterns and degrees across the populations. The function of this research is to simplify the job of the user, manufacturer, and rehabilitation specialist in compensating for factors detrimental to user performance.

The barriers faced by individuals with cognitive impairments are much more difficult to identify and reduce than those facing individuals with other types of impairments. Fortunately, however, the same measures which can be used to make computers—and particularly computer software—more accessible to individuals with mild cognitive impairments also make them easier to use and easier to learn for the average user. As a result, recommendations for accommodating individuals with mild cognitive impairments can be quite easily incorporated into regular design guidelines.

The problem for individuals with severe cognitive impairments is somewhat different. The issue of "access to all software" becomes less important. It may not be necessary, for example, to provide access to sophisticated computer programs such as spreadsheet software. At the same time, the sensitivity of the interface to individual needs must be considered in the design of each piece of software. If a computer program that could enhance the life of someone with cognitive impairments has a user interface that is too complex or confusing, the program won't be able to benefit that person. This issue is particularly pressing in the area of educational software. Computer and software designers who serve special education populations need to know—by some means other than intuition or guesswork—how well their designs will suit their intended audience.

As computers and computer-based electronic devices are being incorporated more and more into our environments (work, home, and community), it is increasingly important to make these systems as accessible as possible. If we can't facilitate this accessibility, our efforts to allow individuals with cognitive impairments to live, work and move about with increasing independence will be hampered by the inability of these individuals to operate the devices in their various environments. There is also a danger that by increasing the technical complexity of our environment, we may in fact be increasing the number of individuals who experience handicaps in daily life.

Program Goals

The Trace Center's overall program goal in the area of cognitive impairment is to make standard computer tasks accessible to persons with cognitive disabilities. This can be accomplished either by decreasing the complexity of the input controls (interface) or by increasing the specificity of help for task planning and comprehension (prompting). Specifically, the goals to be addressed by this research are:

- identify, describe, and characterize barriers to computer access, and strategies for overcoming difficulties;
- systematize and quantify factors which contribute to difficulty in controlling computer interfaces, and use this information to optimize the interfaces for cognitively disabled persons;
- compile the best available knowledge about strategies for providing access to computers by cognitively disabled persons, for easy use by disabled persons and their families, therapists, manufacturers, and other researchers;
- Conduct research which describes and predicts performance of people with cognitive disabilities in operating computer input devices.

The results of these efforts are being disseminated through the individual projects described here, as well as through projects in the Cross-Impairment Focus Area, particularly design considerations documents.

The incorporation of cognitive principles into the design of computers and electronic devices is a new frontier in human factors. The Trace Center's cognitive impairment programs are meant to help lay the groundwork for this important effort. In addition to the program's long-term contribution to disability accommodation in design, the program will provide immediate, short-term benefits: it will generate information that educators can use to better understand how cognitive factors may affect performance and learning with computer input devices.

Identification and Quantification of Cognitive Tasks in Computer Operation

Project Team: Cynthia J. Cress, MS, MA; Greta French, MS; Gregg C. Vanderheiden, PhD; Jon Miller, PhD; Roger O. Smith, PhD; Tereza Snyder, BFA

Background

In order to understand the difficulties that persons with and without disabilities have in operating computers, researchers must understand the role of various task components involved in computer operation. This project is concerned with the ways in which different interfaces (input mechanisms) affect the difficulty of computer tasks. This is particularly important for persons with cognitive disabilities, for whom the interface may contribute additional procedural or memory load that interferes with the ability to accomplish the computer task. We need information about what skills are involved at different stages of computer operation, and how different combinations of computer features affect performance in computer use.

Approach

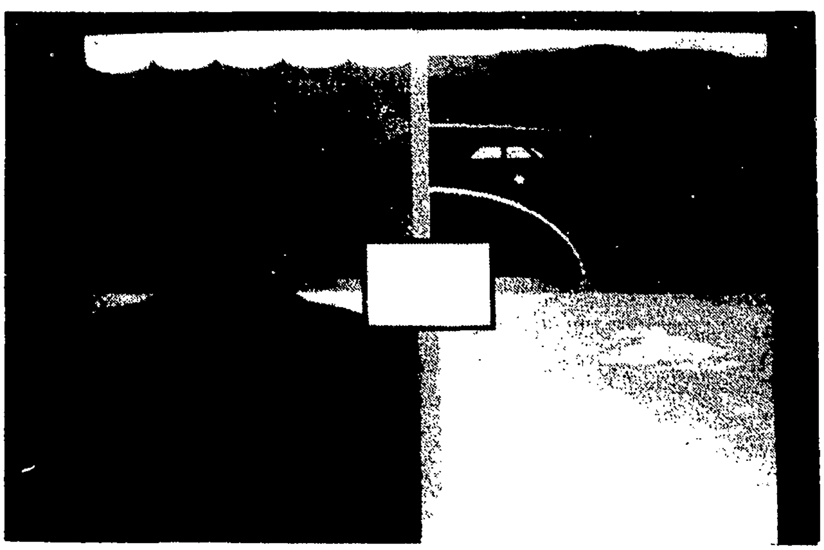
This project is split into three study areas, each of which will be addressed with the three designated subject groups: computer-experienced adults, normally developing children, and children with cognitive disabilities.

1) Qualitative and quantitative comparison of subject performance with different interfaces.
2) Relationship of different aspects of interface performance to cognitive skills of subjects.
3) Analysis of sources of cognitive load for subjects both between tasks and during interface use (i.e. by subtasks within interface operation).

All of the studies are within-subject designs, with all subjects completing experimental tasks with all relevant devices. Subjects serve as their own controls, and comparisons are made both within subjects (between devices) and between subjects (within conditions).

Subjects use five different interfaces for computer operation: touchscreen, mouse, keyboard, locking and nonlocking trackballs. Two computer tasks are compared: moving a visual object on the screen and sorting pictured objects into categories. Cognitive and perceptual-motor skills are sampled by several standardized and non-standardized measures, as well as parent questionnaires.

Quantitative data collected include error rate, time for task completion, and time for each stage of interface operation. Qualitative experimenter scoring of performance reflects the completeness, accuracy, clarity, and promptness of responses. Additional information collected includes types of errors, learning patterns, and computer experience.



Subjects are required to "move" an object to its appropriate environment

Status

Adult subjects have completed the full protocol and a paper summarizing their performance characteristics has been submitted for publication. Data collection for normally developing children has been completed, and a brief summary of the results was presented at the RESNA conference in 1991.

Comparison of the average total times across subjects for each of the five interfaces showed that the same relative order of interface speed was maintained across tasks, with touchscreen fastest and keyboard slowest. In terms of number of failures by interface, the locking trackball was the most consistently failed interface across tasks, followed by the mouse and keyboard. Results also indicated that children across all ages were able to achieve equivalent proficiencies with the interfaces, but that younger children were more frequently unable to learn interface operation, even given knowledge of the task and minimal motor prerequisites.

Data collection for subjects with cognitive disabilities has also been completed, and the results analyzed. Quantitative and qualitative results of this study area guided development of two additional project areas: (1) Interface Training and Use by Young Children, and (2) Interface Training and Use by Persons with Cognitive Disabilities. See separate project reports on these two topics.

Selected publications

Cress, C. J. & Goltz, C. C. (1990). Cognitive factors affecting accessibility of computers and electronic devices. *Proceedings of the Twelfth Annual RESNA Conference.*

Cress, C. J. & Tew, J. P. (1990). Cognitive skills associated with the operation of various computer interfaces. *Proceedings of the Thirteenth Annual RESNA Conference.*

Cress, C. J. , French, G. J. & Tew, J. P. (1991). Age-related differences in interface control in normally developing children. *Proceedings of the Fourteenth Annual RESNA Conference.*

Interface Training and Use by Young Children

Project Team: Cynthia J. Cress, MS, MA; Greta French, MS; Gregg C. Vanderheiden, PhD; Jon Miller, PhD; Roger O. Smith, PhD; Tereza Snyder, BFA; Julie Gamradt, MS, CCC-SLP

Background

Given the relative difficulty of different computer controls and the performance characteristics of users identified in initial Trace Center studies of cognitive tasks in computer operation, it is necessary to translate these results into a form useful for application by educators and therapists. This study area is concerned with the process by which children who are still developing the cognitive skills necessary for interface operation learn to successfully control computer tasks.

Approach

This project was derived from the quantitative analysis described in the report on "Identification and Quantification of Cognitive Tasks in Computer Operation," adding two primary components. First, a hierarchical training sequence was derived, to compare the kinds of instruction necessary for children with different levels of cognitive skills to learn interface operation. This training hierarchy also allowed identification of children who are in the process of acquiring interface skills but who are not yet independently proficient. Second, information about children's learning and error patterns was incorporated into learning profiles, to help predict children's long-term performance from short samples of behavior.

Children were given two simple demonstrations of interface function and allowed the opportunity to intuit the operation of the interface from practice given this experience. If this was unsuccessful, the children were given increasing levels of cues (from explicit demonstration to graded manual contact) until they could successfully operate the control. If children could not decrease their level of cueing within the task restrictions, the more complex movement and sorting tasks were not be given. Performance and error patterns were assessed both over time (by task) and between children (by cognitive skill).

Status

This project is completed. Training and learning profile data were collected from 48 normally developing preschoolers between 2.5 and 5.0 years of age. Presentations of these data were given in October, 1991 at Closing the Gap (Minneapolis, MN) and the Third Annual Midwest Regional RESNA Conference (Lansing, MI). These presentations provided evaluation and training guidelines for interface training with young children, to assist in overcoming specific error patterns of individual children. Individual differences in learning styles noted included: forgetting the sequence of interface operation, failure to self-correct inappropriate interface activities (such as moving the object off screen), interference between operation methods of different

Young subject uses a touchscreen to move the image of an object interfaces, and deterioration or incomplete grasp of method for interface operation (for instance inserting "superstitious" activities to make the interface work).

Selected publications

Cress, C. J. & French, G. J. (1991, Oct.). Microcomputer interface training with cognitively impaired young children. In *Proceedings of Closing the Gap*, Minneapolis, MN.

Cress, C. J. (1991, Oct.). Tools and techniques for expanding our knowledge of communication technology. In *Proceedings of the Third Annual Midwest Regional RESNA Conference*, Lansing, MI.

Interface Training and Use by Persons with Cognitive Disabilities

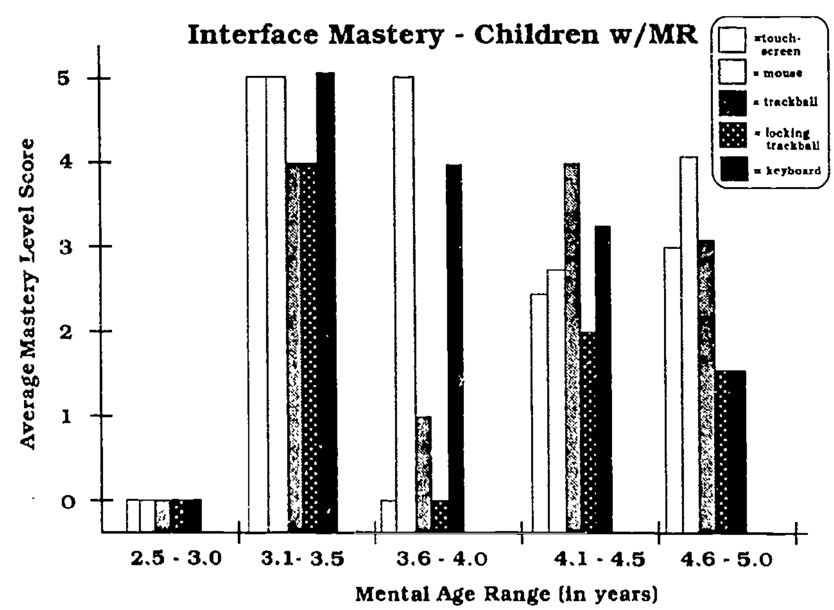
Project Team: Cynthia J. Cress, MS, MA; Greta French, MS; Gregg C. Vanderheiden, PhD; Jon Miller, PhD; Roger O. Smith, PhD; Tereza Snyder, BFA; Julie Gamradt, MS, CCC-SLP

Background

Because of the differences in learning styles and skills of persons with cognitive disabilities, we cannot assume that data from nondisabled subjects will necessarily predict or accurately describe performance in subjects with cognitive disabilities. Consequently, independent sampling of computer interface training needs to be conducted with persons who have similar levels of selected cognitive skills to the preschool children sampled in the previous study area. The results of this study will also contribute to theories of mental retardation, by examining different patterns of learning across tasks, etiologies and mental age measurements.

Approach

The studied examined children's skills at mastering the operation of five different computer controls: mouse, touchscreen, trackball, locking trackball, and keyboard. Thirty-nine normally developing children and fifteen children with mental retardation, with mental age measurements ranging from 2.5 to 5.0 M.A., used each of these devices to move objects on a computer screen within a simple game-like task. Children received baseline measures of performance, criterion-based training in device operation, and samplings of maintenance and generalization of skills.



Interface mastery by subjects with cognitive impairments

Status

Studies have been completed. Results examined potential factors which were predicted to contribute to group differences between normally developing children and children with mental retardation. Children with mental retardation achieved lower levels of mastery of the devices than their M.A.-matched peers. Factors associated with this difference included lower scores on cognitive measures of spatial problem solving, and poorer performance on sensory/motor integration subtests of a general developmental measure. Children with mental retardation did not perform significantly poorer on controls with highly simultaneous vs. sequential operation relative to normally developing peers. Children with mental retardation maintained and generalized newly acquired control skills as well as normally developing peers, which may have been related to content familiarity and clarity of instructions. Differences in the impact of training factors on control skills were found for amount but not specificity of training. While expected levels of skill acquisition based on data from normally developing children were not reached by children with mental retardation, several learning characteristics typically associated with mental retardation did not differentially affect performance on these tasks.

Publications:

Cress, C. J. (1992). Development of Computer Control Skills in Children with Mental Retardation. Doctoral dissertation.

Computer Use by Individuals with Aphasia

Project Team: Katharine H. Odell, PhD; Michael J. Collins, PhD; Jay Hinkens, BS; Charles C. Lee, MS

Background

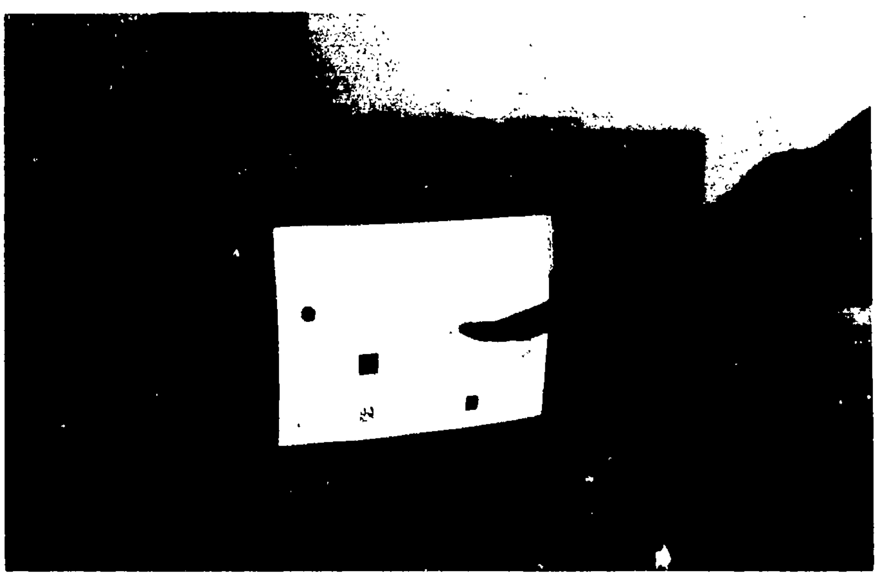
A number of studies are being conducted to examine the reaction and performance of individuals with aphasia in operating certain computer interfaces. These studies are examine the use of certain interfaces in standard tests administered to individuals with aphasia; however, they also have implications in understanding general cognitive issues in computer access.

Approach

This project involves a series of studies to investigate the feasibility of using microcomputers in the diagnosis and treatment of adult individuals with aphasia. The first study compared the performance of subjects with aphasia on a computerized version and the standard version of the Colored Progressive Matrices, a visual, nonverbal problem solving task. This study has been completed.

The second study examined the relative efficiency with which adults with aphasia use different computer input systems (i.e., keyboard, long range light pen, stylus, touch sensitive screen and joystick); performance on a measure of reading comprehension was compared across all interface systems. Results of this work will assist in the selection of appropriate input systems for aphasic users. Further, analysis of response characteristics using each of the interface systems will address the theoretical question of competition for cognitive resources: i.e., the degree of cognitive ability required of aphasic users to both operate the device and proceed with the test.

A third study in the series investigated computer strategies for the Revised Token Test (McNeil and Prescott, 1978), a measure of auditory comprehension on which subjects with aphasia are likely to display perseveration or self-correction tendencies. An experimental computerized version of the RTT gave instructions to subjects by digitized voice and the subjects "moved" tokens on the computer monitor by moving a finger across a touch screen.



Touchscreen allows subjects to "move" tokens on screen in computerized Revised Token Test

Status

Study 1: This study has been completed.

Study 2: The reading measure for this project is a multiple choice synonym identification test, with two levels of difficulty. A different test was developed for each interface system; all tests were designed to be equivalent in grade level. Algorithms for scoring and response time data collection were devised. Subjects have been tested, and data collection has been completed.

Results of a Friedman two-way ANOVA nonparametric statistical text indicated no significant differences among the six response conditions (five computer inputs and pen-and-paper) in terms of accuracy. Speed of response was evaluated across only the computer input systems, since similar precision of response time measurement could not be achieved for the pen and paper version of the test. A separate Friedman test indicated a speed difference among the five computer conditions. Post-hoc analysis was not undertaken, but visual inspection of the data suggested that responses were slowest in the joystick condition.

Study 3: The software routine developed for the Revised Token Test has been completed, including token movement, scoring, data collection and speech generation algorithms. Preliminary testing of software with ten normal subjects was completed and revisions made to the computerized RTT.

Five subjects with aphasia have been tested so far. Non-parametric statistical comparison showed no significant differences between the two versions for the overall scores, individual subtest scores or individual score category totals. Additional subjects will be run to more fully substantiate these preliminary results. The ultimate aim is to validate the use of the computerized RTT, then seek funds to support the conversion of the current version to contemporary IBM and Macintosh computers for commercial distribution.

Selected publications

Odell, K. H., Collins, M. J., Dirkx, T., & Kelso, D.P. (1985). A computerized version of the colored progressive matrices. In R. Brookshire, Ed., *Clinical Aphasiology Conference Proceedings 1985*. Minneapolis: BRK Publications.

Collins, M. J., & Odell, K. H. (1986). Computerization of a traditional test for nonverbal problem solving. *Cognitive Rehabilitation, 4*(5), 16-18.

Odell, K. H. & Miller, S. B. (1994). A comparison of aphasic performance on the standard and an experimental computerized version of the Revised Token Test. *Clinical Aphasiology Conference Proceedings 1994*. Minneapolis: BRK Publications.

Cross-Impairment Focus Area

The three preceding sections of this report describe research and development efforts aimed mostly at specific areas of impairment: movement, sensory and cognitive. Many Trace Center programs, however, cut across disability areas, or relate to the needs of people with multiple impairments.

In many cases, the results from multiple individual projects from the specific impairment areas come together in these cross-impairment projects. For example, the generation of design guidelines to facilitate access for persons with one type of disability cannot be done in the absence of considerations of their impact on other users with other disabilities, or on users with multiple disabilities.

The primary needs which have been identified that are cross-impairment in nature are:

1) The need for guidelines and other types of information that industry can use to understand the access problems faced by persons with disabilities.

2) The need for technical support and consultation to manufacturers. This assistance can include testing of companies' individual approaches for providing accessibility in their designs.

3) The need to improve the design of information systems to accommodate people with disabilities.

4) The need to establish standard connection and information transfer formats to allow specialized interface devices to successfully connect to standard computer equipment.

5) The need to standardize functional assessment in order to assess the impact of interventions, including technology services.

Development of accessibility design guidelines and manuals

Although a fair amount of research at the center is being directed toward identifying the best interface techniques for individuals with different disabilities, these advancements are of no value unless they are translated into commercially manufactured devices. In doing this, there are two approaches that can be taken.

The first and easiest approach is to have the specialized interface devices manufactured by specialty rehabilitation manufacturers. The other, more difficult, approach is to cause the accessibility features to be built into the computers and electronic devices *as they are originally manufactured*. This second approach is preferable when possible. It represents the primary goal of the Trace Center's work.

In practice, of course, both approaches are necessary in order to meet the needs of the full range of types and degrees of disability. For individuals with mild to moderate impairments, the adaptations can often be incorporated into the original design of the equipment—usually increasing the ease of use for all users. Individuals with more severe impairments often need adaptations which are too extensive to include directly in the standard manufactured products. In these cases, the best approach is to have the adaptations designed and built by specialty rehabilitation manufacturers. These special adaptations, however, still need to be connected to the standard equipment. The manufacturers of standard products must still be involved in order to provide mechanisms by which the special access devices can be connected when necessary.

The key role of the standard product (mass market) manufacturers in this process is evident. An understanding of the need for increased awareness led to the initial efforts to develop information about computer accessibility features in standard computers. In response to requests from industry for this type of information, a "White Paper" was generated by Trace Center staff, followed by a document titled "Considerations in the Design of Computers and Operating Systems to Increase Their Accessibility to Persons with Disabilities." The "Considerations" document was prepared by Trace Center staff working in conjunction with researchers, rehabilitation equipment manufacturers, and standard computer manufacturers throughout the U.S.

In addition to being used by industry, the "Considerations" have also been used by the government (DOE/GSA) as the basis for developing the regulations regarding the purchase and lease of computers and electronic office equipment.

The Trace Center has also initiated three other projects similar to the "Considerations" document: a set of guidelines for disability accommodation in consumer electronic devices, a manual for implementing accessibility in computer laboratories in higher education institutions, and a set of guidelines for accessibility of application software. The center has also developed a set of design goals for future generations of TDDs (Telecommunication Devices for Deaf individuals).

Technical and Research Support to Industry

For industry to be able to effectively assimilate and incorporate accessibility information in their designs, they usually need more than printed documentation. In addition to general discussions, we have also found that industry requires information on a wide range of topics, from demographics and descriptions of the different types of disabilities to detail on specific accessibility strategies and evaluation of specific designs or approaches.

In order to address the wide range of needs, three ongoing activities have been established:

1) *Support of the Industry/Government Cooperative Initiative on Computer Accessibility.* The Trace Center serves as a coordinator for this coalition of industry, government, consumers and researchers.

2) *Development of simulations of specific alternate access techniques and operating system hooks.* The Trace Center develops these software prototypes so that industry can use them to gain understanding and experience in developing their own solutions.

3) *Direct technical consultation with individuals from companies.* Requests range from demographics to descriptions of specific disability characteristics to field testing of specific features.

Consumers are involved in many of these projects in order to check ideas, evaluate designs, and provide specific quantitative information about different control parameters for their disabilities.

Access to Information Systems

Although access to computer hardware has been a primary concern of the Trace Center, information systems—such as publicly available computerized databases or public information terminals and kiosks—also poses access barriers to people with disabilities. The use of such systems places such as shopping malls and government offices is on the rise, yet good strategies for making these systems accessible have not been developed. The Center is exploring these issues in part through its efforts at developing informational databases related to assistive technology and disability-related services. These design of these databases is being used as a test bed for new accessible information system concepts.

Interconnection Standards

The Trace Center first became involved in the standardization area in order to deal with the problems surrounding user interfaces to communication, control, and computer access aids. The Trace Center initiated an effort to develop a Simple Electrical Transducer Interconnection Standard (SET standard). Today, the major manufacturers of these types of assistive devices support the standard, either directly or through adaptors, and it is estimated that between 85% and 95% of all the interfaces sold today follow the standard.

The Trace Center has been involved in the development of a Keyboard Emulating Interface (KEI) standard, to allow standardized connection of special communication and computer access devices to commercially available computers. With the addition in recent years of new input devices, such as the mouse, access to keyboard functions is not enough. The Trace Center has developed a General Input Device Emulating Interface (GIDEI) standard as well, to cope with the new input devices.

The Trace Center helped start a field-wide initiative to establish a standard for safe control of wheelchairs via serial output devices such as electronic communication aids. This effort looks ahead to the coming development of "smart" wheelchairs that will accept external control in the form of digital data.

Improved Assessment Data Management

The Trace Center is involved as well in standardization efforts in the area of service delivery. Specifically, the center has helped lead the development of a more systematic and universal structure for integrating functional assessment data in occupational therapy. Several years of work in this area resulted in the release of a software package called OT FACT (Occupational Therapy Functional Assessment Compilation Tool). As this new protocol is established in the field, it will help improve the provision not only of technology-related services, but of a full range of therapeutic services for people with disabilities.

Computer and Operating System Accessibility Design Guidelines

Project Team: Gregg C. Vanderheiden, PhD; Roger O. Smith, PhD; David P. Kelso, MS; Cynthia J. Cress, MS

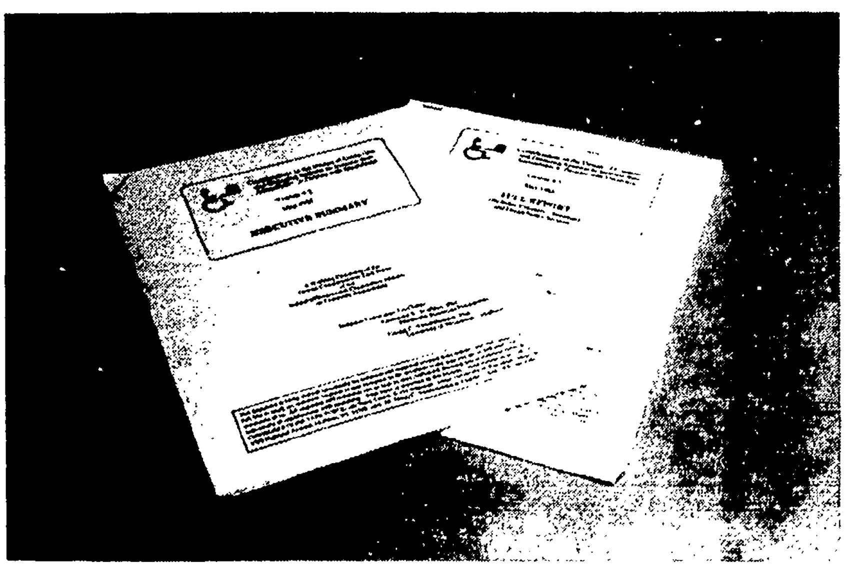
Background

Extensive work has been done by the Trace Center working with others in this field. A "White Paper," a "Design Guidelines" document, and an overview of design considerations have all been prepared and are currently being used by the computer industry.

These documents, designed as working documents subject to updating and revision, have been received very well by the computer industries. At least two major computer manufacturers have incorporated (often verbatim) materials from the documents in their internal company documents. Three major computer corporations are known to be incorporating features and solution strategies from the "Considerations" into their future computers and operating systems. One company, Apple Computer, has already incorporated multiple design recommendations from these materials into their standard manufactured computers. Since 1988, all Macintosh computers sold by Apple have included a feature in the standard operating system (shipped with the computers) which allows use of the Macintosh keyboard with a single finger, mouthstick, or headstick using a "StickyKeys" design developed by the Trace Center. The built-in accessibility features also allow an individual with a headstick or poor hand control to create simulated mouse activity and direct the mouse cursor directly from the standard computer keyboard. Finally, both Apple and IBM are also known to be using the "Considerations" document internally as a score sheet against which they are evaluating new hardware and system designs.

Approach

The existing design guidelines have been designed using a U.S. mail based open Task Force approach. The Task Force is "open" in that anyone can join the group—including consumers, designers, computer manufacturers, researchers, and rehabilitation equipment manufacturers. Membership in the group is defined as those individuals who remain active. All communication is conducted by mail; electronic versions are available (formatted for the major computer brands), to accommodate people with disabilities who can't read or handle paper. The Task Force approach has meant that individuals from different companies, geographic locations, or with different disabilities can all access and participate on an equal footing. This procedure has worked very well to date, and has resulted in the materials discussed previously. Because information can also be sent anonymously or in confidence, it has also allowed manufacturers and specific individuals from corporations to freely express concerns without adverse reaction from others to-



Full report and executive summary of "Considerations" ward that particular company. Development and review of content and format of the design manual is being carried out in this same fashion.

Status

A version 4.2 of the "Considerations" document is currently being disseminated to the field for review. It has been adopted and adapted by two major computer companies and was used in the final preparation of the GSA's guidelines. Version 5.0 is in progress.

Dissemination of the "Considerations" document (and intermediate results from this project) will be done through the Industry/Government Task Force on Computer Accessibility, and through the Trace Center's Reprint Service. These, combined with open copying policy, have resulted in widespread dissemination of materials to date, particularly within the computer companies.

Selected publications

Vanderheiden, G. C., & Lee, C. C. (1988). *Considerations 4.2: Results of the Industry/Government Cooperative Effort on Computer Accessibility for Disabled Persons.* Madison: University of Wisconsin, Trace Research and Development Center.

Vanderheiden, G. C., Lee, C. C., & Scadden, L. A. (1987). Features to increase the accessibility of computers by persons with disabilities: Report from the industry/government task force. *Proceedings of the Tenth Annual Conference on Rehabilitation Technology.* Washington, DC: RESNA.

Guidelines for the Design of Consumer Electronic Products

Project Team: Gregg C. Vanderheiden, PhD; Katherine Vanderheiden, BBA, CPA; Christine Thompson, BS

Background

In addition to the need for access to computers, people with disabilities have the need to access other electrical/electronic devices. An important class of these devices is consumer electronics. This category includes televisions, radios, tape players, and home appliances such as microwave ovens and washing machines. It also includes devices built into homes, such a smoke detectors, alarms, and doorbells. As with computers, there are simple design modifications that can be made in order to accommodate the needs of disabled people, without substantially adding to the cost of production or inconveniencing non-disabled people.

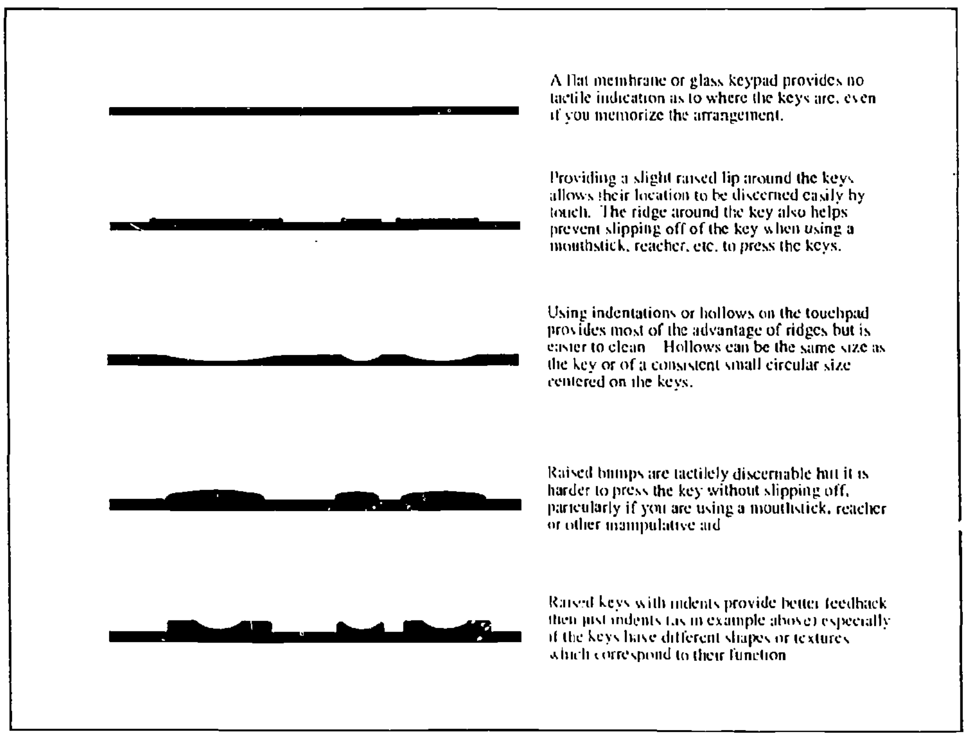
At this time no design guideline summary such as that which the Trace Center has developed for computers yet exists for consumer electrical and electronic products.

Approach

Different types of impairment can lead to restrictions in use of consumer electronic products or even render them unusable by people with disabilities. As with computers, there are simple design modifications that can be made in order to accommodate the needs of disabled people, without substantially adding to the cost of production or inconveniencing non-disabled people.

The purpose of this project is to create a set of guidelines to be used voluntarily by designers and manufacturers. These guidelines discuss the full range of needs of persons with physical, sensory and cognitive disabilities and discuss possible solutions. Not all solutions suggested are low- or no-cost, but these are suggested where feasible. The usefulness of certain modifications to non-disabled consumers is stressed—such as location and ease of use for controls.

The guidelines are treated as a working document, sent out to consumers, researchers and manufacturers for comment. These comments, along with additional material developed at the Trace Center, will be added to future editions of the document.



From the design guide: diagram explaining accessible keypad design

Status

A task force has been formed, similar to that developed for the design considerations for computers. The initial members of the task force include those individuals who have contributed to computer design considerations, as well as individuals who have expressed an interested in this topic to the staff of the Electronic Industries Association. Other individuals and organizations are able to join simply by expressing an interest and contributing ideas.

A full draft of the guidelines was forwarded to the task force for review in the fall of 1991, in cooperation with the Assistive Devices Division of the Electronic Industries Association and the Consumer Products Technical Group of the Human Factors Society. The most recent revision of the document (version 1.6) was released in Dec., 1991.

The guideline document is now being used by Microsoft Corporation as part of their Microsoft At Work Software Adaptation Kit for developing fax machines and printers compatible with Microsoft At Work architecture.

Selected publications

Vanderheiden, G. C., & Vanderheiden, K. (1990). *Accessible Design of Consumer Products: Guidelines for the Design of Consumer Products to Increase Their Accessibility to Persons with Disabilities or Who Are Aging.* Madison: University of Wisconsin, Trace Research and Development Center.

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Left: Table of Contents from the design guide

Development of Design Guidelines for Standard Application Software to Increase Usability by Persons with Disabilities

Project Team: Gregg C. Vanderheiden, PhD; Christine Thompson, BS

Background

Although there are many software programs designed specifically for people with disabilities, a primary and growing concern is the ability of individuals with disabilities to use standard software as well. Unless access to standard software is possible, individuals with disabilities will not be able to participate in those educational, employment and community settings where that software is used.

There are basically three components in making standard software accessible:

1) In some cases, access can be provided by special adaptations which are purchased by or for the individual.

2) In other cases, access can only effectively be provided through modifications to the design of the computer or operating system—modifications which are usually low-cost or no-cost.

3) In still other cases, it is a feature or the application software itself which causes the problem, and access is only possible through proper design of the application program. It is also important for applications to be aware of and support access features built into computers and operating systems (as in #2 above).

The first strategy is being continually worked on through the research, development and marketing of commercially available special computer interfaces.

The second strategy is being addressed through the work of groups such as the Industry/Government Task Force on Computer Accessibility, and through modifications which have already been made by computer and operating system designers.

The third strategy has not been widely addressed until recently. The Trace Center is now working with the Information Technology Association (ITA), an association of commercial software developers, to develop a support document on the design of standard software to maximize its accessibility.

Approach

The design document is being developed through interaction between ITA members, other software developers, researchers, disabled consumers, and others with specialized expertise.

The process being used is a mail-based task force, similar to that employed to develop another document: "Considerations in the Design of Computers and Operating Systems to Increase Their Accessibility to Persons with Disabilities." The Trace Center serves as a coordinating center for a nationwide task force which expands and refines the document through successive versions. The task force is "open" in that anyone can join the group—including consumers, software developers, computer manufacturers, researchers, and rehabilitation equipment manufacturers. Membership in the group is defined as those individuals who remain active. All communication is conducted by mail; electronic versions are available (formatted for the major computer brands), to accommodate people with disabilities who can't read or handle paper.

The document is meant to cover the full range of information needed regarding the barriers and solutions to software access. This includes:

- information on different types and degrees of disability and their impact on computer use;
- features and program structures that are particularly good or beneficial for persons with different types of disabilities;
- features and program structures that cause particular problems for persons with different disabilities;
- suggestions and options for program design to facilitate access; and
- suggestions and options for program design to facilitate compatibility with computer and operating system access features.

Status

An initial version of the software guidelines was created and sent out for comment. Revisions were incorporated, the current revision of the document (1.2) is being distributed. It will be revised again based on comments received, with the next revision due to be released in late 1994. The document is being distributed in the form of a "white paper" setting forth the need for application software accessibility and outlining what is currently known about barriers and solution strategies.

The Information Technology Foundation has printed 3,000 copies of the document, distributing it to the membership of the Information Technology Association and also the Software Publishers Association. Microsoft Corporation distributed 4,700 copies to developers attending their Windows NT Developers Conference. In addition, they took the general suggestions from the White Paper and created a brief document describing how they specifically applied to Windows, and provided recommendations for their implementation.

Selected publications

Trace Research and Development Center. (1991). *Making Software More Accessible to People with Disabilities*. University of Wisconsin-Madison: Trace Research and Development Center.

Condensed table of contents from White Paper on application software accessibility

Campus and Library Information Systems Accessibility Manuals

Project Team: Jane R. Berliss, AMLS; Peter A. Borden, MA; Gregg C. Vanderheiden, PhD; Roger O. Smith, PhD

Background

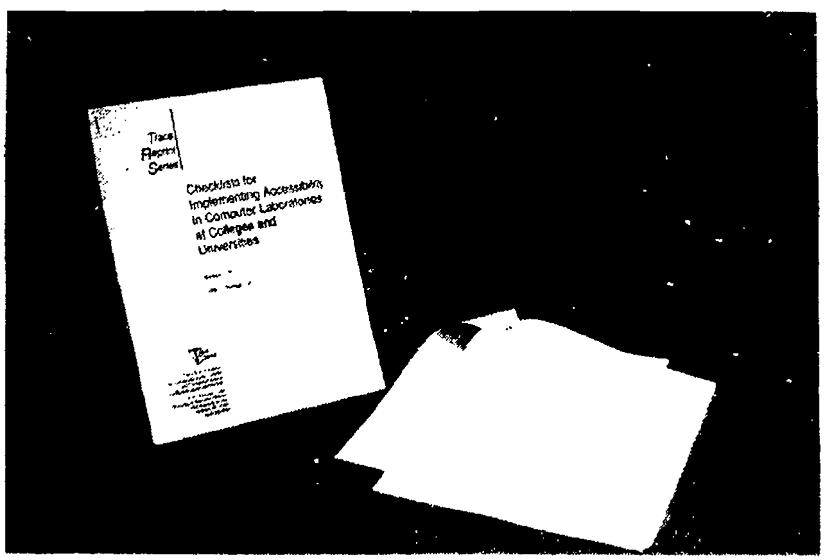
Disabled (and able-bodied) individuals encounter computers and information systems in three main environments: daily living, employment, and education. In the education environment, there have been many computer access initiatives aimed at elementary and secondary special education students, both in and out of mainstream classes. By comparison, however, little has been done in post-secondary education (colleges and universities) and adult education (schools and public libraries) to assure that disabled people can access computers and information systems. The gap will continue to widen as electronic information systems are used more and more extensively on campuses and in libraries.

Trace Center has made a number of initial contacts with public libraries and with university computer laboratories and disabled student service offices—both by phone and through presentations and discussion forums at conferences for these types of service providers. Through these initial contacts, it has been determined that there is a general willingness to provide computer access, but that lack of knowledge and lack of resources have been the major obstacles. Information programs can provide a groundwork for acquiring the knowledge necessary to implement computer access. In addition, information can be provided on how to maximally exploit available resources, allowing and encouraging libraries and campuses to pursue more aggressive computer access programs.

Approach

A number of steps have been taken to create and disseminate information materials to libraries and campuses. Initial efforts were targeted at university campuses.

A document titled "Checklists for Implementing Accessibility in Computer Laboratories at Colleges and Universities" was developed. This document covers generic implementations of equipment—with steps delineated by time and money required to carry them out—and also procedures for assisting individuals who require more specialized equipment. An actual checklist form is provided, on which staff can mark steps as they are implemented. The document provides a thorough explanation of the steps involved, along with lists of additional resources to consult.



Version 1.0 of the checklist document

The purposes of the checklists are: (1) to make it easier for administrators to plan and coordinate computer access efforts and to set priorities; (2) to provide a source of information and a common ground for planning for computing centers and disabled student services offices; (3) to provide a comprehensive reference for computer access needs and strategies. Other steps in the process of creating effective information materials include pilot evaluations of computer access programs at several universities and presentations to appropriate audiences at conferences.

The campus checklist document was followed by one aimed at libraries. Titled "Checklists for Making Library Automation Accessible to People with Disabilities," the document has a similar structure to the campus document, with accessibility steps described in terms of cost and time required, and actual checklist forms provided. The document has material specifically aimed at the needs of libraries, including provisions for smaller libraries. It was reviewed by library personnel and revised based on their comments.

Status

The Checklist documents were completed in draft form and distributed for comment—including distribution at national conferences related to computers and disability. Revisions were made, and publication versions of the checklists are now available. The Checklists are available to any interested parties, through the Trace Center Reprint Service.

In addition to the Checklist project, the Trace Center has played a role in cooperative efforts related to computer access on campuses and in libraries. Trace Center staff are involved in Project EASI (Equal Access to Software for Instruction), a national initiative which is a subgroup of EDUCOM, an organization of representatives from over 500 college and university computing labs. With input from Trace Center staff, Project EASI has created two informational publications: (1) "Computers and Students with Disabilities: New Challenges for Higher Education," a booklet that provides background information and lists resources; (2) "EASI Fixes," a set of accessibility guidelines for developers of software for use in post-secondary education.

Trace Center staff have presented on campus/library computer access issues at several conferences, including RESNA, Closing the Gap, CAUSE (a professional association for computing and information technology in higher education), the American Library Association, EDUCOM, and the Association of Handicapped Student Service Providers in Postsecondary Education (AHSSPPE).

Selected publications

Berliss, J. R. (1989). Maximizing "bang-for-the-buck" when purchasing adaptive computer equipment. *Proceedings of the AHSSPPE 1989 Conference.*

Berliss, J. R., & Vanderheiden, G. C. (1989). It's academic: Computer accessibility issues in higher education. *Proceedings of the RESNA 12th Annual Conference.*

Berliss, J. R., Bartlett, L., Farha, R., & Knox, J. (1990, Oct.). Computer User Groups for Students with Disabilities. In *Proceedings of the Closing the Gap Conference*, Minneapolis, MN.

Berliss, J. R. (1990). *Checklists for implementing accessibility in Computer Labs at Colleges and Universities.* Madison: University of Wisconsin, Trace Research and Development Center.

Berliss, J. R. (1992). *Checklists for making library automation accessible to patrons with disabilities.* Madison: University of Wisconsin, Trace Research and Development Center.

Accessibility of TDDs for Hearing Impaired Individuals With Multiple Impairments

Project Team: Julie Gamradt, MS, CCC-SLP; Joseph Schauer, BSEE; Gregg C. Vanderheiden, PhD; Laurie Fox, BSEE, OTR; Sharon Esser; Roger O. Smith, PhD

Background

For many individuals with hearing impairments, use of a Telecommunication Device for the Deaf (TDD) is the only way to have access to telephone communication. There is a substantial population of hearing impaired individuals who have other impairments which either hamper their use of a TDD or make use of the TDD impossible for most practical purposes. These other impairments can include English language impairments, cognitive impairments, or physical impairments.

Although many adaptations have been developed or are in the process of being developed to make other electronic equipment more accessible for individuals who have impairments (e.g., adaptations of computer hardware and software), little has been done to make the TDD more accessible to hearing impaired individuals who have other impairments. As the emphasis for community integration for individuals who have multiple impairments continues, the importance of having needed equipment accessible to them also increases. Access to phone communication is basic to safety and independent living for all individuals who live in the community. Making TDDs more accessible to hearing impaired individuals who have multiple impairments is a critical issue that needs immediate attention.

Approach

Since the need for improved access to telecommunications for people with multiple impairments has not be addressed very extensively in the marketplace, this project started with needs assessment and problem identification

First a state-of-the-art and needs-analysis meeting was held, to identify major issues in phone communication access as they affect individuals with multiple impairments. On Nov. 12, 1990, a group of sixteen people met, representing researchers, TDD users, deaf educators, the TDD industry, and clinicians whose clients have multiple impairments. The group developed a list of 65 problems and potential solutions in the area of telecommunications access. Some of the solutions could be implemented by changing the design of the standard TDD. Others would employ other telecommunications equipment such as computers and modems. The annotated list was sent out to those who attended the meeting for additional ideas and comments.

The second initiative in the project was to explore the development of a software system for telephone com-

Most TDDs today rely on a keyboard for input and an alphanumeric visual display for output munications using a computer and TDD-compatible modem. Such software would (1) make it easy for those with little or no computer experience to use the computer for telephone communication, (2) allow the use of existing off-the-shelf computer adaptations for users with physical impairments, and (3) provide a non-alphanumeric system for communication which can be used by people who have limited or no reading and spelling skills. Since all current TDDs require both reading and spelling, this software would involve completely new design requirements. The goal of this development work was to explore the technical problems inherent in designing such a system and to examine its practical usefulness to potential users and the people they would communicate with.

Status

The state-of-the-art meeting has been held, and the resulting list of suggestions sent out for comment.

The software development phase of the project was carried to the proof-of-concept stage, so that commercial manufacturers could see how such a system might operate. A mockup of the system was tried with some potential users, to investigate the feasibility of picto-telephonic communication and to identify potential needs and problems. The project team provided the design to a company which makes an augmentative communication software program containing some of the elements desired for the software. As yet there are no plans to develop it into a commercial product.

Development of User-, Professional- and Public-Accessible Database Interface Techniques

Project Team: Gregg C. Vanderheiden, PhD; Joseph M. Schauer, BS; David P. Kelso, MS; Tereza Snyder, BFA; Kelly Ford, BA; Roger O. Smith, PhD

Background

One of the greatest obstacles to effective, widespread use of assistive and rehabilitative technologies has been the difficulty which consumers and services providers encounter in trying to find accurate and timely information about products and services. One practical solution to this problem has been to use computerized databases to collect, access and distribute information.

The Trace Center has been developing a cooperative model for collecting and disseminating information on disability in electronic form, through its Cooperative Electronic Library program (see next project report). Electronic information, however, requires a user interface for presentation. Basic issues in the design of this interface must be resolved in order to assure the databases are optimally effective for all potential users. The strategies developed will apply not only to the particular databases currently being created, but also to other public information systems, such as electronic kiosks, automated teller machines, and cable-TV information services.

Approach

Database development work at the Trace Center addresses four needs:

1) *Availability: The need for databases to be available through a wide variety of channels and media.* CD-ROM, computer bulletin boards, public on-line systems, and Internet are all possible ways to make disability information sources available.

2) *Accessibility: The need for the database user interface to be optimized for different types of impairments.* Database users who have physical, sensory or cognitive impairments may find that features which make the database easy to use for others make it difficult for them. Once again, the need is for effective, direct access by the person with a disability.

3) *Usability: The need for databases to be easy for novices to use with little or no training.* This need arises from the need for consumers, their family, friends and service providers to more directly access the information they need. Few of these individuals are willing or able to undergo extensive computer and database training.

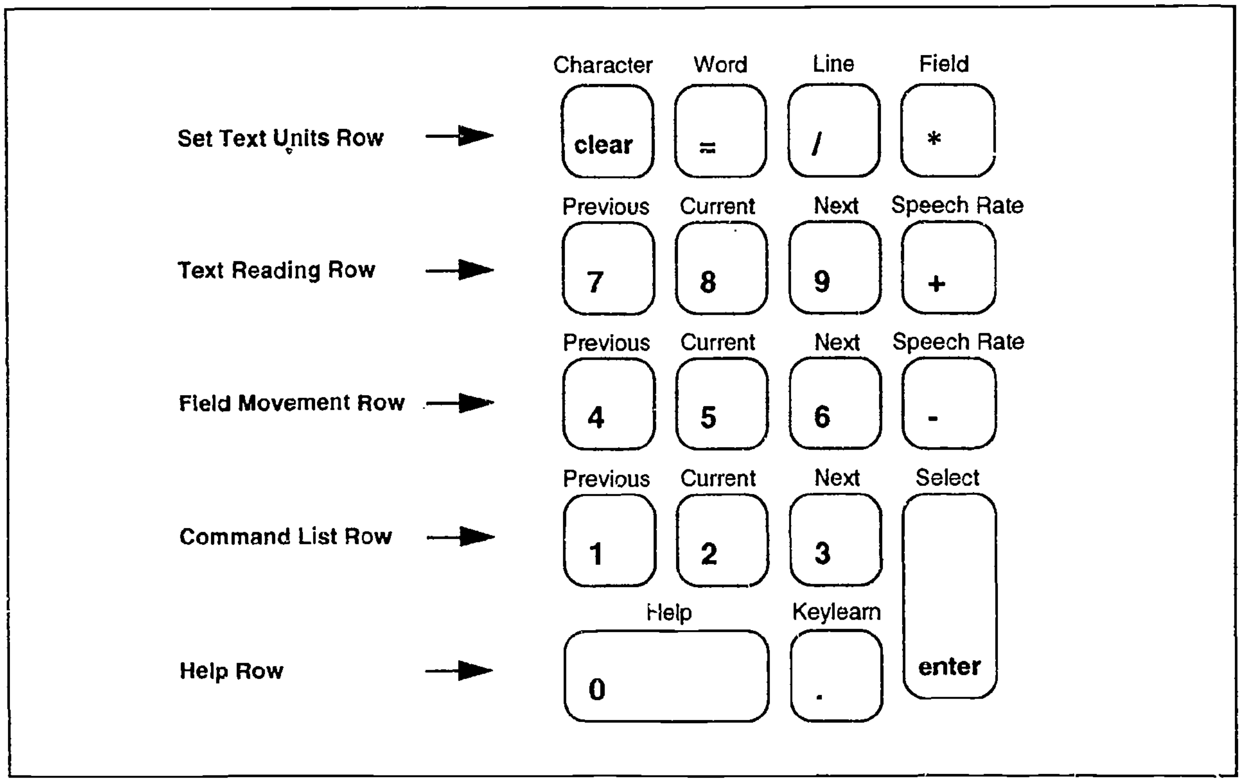
4) *Usefulness: The need for data to be valuable to users.* Databases should contain current information that is of maximal use to people with disabilities, family members, and professional serving them.

The efforts in database interface techniques primarily address two needs of *accessibility* and *usability*. First, the databases must allow independent use by people with disabilities. Second, they must simple and obvious for all users (disabled and non-disabled), especially novice users with little or no computer or database experience.

Status

The need for databases to be easy for novices to use is being met through extremely user-friendly database designs. Some of the design features the Trace Center has worked with so far are: familiar visual analogies on screen (such as book pages and index cards); context-sensitive instructions; prompts to the user to seek instructions; expanding-outline format for search terms; direct selection of choices from scrolling alphabetical lists; and location of geographic information by direct selection on a map.

The need for databases to be accessible to users with disabilities is being met through alternative interface strategies for databases. The Trace Center has developed alternative interfaces which circumvent visual or movement-based features that may be difficult or impossible for users with visual or movement impairments. Some examples of strategies for users with visual impairments are: text enlargement; presentation of information and instructions in synthesized voice; and control from the keyboard rather than the mouse. Users with physical impairments are accommodated



Keyboard commands enabling users who are blind to navigate a database. This set is used in the Blind Access Mode of Hyper-ABLEDATA. Information is read to the user by synthesized voice.

through providing alternatives to mouse movement.

The goal of this effort is to implement functioning examples of the *Seamless Human Interface Protocol.* This protocol, being developed by the Trace Center, defines how a user interface can integrate different modes for users of widely varying abilities (e.g., mouse/keyboard, large print/standard print). Under the protocol, each mode of operation provides equivalent access to the functions of the software, but each mode is optimized for the needs of the users it is aimed at.

The initial effort at addressing the need for accessibility in database interfaces was the development of a blind access mode for the Trace Center's Hyper-ABLEDATA software. (The Hyper-ABLEDATA program provides easy access via personal computer to the ABLEDATA database of 19,000 assistive technology products.) The blind access mode provides complete independent access to the database for users who are blind, with all control functions being accomplished with the numeric keypad of the keyboard, and all information being transmitted in synthesized voice.

A recently released prototype of a "Publications, Media and Materials" (PMM) database includes the first implementation of the Seamless Human Interface Protocol. The software includes seamless presentation of text from standard size up to 72 points (about one-inch characters), as well as complete access to information through synthesized voice. Keyboard alternatives to mouse actions are also seamlessly integrated into the interface.

The interface techniques being developed by the Trace Center are being applied to several databases. The contents of these are described more fully in the report on the "Cooperative Electronic Library on Disability" project.

Selected publications

Vanderheiden, G. C. (1990). Development of an ultra-user friendly, disseminable database system for information and referral. *Proceedings of the National Symposium on Information Technology.* Columbia, SC: Center for Developmental Disabilities, University of South Carolina.

Vanderheiden, G. C. (1990). Development of a public domain, user-accessible interstate directory/database for assistive technology service programs. *Proceedings of the Thirteenth Annual RESNA Conference.*

Cooperative Electronic Library on Disability: A Model for Database Design, Compilation and Dissemination

Project Team: Gregg C. Vanderheiden, PhD; Joseph M. Schauer, BS; David P. Kelso, MS; Tereza Snyder, BFA; Kelly Ford, BA; Peter Borden, MA; Roger O. Smith, PhD

Background

One of the greatest obstacles to effective, widespread use of assistive and rehabilitative technologies has been the difficulty which consumers and services providers encounter in trying to find accurate and timely information about products and services. One practical solution to this problem has been to collect and centralize sources of information, allowing one organization to collect, organize and update information and then make their information system available for general use.

Computer technology has been extremely useful in allowing storage and retrieval of these large quantities of information. However, due to the constraints of the technology at the time systems were first developed (the late 1970s and early 1980s), most large computerized databases were stored at a central location and accessed over the phone lines using a modem. Now, new technologies (including enlarged storage and memory, and CD-ROM) allow larger, more sophisticated databases to be stored on microcomputers—machines that are directly used by clinicians, educators, agencies and individuals. This allows the assistive technology field to take advantage of new, more diversified models for collecting information, presenting it to users, and distributing it as widely as possible.

Approach

The Trace Center's database development efforts address four primary needs:

1) *Availability:* The need for databases to be available through a wide variety of channels and media.

2) *Accessibility:* The need for the database user interface to be optimized for different types of impairments.

3) *Usability:* The need for databases to be easy for novices to use with little or no training.

4) *Usefulness:* The need for data to be valuable to users, including people with disabilities, family members, and professional serving them.

The needs of *accessibility* and *usability* are being addressed through the Trace Center program of database interface development (see previous project report). The

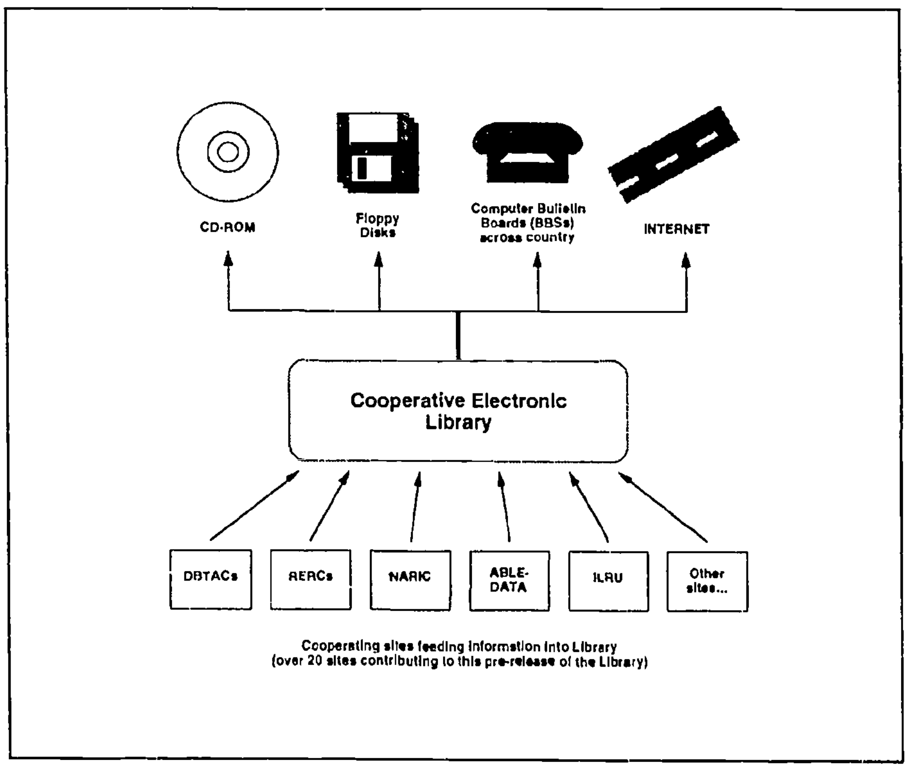


Fig. 1: The Cooperative Electronic Library model

needs of *availability* and *usefulness* are being met through development and coordination of the *Cooperative Electronic Library on Disability.*, an integrated collection of information sources on disability. The overall *usefulness* of the information is increased by the collection of key resources from many organizations, using a cooperative model. *Availability* is increased by designing the Library to be disseminated through a wide variety of channels. (See Figure 1.)

Status

The Cooperative Electronic Library now incorporates 16 databases and over 30 full-text documents. The cooperative effort to collect information has involved over 50 organizations, some of which have information in the current version of the Library and some of which will contribute to future versions. Among the organizations involved in the Library so far are: various state "Technology Act" programs, regional ADA resource centers (DBTACs), the National Rehabilitation Information Center (NARIC), the ABLEDATA project, Independent Living Rehabilitation Utilization (ILRU), and the National Information Service (NIS) at the University of South Carolina.

Four main types of data sources are currently included in the Library:

1. Cooperative Service Directories (CSD): This software allows for the creation of databases of disability-related services. The Library currently contains 11 CSDs covering statewide, regional and national resources.

2. ABLEDATA: This database of assistive technology products includes descriptions of 19,000 items, covering the full range of assistive technology.

3. Publications, Media & Materials: This software can include multiple databases listing information resources on disability. The current version of the Library contains four databases, one of which is the 41,000-item REHABDATA database, maintained by NARIC.

4. Text Document Library: Contains full texts of key disability-related documents. Over 30 documents are in the current version of the Library, including the complete text of the ADA and technical assistance manuals.

To accommodate the need for multiple dissemination channels, the Library is being disseminated through: CD-ROM, floppy disks, computer bulletin board system (BBSs), the Internet, and other information services which provide gateways to the Internet. The Library can also serve as a comprehensive resource to information centers serving consumers who do not have access to computers.

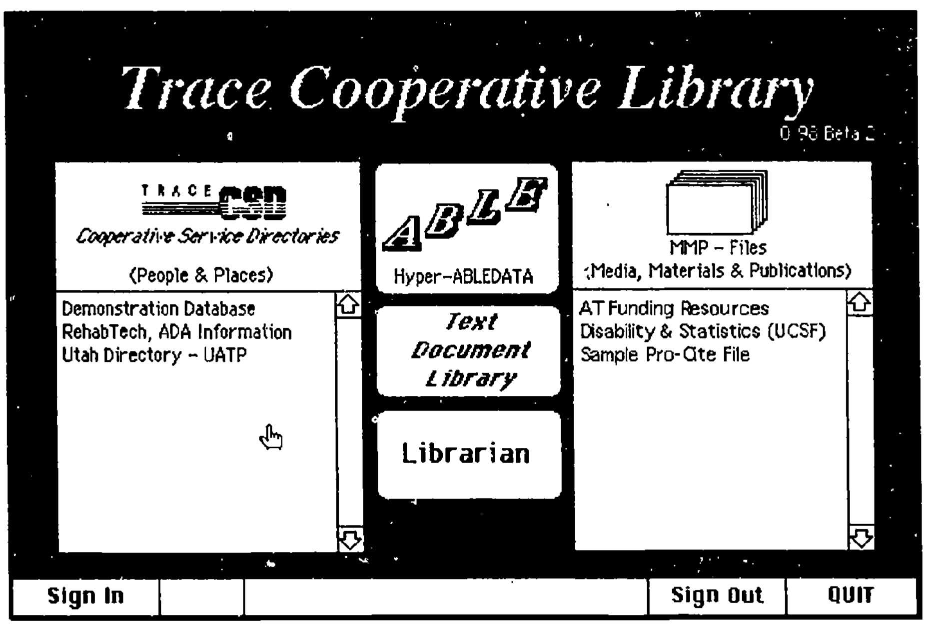


Fig. 2: Opening screen of the Library software

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General Input Device Emulating Interface (GIDEI) Standard

Project Team: Joseph Schauer, BSEE; Charles C. Lee, MS; Gregg C. Vanderheiden, PhD; Mark Novak, BS, BS, PE; David P. Kelso, MS

Background

Certain people with physical disabilities cannot operate standard input devices for commercially available computers. Many of these individuals can, however, operate a special communication or computer access aid, using a control system such as an optical headpointer or a single switch. The aid in turn can be interfaced to the computer and used as an input device.

In the past, Keyboard Emulating Interfaces (KEIs) have been used to connect an aid to a computer. However, newer models of computers and software require the use of other standard input devices, particularly the "mouse" type of pointing device. Thus, the computer user must now be able to use the mouse in addition to the keyboard to operate the computer.

In order that KEIs can be standardized across most all communication and computer access aids, the Trace Center has developed and supported a KEI Standard. This was done to insure better compatibility among devices built by different manufacturers and thereby to increase the number of suitable options a user can choose from. Similarly, to address the need for standard emulating interfaces for input devices other than just the keyboard, such as the mouse, the Trace Center has developed a General Input Device Emulating Interface (GIDEI) standard.

Approach

The GIDEI Standard is a document containing specifications for directing actions to be performed with the

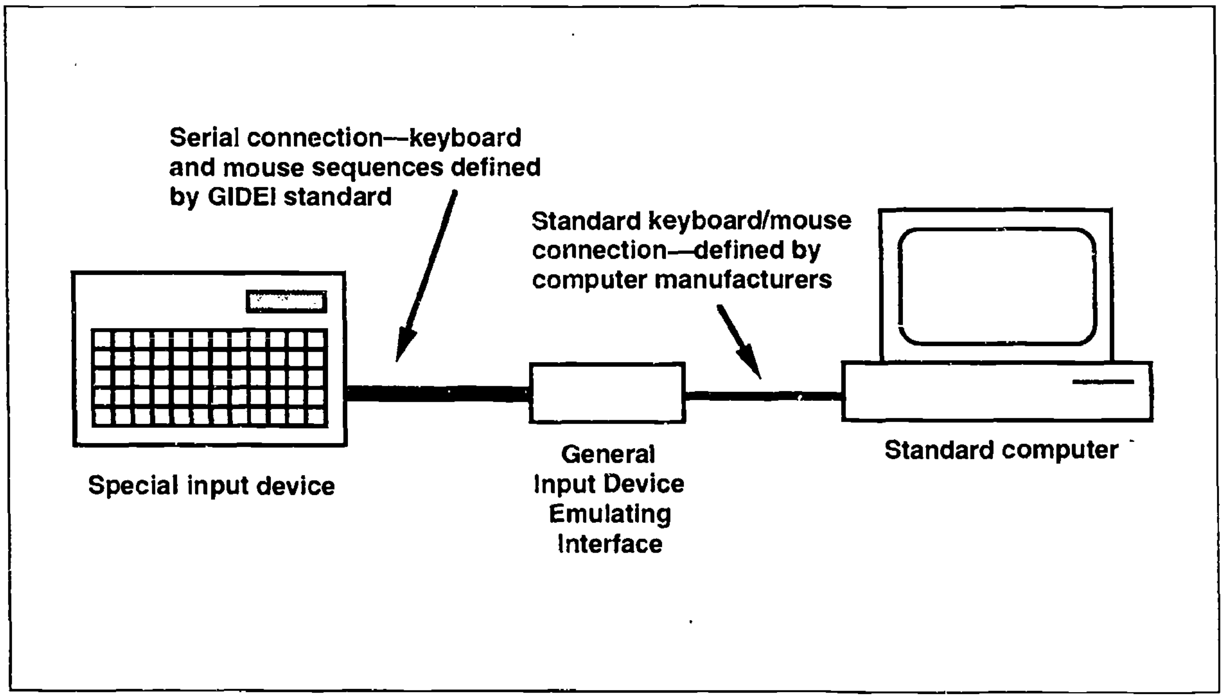


Diagram showing the function of the GIDEI standard keyboard and mouse using a standard protocol. Communication and computer access aid manufacturers whose devices do not directly emulate input devices as a built-in feature are encouraged to design their devices with the capability to use the standard. Manufacturers who create general purpose emulating interfaces are also encouraged to support the GIDEI communication protocol.

Status

Version 1, Revision 5 of the GIDEI Standard is completed. The GIDEI standard has been incorporated into several commercial products, including the Trace Transparent Access Module (T-TAM)—now sold by two major communication aid manufacturers—and the Ke:nx and Darci Too computer interfaces. The GIDEI is also a part of the keyboard/mouse adaptations the Trace Center has developed for the Microsoft Windows operating system, as part of a feature called "SerialKeys." This feature is also included in the AccessDOS accessibility software developed by the Trace Center for IBM's DOS.

The extension of the GIDEI to cover non-U.S. keyboards is currently being investigated.

Several manufacturers are already implementing the latest GIDEI in their products or are designing their products with the capability to use the standard. The GIDEI specifications are available to manufacturers, and made available to other interested parties through the Trace Center Reprint Service.

Selected publications

Rodgers, B. L., Vanderheiden, G. C., Kelso, D. P., & Gunderson, J. R. (1984). *Keyboard emulating interface (KEI) compatibility standard, proposal 1.1.* Madison: University of Wisconsin, Trace Research and Development Center.

Schauer, J. M., Kelso, D. P., Vanderheiden, G. C., & Lee, C. C. (1989). *Keyboard emulating interface (KEI) compatibility standard, 1989 revision.* Madison: University of Wisconsin, Trace Research and Development Center.

Schauer, J. M., Novak, M., Kelso, D. P., Vanderheiden, G. C., & Lee, C. C. (1990). *General input device emulating interface (GIDEI) compatibility standard, 1991 revision.* Madison: University of Wisconsin, Trace Research and Development Center.

Simple Electrical Transducer (SET) Standard

Project Team: Joseph M. Schauer, BSEE; David P. Kelso, MS; Gregg C. Vanderheiden, PhD

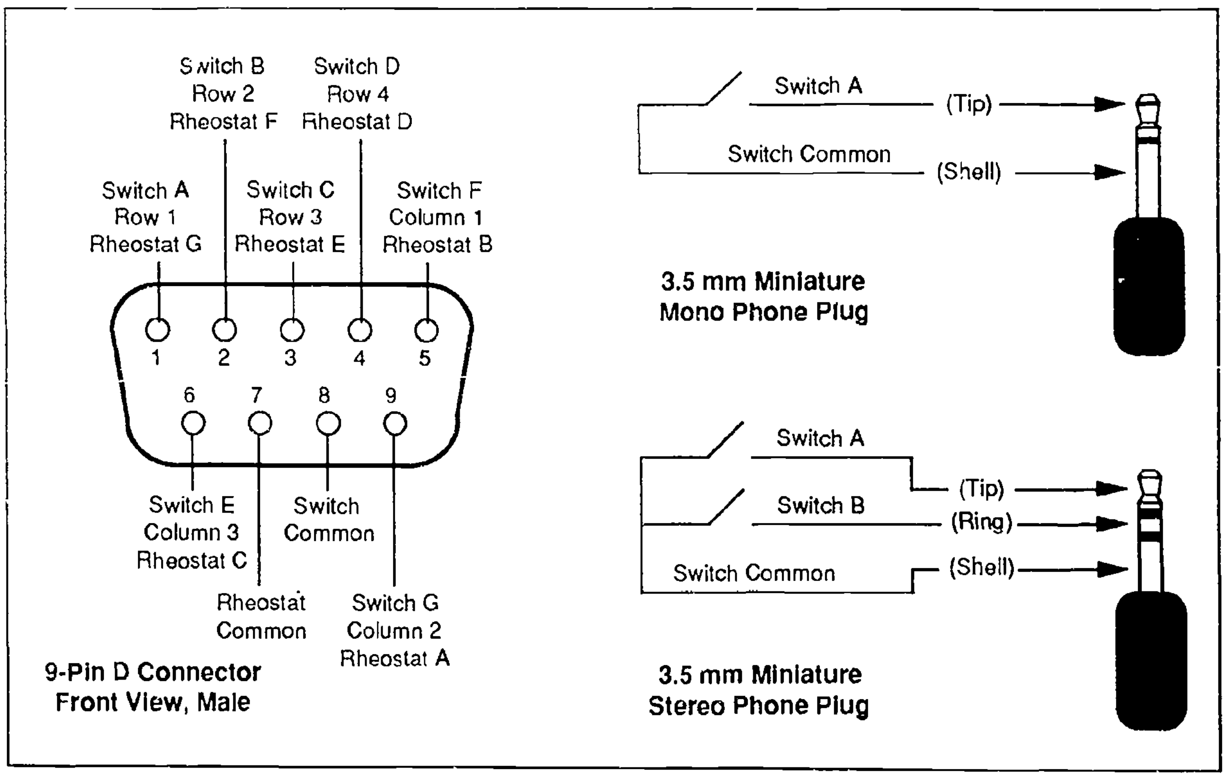
Background

The Trace Center first became involved in the standardization area in order to deal with the problems encountered with user interfaces to communication, control, and computer access aids. At the time, there were approximately 65 specialized interfaces commercially available. Unfortunately, no two manufacturers, even by accident, chose the same connectors or connector pin assignments for their controls. As a result, clinicians were restricted to the use of only a small number of these interfaces, since the interfaces were not interchangeable across aids without rewiring either the interface or the aid.

The Trace Center initiated an effort and, working with manufacturers and researchers from North America, Europe and Japan, developed a Simple Electrical Transducer Interconnection Standard (SET standard). The original SET efforts led to an initial voluntary standard (SET Version 0.2), which was agreed to by a group of manufacturers. Since its introduction, about 80% to 90% of controls and devices addressed by the SET have conformed to most or all of the specifications. During 1987-88, a revision of the first standard was issued (SET Version 1.0), taking into account the suggestions and comments received from the field.

Approach

The SET Standard seeks to standardize: (1) the



The SET standard sets pin assignments for particular connectors physical connections between user controls and electrical/electronic aids; (2) the electrical specifications of the interfaces between controls and aids; and (3) the categorization and labeling of controls and aids as to their electrical makeup.

The standard has been circulated as a working paper among interested parties. The document is distributed through the Trace Center Reprint Service. The document lays out all aspects of the standard as simply as possible while still remaining accurate. Appendices provide a quick reference to pin assignments for connectors.

Status

A final version of the SET is completed and in use by manufacturers in the augmentative communication field. The Trace Center distributes the standard through its Reprint Service, and answers questions from manufacturers regarding compliance with the standard.

The Trace Center will continue to support other organizations in their adoption of the SET standard. Future revisions or expansions of the standard may also be undertaken, but none are now planned.

Selected publications

Rodgers, B. L., Kelso, D. P., & Vanderheiden, G. C. (1984). *Simple electrical transducer (SET) standard, proposal 0.2.* Madison: University of Wisconsin, Trace Research and Development Center.

Schauer, J. M., Kelso, D. P., & Vanderheiden, G. C. (1988). *Simple electrical transducer (SET) standard, version 1.0.* Madison: University of Wisconsin, Trace Research and Development Center.

Serial Wheelchair Control Interface Standard

Project Team: Joseph M. Schauer, BSEE; David P. Kelso, MS; Gregg C. Vanderheiden, PhD

Background

As electronic communication aids and environmental control devices become more advanced, their ability to perform more sophisticated functions expands. As a result of this increased capability, there is a growing interest in interfacing suitable assistive devices (such as communication aids) to wheelchairs. In this model, the aid assumes the control functions typically performed by the joystick or other standard control built into the wheelchair.

However, devices such as communication aids can only be used as controls if they can be effectively interfaced to the wheelchair. At the present time, special aids must be individually customized for each model of wheelchair they are to be used with. No common interfaces exist among powered wheelchair controllers, but several manufacturers are interested in developing them.

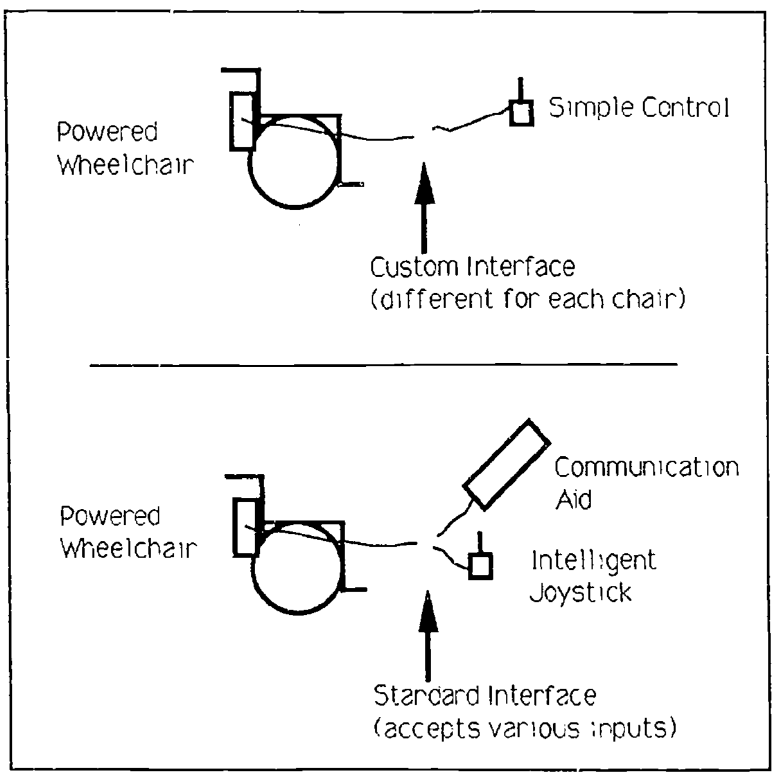
To assist in the development and application of new control devices, Trace Center engineers began developing a protocol for a standardized connection. As long as both the control and the wheelchair conform to the specifications of the standard, any manufacturer's control device can be used with any manufacturer's wheelchair.

Approach

The standard was discussed in meetings of wheelchair manufacturers, communication aid manufacturers and researchers at the annual RESNA conferences in 1988, 1989 and 1990. A RESNA subcommittee on wheelchair standards has been created to review and further develop the standard. Since RESNA is the representative on wheelchair issues to ANSI, the standard is also under consideration for adoption by ANSI. RESNA, through ANSI, submitted an application to the International Standards Organization (ISO) to establish a working group on the standard within ISO. In November, 1990 ISO established the working group (ISO/TC173/SC1/WG-7).

Status

The ISO Serial Interface for Electronic Wheelchair Controllers has evolved into a more sophisticated standard called the M35 Standard. Copies



Current (top) and serial control models of the draft ISO standard are available to interested parties from the ISO, ANSI or RESNA.

Selected publications

Schauer, J. M., Vanderheiden, G. C., & Kelso, D. P. (1990). *Serial wheelchair control interface standard.* Madison: University of Wisconsin, Trace Research and Development Center.

Schauer, J. M., Kelso, D. P., & Vanderheiden, G. C. (1990). Development of a serial auxiliary control interface for powered wheelchairs. *Proceedings of the Thirteenth Annual RESNA Conference.* Washington, DC: RESNA.

Case Studies on Facilitated Communication

Project Team: Julie E. Gamradt, MS, CCC-SLP; Ruth A. Huebner, MS, OTR; Paul H. White, MA; Julia E. McGivern, PhD; Mary Klund, MS, OTR

Background

According to Crossley, Facilitated Communication (FC) is a training technique aimed at developing the individual's ability to accurately, and ultimately independently, point at words, letters or pictures on a communication display in order to communicate. Training is performed by another person, called a facilitator, who makes direct hands-on contact to the person's hand, shoulder, clothing or waist and fades that contact as the individual achieves more independence. Although the influence of the facilitator in guiding the client to construct messages is unclear, it is clear that the facilitator provides input, for example, to decrease fatigue or reduce impulsivity in responding. This training technique is thought to provide appropriate sensory and motor input to increase hand function, emotional support, and in some cases training on how to use a communication system.

FC was brought to international attention among parents and service providers by Rosemary Crossley of Australia and Douglas Biklen of the United States. Although there have been many anecdotal claims of the effects of FC on persons with autism or other severe communication disorders, there has not been any quantitative research to explore the efficacy and delineate the practice of FC, excluding some studies looking at the specific issue of the authorship of messages generated by individuals while using FC. Furthermore, there has been dramatic and provocative national media coverage of individuals successfully using FC and showing overall quality of life benefits. This coverage and consequent polarization of reactions among professionals, concerned parents, and the public has had repercussions for all those associated with persons having severe communication impairments.

At the initiation of the project in June, 1992, , literature on FC was sketchy and confusing, and opinions were divided. Many questions remained unanswered, such as: What are the characteristic components of the intervention referred to as FC? Who, if anyone, would benefit from the use of FC-like interventions? What, if any, changes are likely to occur in behavior, communication, motor skills or independent living skills when using FC-like interventions? How much does the facilitator influence the messages produced by individuals engaging in FC-like interventions for communication?

Approach

To explore the efficacy and collateral impacts of FC, a multidisciplinary approach and philosophy was adopted, since research questions and practice concerns transcend specialties. The resource team which guided the project protocol design included professors from special education and communication disorders, a pediatrician, an occupational therapist, a program administrator, and a psychologist.

Seven adults with a history of severe speech impairment and failure of using traditional augmentative communication systems were chosen from a pool of nominees from the local county. Medical, historic and functional status information was obtained and assessment of sensorimotor performance, behavior, communication and independent living skills were performed prior to intervention. This pre-testing phase of the project was followed by an introductory phase as individuals began using FC under the guidance of a highly experienced facilitator from the community.

This first phase was followed by a six-month intervention phase, in which project staff met weekly with participants and their community team members who were using facilitating communication with them. During this time, participants were to regularly use FC with community team members. Project staff made systematic observations concerning the components of the FC approach used during the sessions and the participant's behavior and communication. The final phase included post-testing, debriefing and case study summaries.

This exploratory case study project was designed to complement other similar efforts to describe clinical procedures encompassed by the term "facilitated communication." The goals of this project were to idenfiy specific intervention components frequently identified with FC, and to identify observed collateral effects correlated with the use of this intervention. This information should also provide for more researchable questions pertaining to FC-like interventions.

Status

The post-testing and debriefing portions of the final phase have been completed. Write up of the results and implications of the project are in progress as of June, 1994. An updated review of the literature is also in process, in response to the number of research articles that were published during the course of the project.

Some of the preliminary conclusions state that:

1. FC is a multiple-component intervention.
2. The apparent risks overshadow the benefits of using FC in the absence of clear, objective evidence that the messages produced in conjunction with FC are authored by the communicator, and not the facilitator.

It is recommended that useful practices be extracted from FC and implemented within the context of other skill development and service delivery programs. Examples of practices or philosophies that could be extracted from FC include: age-appropriate regard; use of touch strategically to enhance skill development or adaptive behavior; participation in extended one-to-one interpersonal interactions; pursuit of a more positive regard and value of individuals who have severe communication impairments; setting a time and a place for reconsidering a person's skills and potentials; creating opportunities for adults with disabilities to use their known literacy skills in their daily lives.

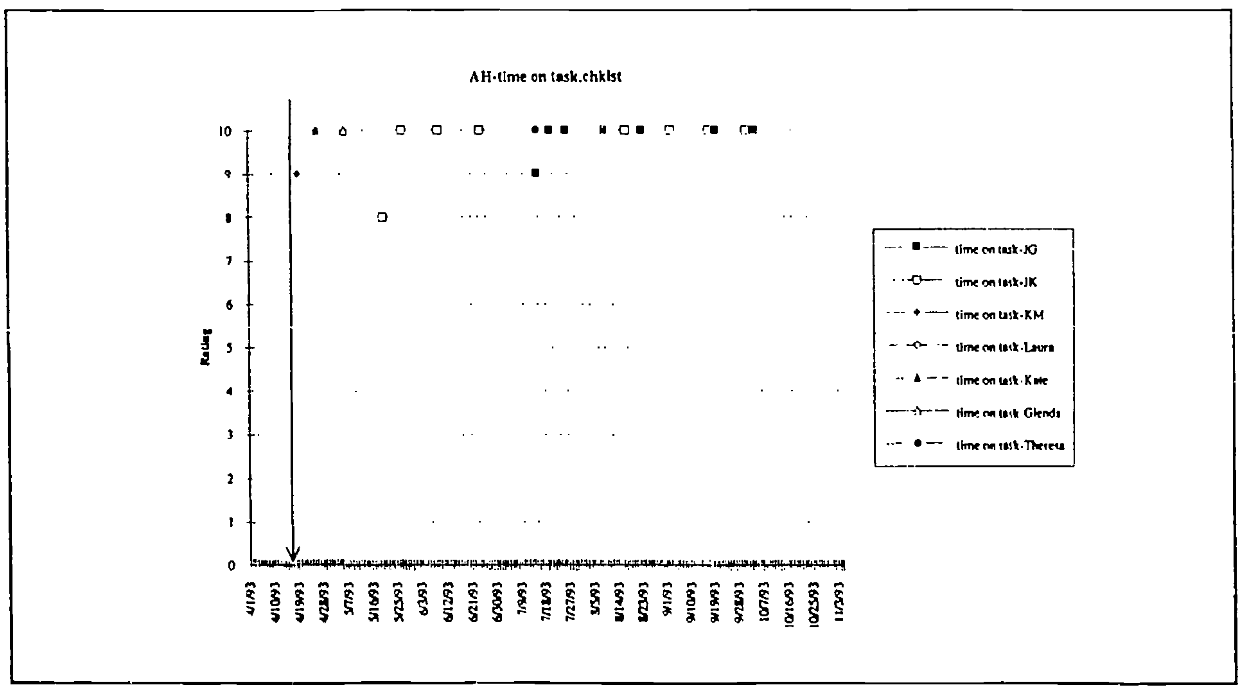
The Trace Center recommends that there must be clear, objective evidence as to the authorship of messages produced in conjunction with FC before FC is used:

- As a method for evaluating skills (e.g., within cognitive testing), or
- As a method of communicating important decisions

The procedures used for establishing authorship should be controlled, scientific procedures. The results of this project along with results of numerous research studies around the country support these conclusions.

Selected Publications

Gamradt, J. E., Huebner, R. A., White, P. H., McGivern, J. E., & Klund, M. (1993). Case Study Exploration of Facilitated Communication. *Proceedings of the Sixteenth Annual RESNA Conference.*



Several observers' estimates of time attending to task during therapy sessions where FC was being used. Consistently high levels of time-on-task were observed for this client.

System for Integrating and Reporting of Occupational Therapy Functional Assessment (OT FACT)

Project Team: Roger O. Smith, PhD, OTR; Jay Hinkens, BS; Gregg C. Vanderheiden, PhD; Kathy Longenecker Rust, MS, OTR; Laurie Fox, BSEE, OTR; Sharon Esser; Peter A. Borden, MA

Background

In 1985 the Standardized Assessment Committee of the American Occupational Therapy Association, along with the American Occupational Therapy Foundation, awarded two grants to begin the development of a profession-wide standardized assessment. The University of Wisconsin-Madison was awarded one of these. For the past five years, faculty and staff in several programs at the university—including University of Wisconsin Hospitals and Clinics, the Occupational Therapy Program of the School of Education, and the Trace Center—have been working on the development and testing of a functional assessment system.

An initial paper form of the SIR-OTFA (System for Integrating and Reporting of Occupational Therapy Functional Assessment) was created and put through pilot testing in the field to test its validity and reliability. The inter-rater reliability found in pilot testing was very high (correlation coefficients were 0.8s to 0.9s). The internal and external validity measures from pilot testing also appeared to be very high.

As the development of the SIR-OTFA progressed, it was renamed OT FACT (for Occupational Therapy Functional Assessment Compilation Tool).

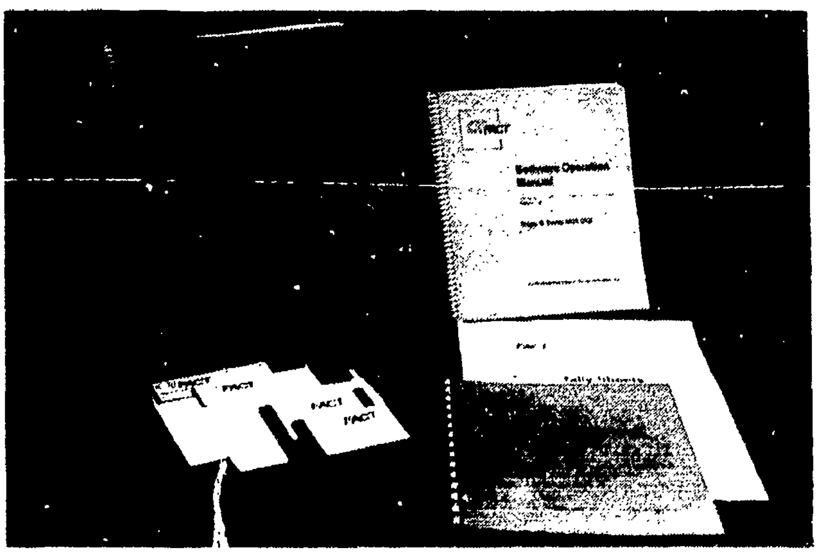
Results from preliminary testing indicated that a properly designed computerized version of OT FACT would greatly facilitate administration, scoring and charting of results. This would make testing of the assessment more accurate (by reducing the possibility of calculation errors), and could serve to increase the number of researchers and clinicians interested in and able to evaluate the assessment.

Approach

OT FACT was initially designed as software for IBMs and compatibles. A Macintosh and Microsoft Windows version is currently in development. Development was supported by the American Occupational Therapy Association, Inc.

The software steps the user through the stages of the assessment, following the nodes of a decision tree. Scores are based on a simple trichotomous scale (total deficit, partial deficit, no deficit), avoiding the complexity and inconsistency of graded scales. The program solicits scores from the user, tabulates and totals scores automatically, keeps records, and automatically charts results graphically. The data thus synthesized presents a functional performance profile of the client. This profile can be used to summarize the client's functional performance, to justify therapy plans, and to document the client's change in status over time.

The American Occupational Therapy Association (AOTA) dis-



OT FACT software package, now distributed by the AOTA seminates OT FACT throughout the occupational therapy profession. The Trace Center has set up a continuing education workshop series aimed at increasing the level of competency of OT FACT users.

Status

Revisions based on the beta testing of Version 0.9 of OT FACT were completed, and Version 1.0 was released by the AOTA in the fall of 1990. Version 1.1 was released in 1992 and is now being marketed nationally.

Version 2.0 for the Macintosh and IBM PCs with Microsoft Windows is due to be released soon. This version has expanded functional categories and enhanced, customizable reporting formats (see figure below).

Validity and reliability studies of the new computerized OT FACT are currently under way at facilities around the country. Research and development of OT FACT continues to be supported by the AOTA, with additional support from Apple Computer, Inc.

Selected publications

Smith, R. O. (1992). The science of occupational therapy assessment (Guest Editorial). *Occupational Therapy Journal of Research*, *12*, 3-15.

Smith, R. O. (1992). OT FACT version 1.1 [computer program]. Rockville, MD: American Occupational Therapy Association.

Smith, R. O. (1990). OT FACT administration and tutorial manual. Rockville, MD: American Occupational Therapy Association.

Smith, R. O. (1990). OT FACT scoring guide. Rockville, MD: American Occupational Therapy Association.

Smith, R. O. (1990). Computerizing a System for Integrating and Reporting Functional Assessment. In *Technology Review '90*. Rockville, MD: American Occupational Therapy Association.

Smith, R. O. (1990). Synthesizing and interpreting functional assessment data for meaningful recommendations. In Charlotte B. Royeen (Ed.), *AOTA Self Study Series: Assessing Function*. Rockville, MD: American Occupational Therapy Association.

OT FACT Features: Versions 1.1 and 2.0

Version 1.1 Features

- Runs on IBM/compatible computers with DOS.
- More than 250 individual items of functional performance.
- Question taxonomy based on occupational therapy theory.*
- Question set customizes itself to match the particular assessment.*
- Computer scoring methodology.*
- Both functional outcome and diagnostic measure so performance.*
- Tables and graphs of data summaries that serve as functional performance profiles.*

* *Also features of Version 2.0*

Version 2.0 Features

- Runs on the Apple Macintosh and on IBM/compatible computers with Microsoft Windows.
- 1000 question categories for specialized areas of practice.
- About 200 categories are core questions, with the other 800 optional, relating to specific areas of practice.
- Extended demographic information can be stored for use in research or program evaluation.
- Auto-merge feature pulls data directly into predesigned forms and formats.
- Copy and paste features for putting commonly used words or phrases into reports.
- Memo templates allow additional information, including results of other assessments, to be included in reports.
- Special scoring types, including self-satisfaction scoring, goal scoring, and co-variate scoring.

Information and Training Programs

Trace Center program plans have always stressed the application of research and development results. The philosophy behind this approach is simple: if the achievements made in R&D are not transferred to those who need them—consumers and practitioners—they are of little or no use.

The Trace Center has a long history of involvement in information and training programs. In the 1970s, the center hosted workshop series on augmentative communication and published an early directory of communication devices, the *Non-Vocal Communication Resource Book*. Today, dissemination activities have increased and broadened, to include preservice and inservice training of professionals, publication of product references such as the *Trace ResourceBook*, and development of computerized information sources on assistive technology.

Research and development programs at the Trace Center also have strong dissemination components. Efforts such as design guidelines and electronic standards (see the Cross-Impairment Focus Area) rely very strongly on circulating information and on support of working groups and committees.

The content of information materials and training programs is not confined to discussing the results of Trace Center projects. It covers the work of other researchers and developers across the field.

Target Groups

Specific dissemination activities have been developed at the Trace Center to meet the needs of the different populations served by the center. Briefly, the target groups which have been identified are:

1) *People with disabilities* (plus parents and other support people): This group represents the end target of most of the research and dissemination efforts. "Support people" includes not only relatives but family, physicians, clergy, roommates, and personal aides.

2) *The rehabilitation products industry*: This group includes manufacturers of special devices, software, and hardware for people with disabilities.

3) *Standard industry*: This group includes all people who design electronic devices, computer hardware and software, and related items for the regular mass market of people without disabilities. This includes both manufacturers who are actively seeking information in this area and manufacturers who are not aware of the problem or need for work in this area.

4) *Rehabilitation researchers*: This group includes researchers based in university, clinical, and industrial settings.

5) *Service providers*: This rather broad group includes rehabilitation engineers and technologists, vocational rehabilitation professionals, occupational therapists, physical therapists, speech and language pathologists, clinical rehabilitation personnel (public and private), independent living centers, special educators, and other information and referral agencies and personnel.

6) *Policy makers and funding agencies*: This group creates the societal rules under which the rehabilitation and special education process must operate.

7) *The general public*: This group is broadly defined as all people who do not have a direct personal or professional interest in people with disabilities.

Information Accessibility

For information to be effective, it must be accessible to the target audience. Trace Center materials are formatted and disseminated to meet the specific needs of each of the target audiences. Individuals with specific disabilities, however, may have additional difficulties in accessing information, particularly if it is in print form.

As a result, all of the materials disseminated by the Trace Center are available in electronic form (on disk) or in other accessible forms (braille, voice, large print) on request. This policy includes working papers and individual letters, which are often mailed in disk form to individuals who are blind or have physical disabilities. The Trace Center's information and referral service also has a TDD (telecommunication device for the deaf) phone number, to allow direct communication between hearing impaired persons and the information and resource staff of the Center.

Cooperative Database Dissemination Network for Assistive Technology (Co-Net)

In addition to its past mechanisms for disseminating information materials, the Center has initiated The Cooperative Database Dissemination Network for Assistive Technology (Co-Net), a cooperative network for the rapid dissemination of up-to-date information on assistive technology to professionals and consumers across the United States. Co-Net is headquartered at the Trace Center. From this point, electronic databases and updates are currently disseminated to approximately 800 information providers.

The primary type of information distributed through Co-Net is electronic in nature. Several databases are being distributed as part of the center's development of a "Cooperative Electronic Library on Disability." These include: *Hyper-ABLEDATA* and *DOS-ABLEDATA*, comprehensive databases of assistive technology products; *Cooperative Service Directories*, computerized databases of services; a *Text Document Library*, containing complete texts of disability-related documents; and *Publications, Media and Materials* databases. These are described in detail in this section of this report.

Training and Demonstration Programs

Assistive technology is a rapidly advancing field, one which is continually changing. Traditional college curricula do not prepare professionals to practice with technology—and even if they did, professionals would need to regularly update their knowledge base as technology changes. In addition, consumers and service providers who have had no exposure to assistive technology education may be placed in a position where they need this knowledge. The Trace Center provides a number of opportunities for students, professionals, and the public to learn more about technologies related to communication, control, and computer access.

Pre-Service Programs: The Trace Center program provides training for new professionals through appointments in academic departments, guest lectureships, and inter-departmental courses. Trace Center staff interact with University of Wisconsin-Madison students in Occupational Therapy, Physical Therapy, Speech & Language Pathology, Rehabilitation Medicine, Rehabilitation Counselling, Special Education, Human Factors Engineering, Electrical and Computer Engineering, and Mechanical Engineering. Pre-service education is also carried out through practicum experiences arranged through the Trace Center and the Communication Aids and Systems Clinic.

The TechSpec and InterACT programs are formal educational programs for both undergraduate and graduate students at the University of Wisconsin-Madison. The programs are coordinated by the Trace Center, and offer a technology specialization certificate.

Workshops: The Trace Center currently hosts a series of workshops on computerized functional assessment in occupational therapy.

Trace Center Introduction and Demonstration Program: In response to the number of people wanting to visit the Trace Center and see assistive devices in operation, the center holds a one-day visitors' program at the beginning of each month. Clinical staff demonstrate current and newly developed equipment and techniques, as well as providing an overview of Trace activities and recent findings. Over 120 people have attended the demonstration program in the past year.

Conference Exhibits: The Trace Center regularly presents an exhibit of their current work and results at national conferences.

Development of an Accessible, Distributable Assistive Technology Database: Hyper-ABLEDATA and DOS-ABLEDATA

Project Team: Gregg C. Vanderheiden, PhD; Joseph Schauer, BS: Roger O. Smith, PhD; David P. Kelso, MS; Tereza Snyder, BFA; Kelly Ford, BA; Jay Hinkens, BS

Background

There are a number of electronic databases which provide information on technology for people with disabilities. In the past, these have usually been made available in "on-line" form; that is, the user connects their computer via modem (over telephone lines) to a central computer containing the data. Typically, these databases require that the person using them have experience in using computers and modems; have experience using databases; be familiar with a large vocabulary of key search terms; and be able to create effective Boolean logic search statements.

The Trace Center and other experts in the field have been aware for some time that these requirements limit the number and variety of people who are able to access the information in on-line databases. An improved interface is clearly needed to make searching easier. In addition, improvements in data storage for personal computers have made it possible for very large databases to be stored directly an individual's computer, eliminating the need to dial in via modem or incur connect time charges.

Approach

The awareness of the need for better database interfaces resulted in part from the number of requests coming into the Trace Center for copies of its electronic database, and the difficulties encountered by consumers and professionals in trying to use this type of database. The Trace database was initially put into a very user-friendly format. This prototype was later used as a model for the development of Hyper-ABLEDATA.

Hyper-ABLEDATA is a microcomputer version of the on-line database ABLEDATA, supported by the National Institute on Disability and Rehabilitation Research. The database lists all the commercial assistive technology products available to consumers in the U.S.—currently over 19,000 items. The interface software created at the Trace Center provides four distinct advantages:

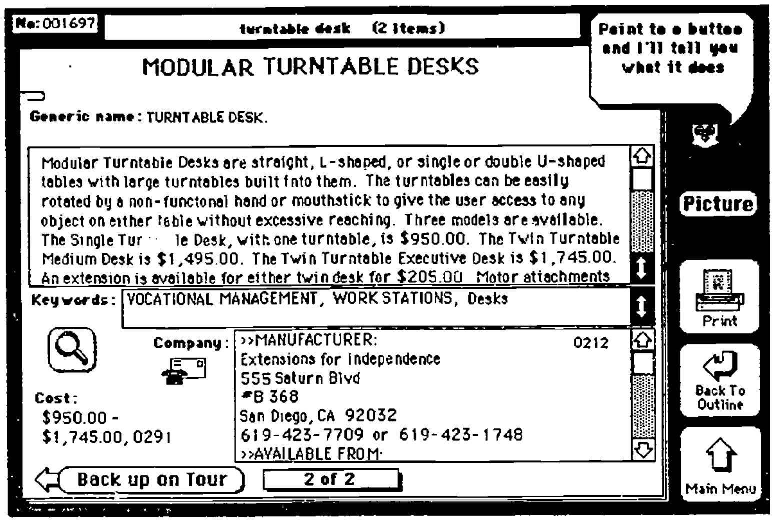
1) The program runs on the user's own microcomputer. This eliminates the need for a modem, the need to know communications software, and the expense of on-line connect time charges. It also makes it possible to design an interface that is faster and more user-friendly, since data and images appearing on the user's screen do not have to be sent over telephone lines.

2) The "point and click" interface does not require the user to be trained in how the system works. Use of graphics, visual analogies to familiar information materials (like file cards), and context-sensitive help messages guide new users

The Co-Net CD-ROM contains the entire Cooperative Electronic Library on Disability, including Hyper-ABLEDATA and DOS-ABLEDATA.

through the system. In addition, the interface has been adapted to be usable by people with visual impairments and to allow for keyboard operation for those whose physical impairments keep them from using the standard mouse.

3) The search routines have been greatly simplified. The on-line version of ABLEDATA requires that the user consult a 4000-term thesaurus, construct search commands, and type them in. Hyper-ABLEDATA presents the thesaurus in "expanding outline" format, allowing the user to browse for the appropriate terms and then go directly to the products that match those terms. Boolean logic searching is also available, for more sophisticated users.



Product description in Hyper-ABLEDATA

4) Data-intensive information such as pictures and sound can be stored and retrieved. Hyper-ABLEDATA currently contains pictures of many products, plus sound samples of products such as speech synthesizers.

5) A "blind access mode" offers complete, independent access to the database for users who are blind. It uses synthesized speech for output.

A version of the software for IBM and compatible computers has also been developed. DOS-ABLEDATA provides all the information included in Hyper-ABLEDATA. The user interface operates in a similar way, but is designed for the character-based screens used in DOS. The program is specially designed to be accessible to screen reader software for computer users who are blind.

Pictures of items are available on-screen or on printouts

Status

Hyper-ABLEDATA and DOS-ABLEDATA are now available to the public through the Trace Center Reprint Service. A secondary dissemination mechanism has been established as well: the Cooperative Database Dissemination Network for Assistive Technology (Co-Net). This network consists of dissemination points around the country who use the databases and who may also serve as distributors of copies.

The databases are updated approximately twice per year. They are being made available on two different media: floppy disk and CD-ROM (Compact Disk Read-Only Memory). DOS-ABLEDATA is also available on the Internet, from a Trace Center server.

The Seventh Edition of the Co-Net disk was released in March, 1994. It included both Hyper-ABLEDATA and DOS-ABLEDATA, with an expanded picture library (now 2,500 pictures). The disk also contains the rest of the Cooperative Electronic Library on disability, including databases of services and information resources, plus full texts of disability-related documents.

User Friendly, Disseminable Database System for Information and Referral: Trace Cooperative Service Directory

Project Team: Gregg C. Vanderheiden, PhD; Roger O. Smith, PhD; David P. Kelso, MS; Tereza Snyder, BFA; Kelly Ford, BA; Joseph Schauer, BS

Background

The rapid advance of technology—and microcomputers in particular—is opening new opportunities in information response and referral (IR&R) services for people with disabilities.

In recent years, large-scale information and referral systems have been primarily designed as centralized information databases. While there are distinct advantages to the centralized database approach from the standpoint of data management, it would often be more effective if the information could be replicated and distributed. Technologies such as CD-ROM have greatly expanded the capability of microcomputers to store and manipulate large databases, making distribution of complete copies of a large database possible. This allows the information to be located directly at the point of inquiry. Such direct access lets information seekers browse through the information to locate that which best meets their needs at very low or no cost.

In order for such IR&R databases to be effective, however, they must require much less training in computer use, database use and specialized searching skills than that required by centralized, mainframe-based databases. The intensive training that can be assured at a single centralized data access point cannot be practically guaranteed in a distributed database network.

The need for training in database use can be in part overcome through the use of ultra-user friendly designs. With careful design, databases can be developed with front ends which are so simple to learn that they can be operated with no instruction and no knowledge of key words, Boolean logic search strategies, or other traditional database search techniques.

Approach

In order to explore the issues in creating an ultra-user friendly distributed IR&R database, Trace Center has developed a prototype computerized service delivery directory for assistive technology services. The database takes advantage of fast searching software, graphical screens and hypertext information linking techniques. The design is based on several crucial design principles:

1) Obviousness;
2) Instructions on each screen;
3) Screen appearance based on metaphors of daily life experience;
4) Provision of visual cues for each context;
5) Clear path back to starting point or to previous context;
6) Concrete cues to movement through data;
7) One page per database entry;
8) Consistency of appearance and operation across database;
9) Options to visualize data in different ways;
10) Ability to customize to user needs;
11) Ability for users to browse;
12) Accommodation of database users with disabilities.

In order to expand the cooperative service directory database beyond proof of concept, the Trace Center has entered into cooperative efforts with state programs funded under the Technology-Related Assistance for Persons with Disabilities Act. Several state programs interested in the design will be using the database in their own assistive technology IR&R services. In addition, the database's structure has been extended to include a full range of disability-related services, so that state IR&R programs do not have to maintain segregated databases for technology-related services.

The taxonomy of descriptive terms in the database has been modified so as to be compatible with field-wide efforts to systematize terminology. This opens the possibility for the interchange of information between the Trace Center-designed service delivery databases and other existing IR&R systems.

The project has also been expanded to include testing of the intra-state database distribution model, as well as direct testing of the user interface with disabled and non-disabled users. This phase will also include the development of instruction and training materials. Parts of this testing and training phase are being done in conjunction with Computers to Help People, Inc., a software training organization run by and serving individuals with disabilities.

Status

In 1992, an initial version of CSD software was developed under Macintosh computers and IBM computers with Microsoft Windows. Seven states participated in the initial development: Connecticut, Illinois, Utah, South Carolina, Wisconsin, Maryland and Maine.

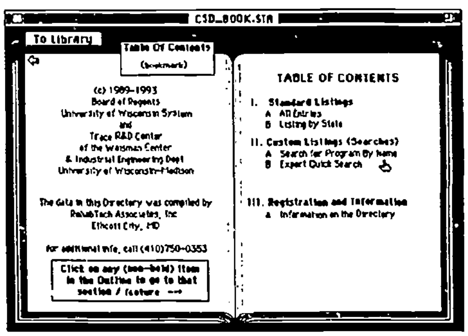
Over 30 different information centers are now participating in the effort, including state Technology Act programs and regional ADA resources centers (DBTACs). A version of the software for IBM PCs running DOS was released in 1993. Sets of CSD data from 11 different sites were distributed to the public on the Sixth Edition of Trace Center's *Co-Net* CD, released in January of 1994.

Selected publications

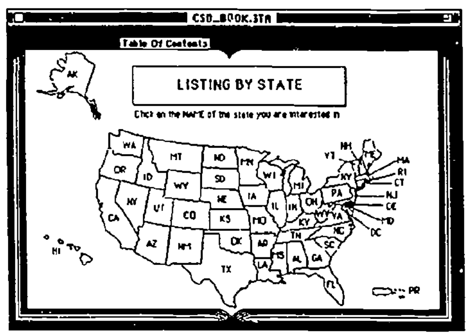
Vanderheiden, G. C., & Borden, P. A. (1989, April). The use of hyper-text in distributable databases for personal computers. *Proceedings of the National Symposium on Information Technology*. Columbia, SC: Center for Developmental Disabilities, University of South Carolina.

Vanderheiden, G. C. (1990, May). Development of an ultra-user friendly, disseminable database system for information and referral. *Proceedings of the National Symposium on Information Technology*. Columbia, SC: Center for Developmental Disabilities, University of South Carolina.

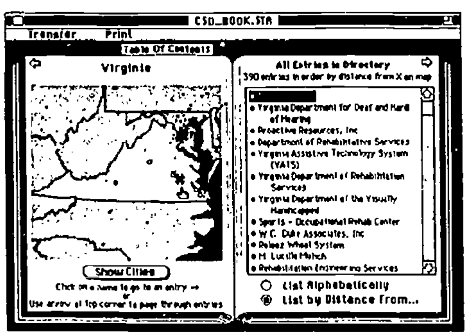
Vanderheiden, G. C. (1990). Development of a public domain, user-accessible interstate directory/database for assistive technology service programs. *Proceedings of the Thirteenth Annual RESNA Conference.*



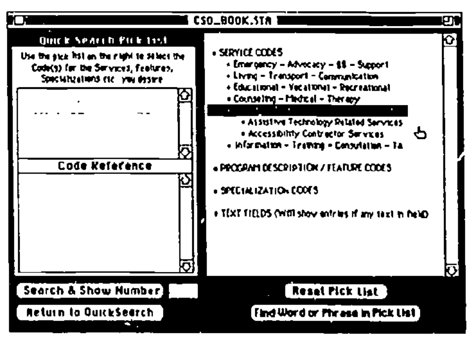
The table of contents resembles a book—putting the user in a familiar context.



States can be selected for searching simply by indicating them on a map of the U.S.



Programs can be listed by name, by county, by zip code, or by distance from a point.



Search features let the user locate service programs by a variety of identifying terms and criteria.

Sample screens from Cooperative Service Directory database

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Databases on Communication, Control and Computer Access: Development and Downloading

Project Team: Peter A. Borden, MA; Kelly L. Ford, BA; David P. Kelso, MS; Sarah E. Fatherly, MA

Background

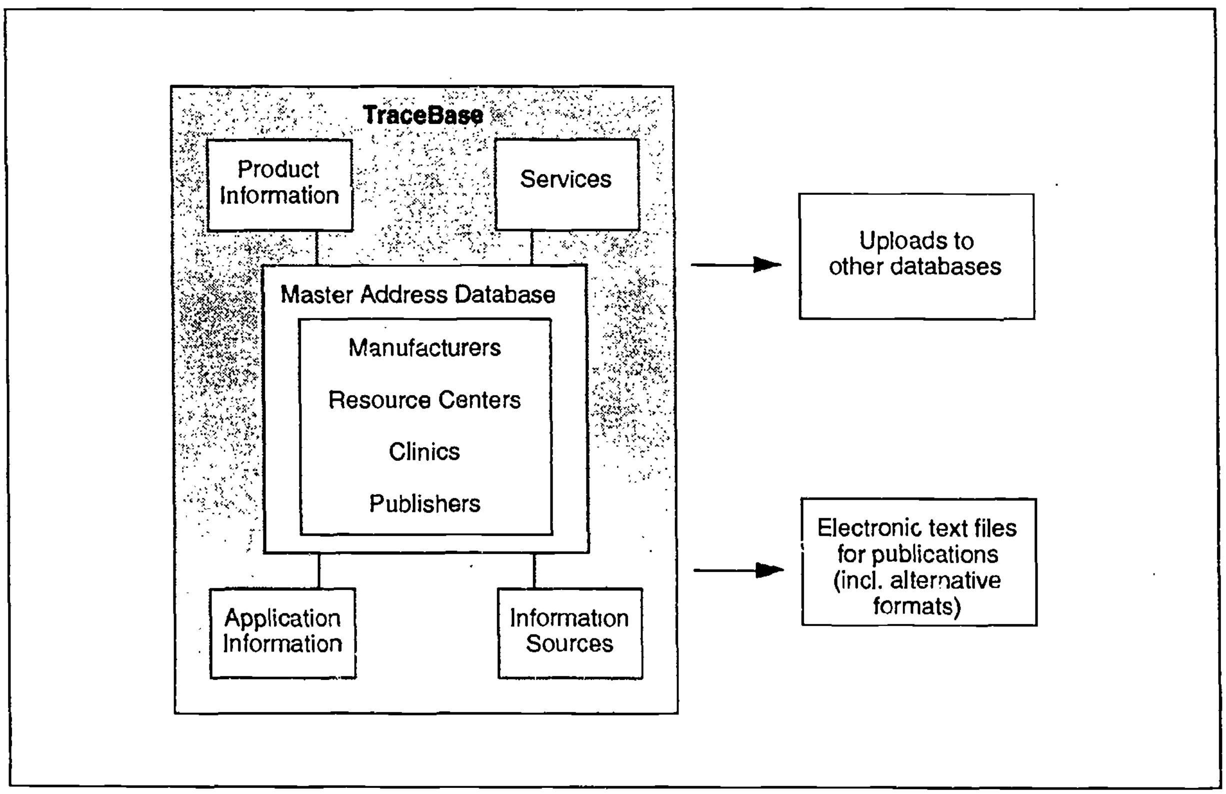
The Trace Center has maintained a number of ongoing information resources since the publication of the first edition of the *Non-Vocal Communication Resource Book* in 1978. Over the past eight years these resources have been converted to electronic database form. This has been done in order to facilitate response and referral, creation of publications, and uploads to other databases.

The core databases (known collectively as "TraceBase") contain information on products, companies, publications, clinical service centers, networks and databases, self-help groups, organizations, and training programs pertinent to communication, control and computer access technologies.

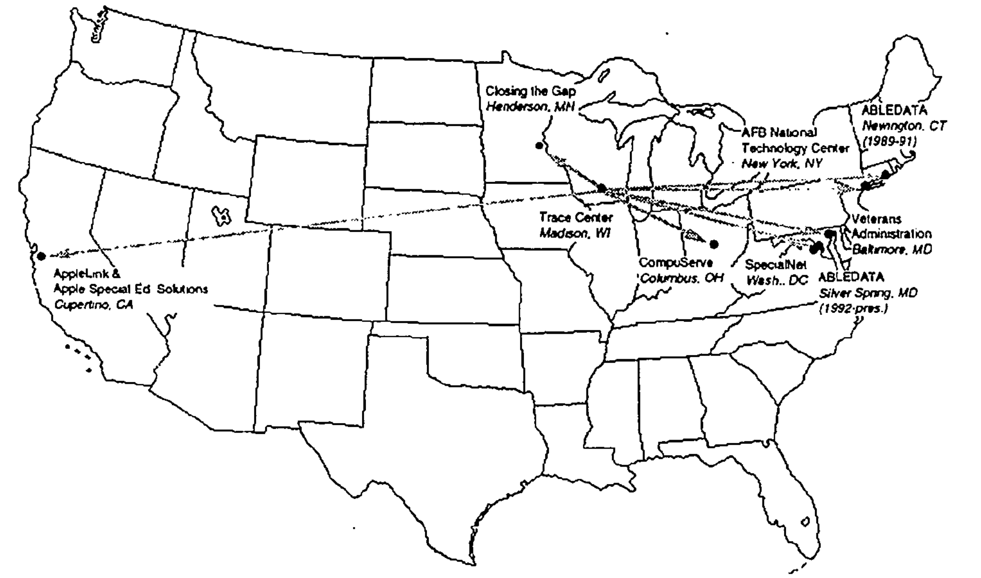
Approach

The TraceBase databases can be searched for data meeting specific criteria, allowing Trace Staff to perform searches for research and clinical purposes, and also to answer specific questions received by phone or mail. Products, for example, are categorized by any of 25 different criteria, such as input form, output form, computer compatibility, etc. Search strategies involving multiple fields allow a high degree of specificity.

TraceBase information is also used to generate nu-



TraceBase internal structure and output products



TraceBase Download Sites

Map showing locations of organizations to which the Trace Center has sent direct database downloads

merous publications, including "Quick Sheets" (currently 25 titles available) and the *Trace ResourceBook* (new edition published in 1993). These are created using database publishing software routines, which allow data to be directly exported from the database and formatted for printing, greatly reducing the amount of manual data entry needed between original entry in the database and printing for publication. Maintaining information resources in computer databases also makes it fairly simple to send data in electronic form to people with disabilities who wish to read it using special input/control or output systems.

Maintenance of data in electronic form also makes it possible to download data directly to other organizations around the country which maintain databases. The Trace Center has worked cooperatively with several such organizations, including:

- ABLEDATA (Newington Children's Hospital, Newington, CT, 1989-91; Macro International, Silver Spring, MD, 1992-pres.);
- AppleLink (Apple Computer, Inc., Cupertino, CA);
- Apple Solutions (Apple Computer, Inc.);
- CompuServe Disabilities Forum (CompuServe, Columbus, OH);
- SpecialNet (GTE Educational Services);
- Veterans Administration Office of Technology Transfer (VA Medical Center, Baltimore, MD).

All information in TraceBase is updated at least once per year, through letters of verification, followed up by phone calls. In addition, the Trace Center cross checks its data with other comprehensive databases (such as ABLEDATA) to assure greater accuracy and completeness for both bodies of data.

Status

In preparation for the 1993 edition of the Trace ResourceBook, all of the product entries in TraceBase have been verified by phone or mail. This includes over 1500 product entries, and over 300 information and service resource entries. New entries have also been added, including over 400 product descriptions added.

Information Response and Referral

Project Team: Julie E. Gamradt, MS, CCC-SLP; Kelly L. Ford, BS; Peter A. Borden, MA; Gregg C. Vanderheiden, PhD; Roger O. Smith, PhD

Background

Awareness of technology for communication, control and computer access continues to increase over time; however, there are still many people who cannot proceed properly without more or better information. Those in need of information include people with disabilities, family members, service providers, agency representatives, and business people. In addition to the need for information, many people need effective referrals. Inquirers frequently need the services of experienced professionals, particularly if they want to obtain or modify a computer for themselves or someone else.

The Trace Center receives approximately 1,200 specific requests for information and assistance each year. These are mostly phone calls and letters, plus fax and e-mail. The vast majority come from the U.S. The Trace Center does not specifically advertise itself as a "hot line" for assistance; nonetheless, the Center is frequently cited as a resource in articles, brochures, and resource lists. In addition, professionals familiar with the Center may refer clients or others to the Center as an information source.

Approach

Responses to questions from professionals and the public are answered as completely as possible within the following constraints:

1) The ability to answer by phone or letter. If an inquirer really needs some type of clinical services (a common situation), a referral is made—either to the clinical programs located at the Trace Center or to clinical centers in the inquirer's area.

2) The expertise of Trace Center staff. If the question is outside Trace Center areas of expertise, the inquirer is referred to some other research center or information resource center for information.

The majority of inquirers need information to assist them with a particular person's situation—either their own or a family member's or client's. In addition, the center receives inquiries from researchers, manufacturers, the press, and policy makers.

In order to provide quality responses with limited resources, the Trace Center has developed numerous brief information documents. These are developed through the Summary Information Materials program at the Center. Titles are created in direct response to the needs of the Information Response and Referral program. These documents include "Quick Sheets" (resource lists on particular topics) and "Commonly Asked Question" sheets (containing non-technical answers to common questions).

Information staff respond to inquiries from consumers, family members, clinicians, researchers and manufacturers

The Center also provides a monthly Trace Center information and demonstration program. The purpose of the program is to regularly provide interested individuals with an introduction to Trace Center activities and to the topic of computer access. The two-hour sessions are open to the public at no charge. They include a description of Trace Center projects and programs, a general introduction to computer access, and demonstrations of computers and adaptive equipment. Past participants have included students, visiting researchers, people with disabilities and other potential consumers, manufacturers and developers, computer retailers, educators, reporters, engineers, and professionals working with clients who have developmental disabilities.

Inquiries from the public are also handled by the Trace Center at conferences. All conferences at which the Trace Center exhibits make their exhibit halls open to the public, giving staff members an opportunity to provide answers and referrals to any interested members of the public, as well as professionals attending the conference.

Status

Response to inquiries is an ongoing effort. Inquiries are handled by primary information staff and referred to other Trace Center staff when necessary and appropriate. The information briefs used to respond to inquiries are reviewed, revised and updated annually. The Trace Center information and demonstration program continues to be held monthly. In 1992-93 the Trace Center exhibited at: the annual RESNA conference, the annual Closing the Gap conference on "Microcomputer Technology in Special Education and Rehabilitation" (in Minneapolis), and the annual California State University-Northridge conference on "Technology and Persons with Disabilities."

Summary Information Materials Program

Project Team: Peter A. Borden, MA; Julie E. Gamradt, MS, CCC-SLP; Kelly L. Ford, BA; Sarah E. Fatherly, MA; Mick Joyce, MS; Gregg C. Vanderheiden, PhD; Roger O. Smith, PhD; Sharon Esser

Background

Experience with information response and referral at the Trace Center has shown that there are many individuals and organizations needing more information in order to proceed in implementing communication, control and computer access technologies. Some inquiries can be responded to with individually written letters and individually compiled materials. However, it has become clear that both the quality and the quantity of responses can be improved greatly by creating and distributing information summaries focused on particular topics.

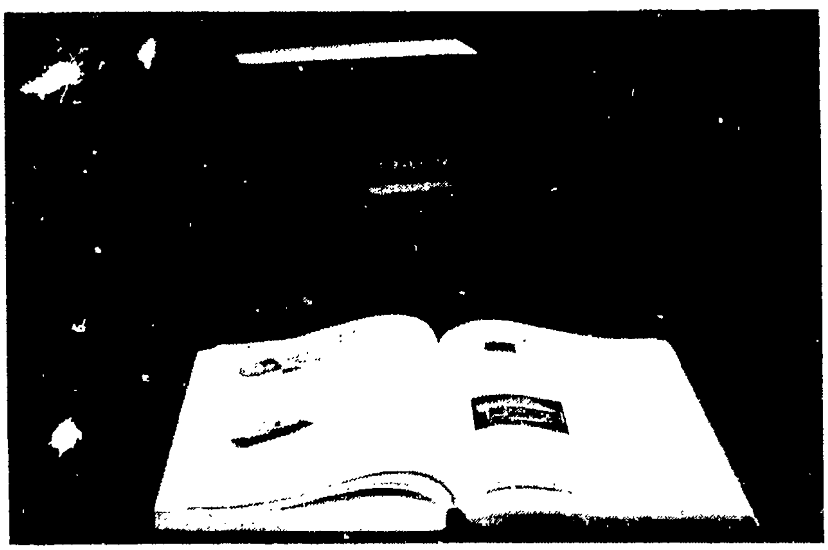
Inquirers who are not very knowledgeable about assistive technology need primarily two types of information: (1) general descriptions of technology and its use, and (2) referral resources, either for more information or for services. These needs can be met effectively with brief summary and resource materials. In contrast, sophisticated inquiries from experienced consumers or professionals most often require detailed, individual responses. Detailed reference materials on assistive technology are most useful to this group of information-seekers.

Approach

Three basic types of information materials are required to meet the needs of both experienced and inexperienced inquirers: (1) information briefs, (2) resource lists, and (3) reference materials. The need for information briefs is met through "Commonly Asked Questions" sheets, which provide answers to common questions about communication, control and computer access technology. Questions are answered as simply as possible while remaining accurate. These write-ups are kept short (1-4 pages) and produced in an easily readable format. The need for resource lists is met through "Quick Sheets," lists which tell readers how to get more information or services. Among the more than 30 current titles are "Service Centers," "Newsletters and Journals," "Networks, Bulletin Boards and Databases" and "Self-Help and Advocacy Groups." Titles are reviewed, revised and updated each year.

For experienced inquirers, detailed reference materials are more useful, as these can provide the specific information this group needs. The *Trace ResourceBook* lists all assistive technology products for communication, control and computer access that are currently available in the U.S. and Canada. The book provides descriptions of each product, pictures where relevant, and information on availability. Products are cross-referenced by functions and features. Other resource materials are provided in appendices.

Other reference materials distributed by the Trace Center include reprinted articles, a bibliography on augmentative communication, and design guidelines



Trace ResourceBook, 1991-92 Edition

for computers and other electronic devices to increase their accessibility for people with disabilities. These publications are disseminated through the Trace Center Reprint Service.

Status

A new edition (1993-94) of the *Trace ResourceBook* was published in the spring of 1993. The volume includes updated information on over 1500 products, including over 300 listed for the first time in this edition. All entries were verified for accuracy before publication.

"Quick Sheets" have undergone annual review and updating. Two new titles are being added to the "Commonly Asked Questions" series.

Most of the Center's summary information is kept in electronic database form, in order to ensure that it can efficiently and accurately be transferred to other organizations that serve as information resources. Electronic texts are also easier to transfer to alternative formats for people unable to read or handle standard print documents.

Selected publications

Borden, P. A., Fatherly, S. E., Ford, K. L., & Vanderheiden, G. C. (1993). *Trace ResourceBook: Assistive Technologies for Communication, Control and Computer Access* (1993-94 Edition). Madison: University of Wisconsin, Trace Research and Development Center.

Trace Research and Development Center. (1993). Quick Sheets. Madison: University of Wisconsin, Trace Research and Development Center.

Smith, R. O. (1991). Technology applications to enhance human performance. In C. Christiansen & C. Baum, Eds., *Human Performance Deficits*. Thorofare, NJ: Slack Publishers.

Berliss, J. R., Borden, P. A., & Vanderheiden, G. C. (1991). *Trace ResourceBook: Assistive Technologies for Communication, Control and Computer Access* (1991-92 Edition). Madison: University of Wisconsin, Trace Research and Development Center.

Trace Research and Development Center. (1989, 1990). Commonly asked questions. Madison: University of Wisconsin, Trace Research and Development Center.

Trace Center Reprint Service

Project Team: Sharon Esser; Katherine Vanderheiden, BBA, CPA; Peter A. Borden, MA; Andrea Joki

Background

The Trace Center produces a wide variety of publications and other media materials. These materials come from various sources: reports of results from research and development projects, dissemination components built into research or training projects, results of projects specifically aimed at information dissemination. In addition, the center receives many requests for information, which require targeted print materials to be answered efficiently and effectively.

However, while program budgets allow for creation of these materials, they seldom allow for printing and widespread distribution. In order to meet the need for an economical way to produce and distribute publications, the Trace Center a number of years ago established a Reprint Service. The service reproduces and distributes Trace Center publications and other media materials.

The primary goal of the Reprint Service is to make available materials which can improve the level of knowledge and awareness among consumers and professionals. Without such a service, most of these publications would likely become "fugitive literature"—information that is extremely valuable but almost impossible to obtain. Because the field of assistive technology is relatively new and always changing, the problem of fugitive literature is a crucial one to address.

Approach

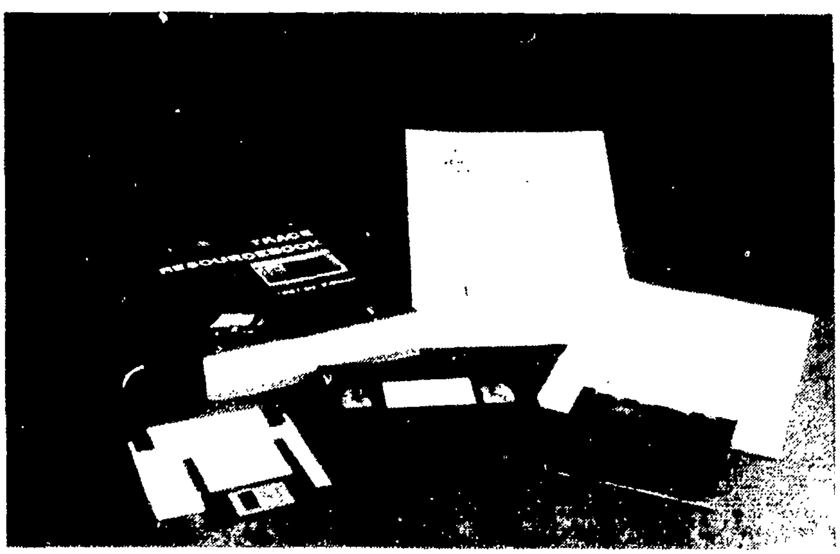
The Trace Center Reprint Service is designed to be self-sustaining, with the costs of reproduction, order fulfillment, and shipping covered by the prices paid by purchasers. The service's offerings are publicized through a brochure, which is updated annually and distributed at conferences, to the service's mailing list, and to interested parties who contact the Trace Center.

Some reprint items result from Trace Center projects and presentations. Others have been created to meet a particular information need, through the center's Summary Information Materials program. Occasionally, exemplary publications produced outside the Trace Center are included as well.

Status

In 1993-94, several thousand reprints were disseminated. Major categories of purchasers were consumers and family, professionals, researchers, and manufacturers. In the 1993 catalog, over 60 items are offered. Titles include:

- Co-Net CD-ROM, Sixth Edition
- Hyper-ABLEDATA Demonstration Videotape
- Trace Voice Sampler
- Trace ResourceBook: Assistive Technologies for Communication, Control and Computer Access (1993-94 Edition)



Reprint Service distributes books, papers, videotapes and software

- Technically Speaking
- Thirty-Something Million: Should They Be Exceptions?
- Development of an Ultra User-Friendly Disseminable Database System
- Commonly Asked Questions - Evaluations
- Technological Approaches to Performance Enhancement
- TechSpec 1989-90 Report
- InterACT Program Description and Application
- Course Guide: Adaptation/Construction of Equipment for People with Disabilities
- Course Guide: Introduction to Assistive and Rehabilitation Technologies
- Course Guide: Microcomputer and Software Applications in Occupational Therapy
- Course Guide: Technology-Related Occupational Therapy Clerkships
- Technology Training for Occupational Therapists: A Survey of Entry-Level Curricula
- Bibliography of Computer Articles in Thirteen Occupational Therapy Periodicals: 1978-88
- Quick Information Sheets
- A Future Perspective on the Holistic Use of Technology for People with Disabilities
- Trace Beeper Box
- A Telephone Communication System Utilizing an Apple IIe Microcomputer
- Issues in Developing a Communication System Incorporating the Use of the Light Talker with Express Software
- An Augmentative Writing System Using an Apple IIe Microcomputer and Adaptive Equipment
- Application of Communication Technologies to an Adult with a High Spinal Cord Injury
- Application Tips
- Activities Using Headsticks and Optical Pointers: A Description of Methods
- Commonly Asked Questions - Communication Aids and Techniques
- Toy Modification Note
- Funding of Non-Vocal Communication for the Severely Speech and Motor Impaired.
- Guidelines for Seeking Funding for Communication Aids
- Bibliography of Vocabulary Frequency and Wordset Analysis Studies
- Communication Interaction Between Aided and Natural Speakers: A State of the Art Report
- Computers as Augmentative Communication Systems
- High and Low Technology Approaches in the Development of Communication Systems
- Communicative Interaction Processes Involving Nonvocal Physically Handicapped Children
- Initiating Communication Systems for Severely Speech-Impaired Persons
- Construction Notes for Laptrays, Portable Communication Boards, and Adaptive Pointers
- Access Issues Related to Virtual Reality for People with Disabilities
- Applications of Artificial Intelligence to the Needs of Persons with Cognitive Impairments: The Companion Aid
- A Standard Approach for Full Visual Annotation of Auditorially Presented Information
- A Dual Information Class Model for Providing Access to Computers with Graphic User Interfaces
- Graphic User Interfaces: A Tough Problem with a Net Gain for Users Who Are Blind
- Development of a Multisensory Nonvisual Interface to Computers for Blind Users
- A Method for Evaluating Head-Controlled Computer Input Devices Using Fitts' Law
- The Graphical User Interface Crisis: Danger and Opportunity
- Checklists for Making Library Automation Accessible to Patrons with Disabilities
- Checklists for Implementing Accessibility in Computer Labs at Colleges and Universities
- Nonvisual Alternative Display Techniques for Output from Graphics-Based Computers
- One Finger Program for IBM Family of Personal Computers - Version 5.05 (Software)
- Commonly Asked Questions - Computers
- Computer Access for Disabled Individuals (VHS videotape)
- Curbcuts and Computers
- Accessible Design of Consumer Products
- White Paper on the Design of Software Application Programs to Increase Their Accessibility for Persons with Disabilities
- Considerations 4.2: Results of the Industry/Government Cooperative Effort on Computer Accessibility for Disabled Persons
- General Input Device Emulating Interface (GIDEI) Standard
- Simple Electrical Transducer (SET) Compatibility Standard
- Serial Interface for Powered Wheelchair Control
- Descriptions of Products Recently Developed at the Trace Center

Technology Specialization (TechSpec) Training Program

Project Team: Roger O. Smith, PhD, OTR; Robert A. Christiaansen, MS, MS, BFA; Gregg C. Vanderheiden, PhD; Julie Gamradt, MS, CCC-SLP; Andrea Johnson, OTR; Laurie Fox, BSEE, OTR; Sharon Esser

Background

Professionals with a variety of clinical and technical backgrounds are needed for assistive/rehabilitative technology service delivery. Historically, formal training programs to improve the competencies of service providers have focussed on inservice training via workshops, conferences, and on-the-job inservice sessions. In occupational therapy, exposure to assistive/rehabilitative technology in preservice professional training curricula has been minimal to nil.

Recently, several professional training institutions in the field of occupational therapy have begun to come to grips with this problem. They have acknowledged that "retrofitting" knowledge through continuing education is critical for therapists currently in practice, but is inadequate for newly trained professionals moving out into the field. It is becoming clear that preservice training is imperative.

In recognition of this need, The Trace Center, in cooperation with the Occupational Therapy Professional Training Program at the University of Wisconsin-Madison, has established an interdisciplinary technology specialization program called TechSpec. The program is funded through a grant from the Office of Special Education Programs, U.S. Department of Education.

Approach

The TechSpec program consists of two main components: (1) direct training and (2) development and distribution of training materials. Direct training involves implementing a technology curriculum and training students at the University of Wisconsin-Madison. Training materials are based on this curriculum. They are designed for those wishing to start similar programs elsewhere.

Direct training is made available at two levels: foundation level and specialization level. Students enrolling at the foundation level complete electives from a series of courses dealing with technology, some of which have been created for the TechSpec program and some of which were already in existence. Students enrolling at the specialization level complete a specified set of courses plus a certain number of electives. Upon the successful completion of classroom and practicum instruction, TechSpec graduates qualify for a certificate in technology specialization.

Status

The TechSpec project has been completed; however, the training continues as the technology track of the InterACT training program (see separate report).

Training under TechSpec began in 1988-89. Six

Techspec students learn about state-of-the-art seating systems courses were included in the original program, including three new courses developed specifically for students in technology training. Course enrollments for the program were: 140 in 1988-89, 100 in 1989-90; 101 in 1990-91; 120 in 1991-92. A total of 41 students have graduated from the program with a specialization in technology.

Several TechSpec publications are now available to the public, targeted at training programs at other universities. Over 500 copies of curriculum publications have been disseminated. Other training programs have reported back on how they are using the materials: TechSpec teaching materials were integrated into "Introduction to Technology" courses and workshops on "Technology Interface," as well as being used as a general conceptual approach to teaching technological applications.

Results compiled from subjective and objective program evaluation data showed substantial gains in both comfort level and competency of students.

Selected publications

Smith, R. O., Christiaansen, R. A., Vanderheiden, G. C. (1989). TechSpec: A technology training model. *Proceedings of the 12th Annual Conference of the Association for the Advancement of Rehabilitation and Assistive Technology (RESNA).*

Smith, R. O. (1990). Course guide: Introduction to assistive and rehabilitation technologies. Madison: University of Wisconsin, Trace Research & Development Center.

Smith, R. O. (1990). Course guide: Technology-related occupational therapy clerkships. University of Wisconsin, Trace Research & Development Center.

Christiaansen, R. (1990). Course guide: Microcomputer and software applications in occupational therapy. University of Wisconsin, Trace Research & Development Center.

Smith, R. O. (1991). Technological applications for enhancing human performance. In C. Baum, & C. Christiansen (Eds.), *Human Performance Deficits.* New York: Slack.

Interdisciplinary Augmentative Communication and Technology Training Program (InterACT)

Project Team: Jon Miller, PhD; Roger O. Smith, PhD; Robert A. Christiaansen, MS, MS, BFA; Gregg C. Vanderheiden, PhD; Jamie Murray-Branch, MS, CCC-SLP; Anne Donnelan, PhD; Julie E. Gamradt, MS, CCC-SLP; Sharon Esser

Background

The rapid advances in augmentative communication and interface technologies have made it possible for children with multiple physical, sensory, cognitive and language disabilities to participate in a range of unrestricted educational environments. The speed of technological development, however, has vastly outpaced the training of professionals who are knowledgeable about the selection, application and use of these technologies. The successful implementation of augmentative communication and interface technologies requires skills and knowledge from multiple disciplines, including speech-language pathology, special education, occupational therapy, physical therapy, and engineering.

Approach

The InterACT program is an interdisciplinary instructional model to help guide students through a learning process where they can obtain the range of skills and depth of knowledge required to implement the use of communication and interface technologies in practice.

The program trains students at four levels:

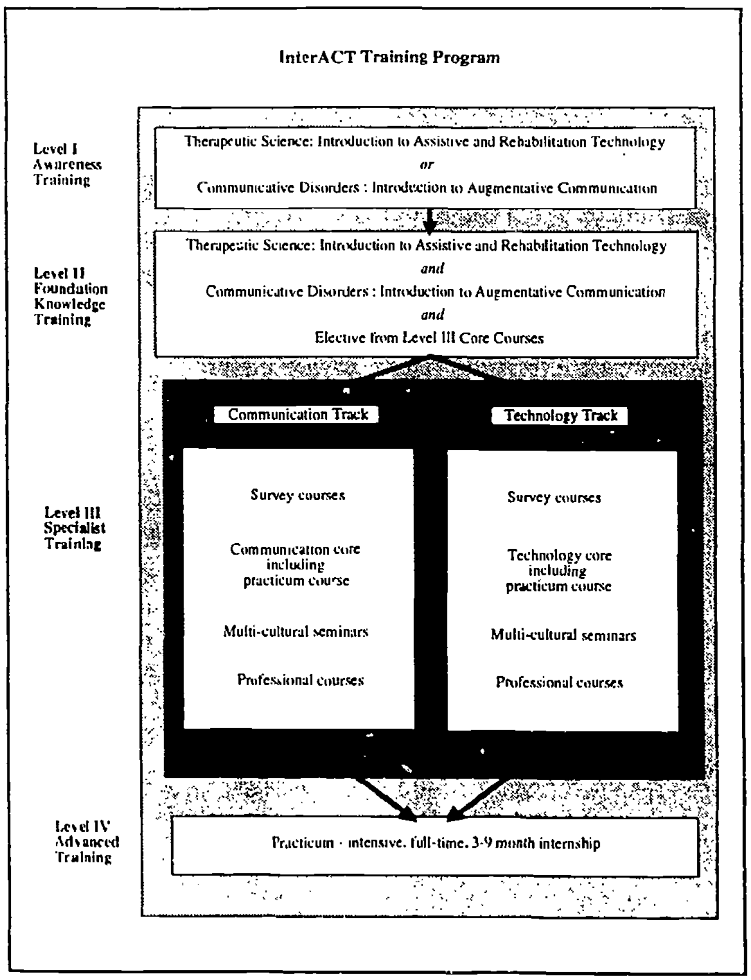
Level I: Basic awareness training;

Level II: Foundation knowledge training for students who desire more in-depth understanding;

Level III: Specialist-level training with extensive coursework and practicum experience;

Level IV: Advanced training with an intensive three to nine month full-time internship.

Each level has parallel tracks of coursework and practica across the following disciplines: Communicative Disorders, Therapeutic Science (including occupational and physical therapy), Special Education, and Rehabilitation Engineering. Students in all levels are required to take an introductory course highlighting fundamental principles across disciplines in augmentative communication and interface technologies. Further coursework on Level II provides students with an understanding of the breadth of the field, integrating communication and interface



Structure of the InterACT training program technologies. Level III allows students to specialize in assistive communication or interface technology. Advanced level training, Level IV, provides intensive supervised experience as part of an augmentative communication and interface team, in preparation for independent professional competency as an augmentative communication or interface specialist.

Level III and Level IV students are provided with training opportunities oriented toward cultural and individual diversity, so they may observe the impact of cultural and language differences on the design and implementation of augmentative communication and technological interface systems.

The program takes advantage of three university courses offered specifically on augmentative communication and three offered specifically on technology interface:

- Introduction to Augmentative Communication
- Augmentative Communication Systems for Persons with Severe Disabilities
- Seminar in Augmentative Communication Systems: An Interactive Process
- Introduction to Assistive and Rehabilitation Technology
- Adaptation and Construction of Equipment for Persons with Disabilities
- Design and Human Disability.

The program also entails standard professional courses and a wide selection of elective offerings across several departments.

The InterACT program has targeted the yearly training of 120 University of Wisconsin-Madison students in augmentative communication or assistive and rehabilitative technology application. Annually, InterACT aims to help 10-12 students become competent augmentative communication or assistive rehabilitation technology practitioners capable of implementing augmentative communication and assistive technology programs with clients. In addition, this project targets a national impact through the development and dissemination of an interdisciplinary curriculum model and course guides.

A comprehensive evaluation plan has been designed to evaluate the quality of the training, with feedback loops to provide input to improve the training program at all levels.

Status

The enrollment of students in the InterACT program began with the fall semester of 1991. Total enrollment in InterACT courses was for 1992-93, by discipline, was:

- Communication disorders: 58;
- Occupational therapy: 100;
- Engineering: 19;
- Special education: 12;
- Computer science: 1;
- Other disciplines: 3.

The program graduated 22 Level III students and 4 Level IV students in the 1992-93 year. To better address the assistive technology and augmentative communication training needs of general and special educators, an Education Track is being created for the InterACT program, to run in parallel with the Communication and the Technology Tracks.

Trace Center Workshop Series

Project Team: Kathy Longenecker Rust, MS, OTR; Roger O. Smith, PhD, OTR; Gregg C. Vanderheiden, PhD; Jerilyn Johnson

Functional Assessment Workshop Series

A number of new developments are occurring in the area of systematizing functional assessment of individuals with disabilities. One of the most important has been in the field of occupational therapy: the development of OT FACT, a system for integrating and reporting occupational therapy functional assessment developed at the Trace Center as part of national initiative of the American Occupational Therapy Association. In order to learn how to effectively implement OT FACT in practice, however, occupational therapists need some direct instruction in the theoretical basis and practical application of the system. OT FACT has been taught at national AOTA conferences, but it was decided that it would be helpful to create more learning opportunities for OTs at more locations.

The Trace Center has created a series of workshops on OT FACT, dealing also with general issues of improving and systematizing functional assessment through computerization. The curriculum also includes basic computer skills, for participants who need them. The workshops are supported through participant fees, as are other Trace Center workshops.

The first OT FACT workshop was held on June 8, 1990 in Madison, Wis. It drew 27 participants. A series of six workshops were held in spring and summer of 1991, in Dallas, Texas; Bryn Mawr, Penn.; Miami, Florida; Boston, Mass.; San Diego, Cal.; and Milwaukee, Wis.

Another series of two-day workshops was held in fall of 1991 and spring of 1992, in Denver, Colo.; Madison, Wis.; Chicago, Ill.; Baltimore, Md.; Buffalo, N.Y.; and Seattle, Wash. The 1992-93 workshops were in Richmond, Ky., Madison, Wis., Lubbock, Tex., Fishersville, Va., Minneapolis, Minn., New York, N.Y. and Baltimore, Md.

In addition, a one-day on-site consultation workshop has been developed. It is being offered for facilities who wish to provide OT FACT training to groups of on-site therapists. These customized sessions present content and technical level tailored to a facility's specific needs. In 1993, site consultations were held in St. Louis, Mo. and Dallas, Penn.

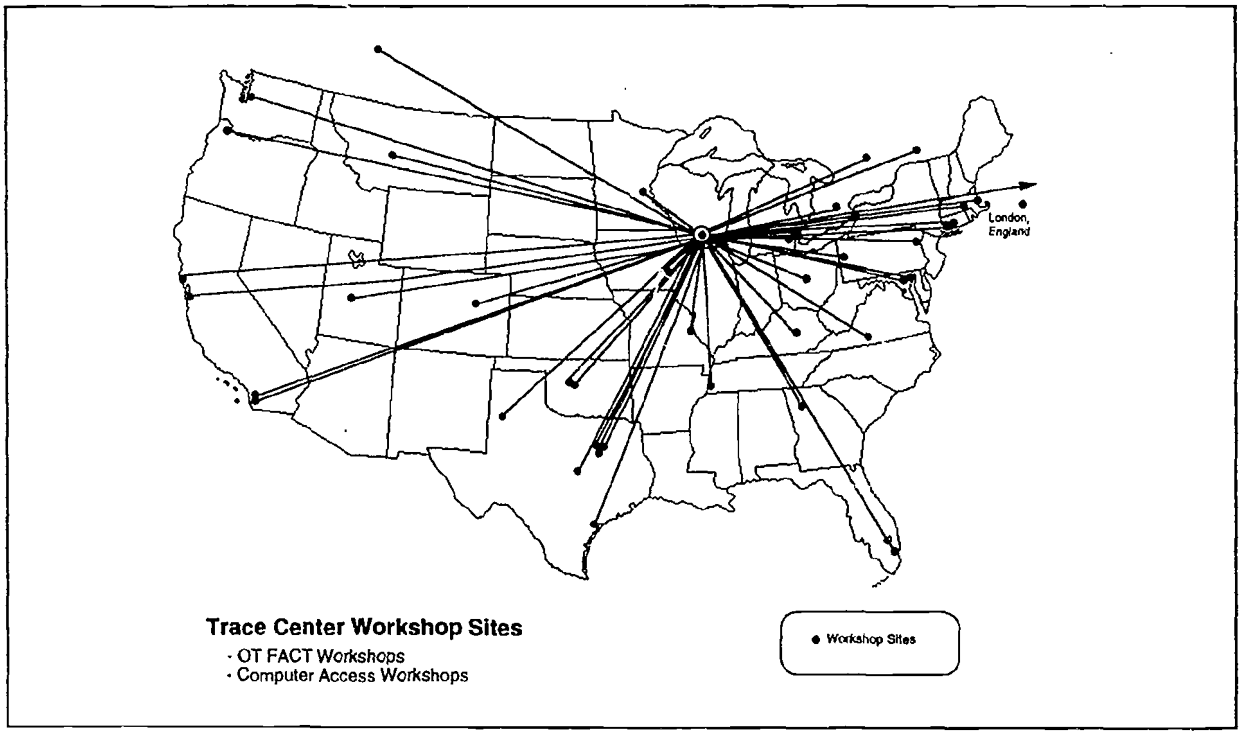
Computer Workshop Series

Despite the increase in available computer access technology and the growing interest in its use, there are relatively few educational opportunities for those wanting to learn more about the subject. Presentations and seminars at conferences require travel expenses that pose barriers to many, particularly consumers, agencies, and school staff. In 1982, the Trace Center initiated a workshop series on computer access and use for disabled persons. Since then, over 20 workshops have been held, at sites distributed around the country.

The "Advanced Workshop in Computer Access and Use" was designed as a two-day intensive workshop designed for attendees with varying levels of expertise, from novices to computer programmers. One half of the first day was devoted to a pre-workshop, aimed at those who need familiarity with the basics of computer operation. This session started with an explanation of how computers work and proceeded to programming principles and basic programming exercises.

The remaining day and a half was devoted to the main workshop. This program covered the key information about computer access needed by clinicians, educators, consumers and family members. The basics were taught regarding how computer access can be provided for individuals with different types of disabilities; an overview of the state of the art and new developments was offered; and uses of particular hardware and software were demonstrated. Topics covered included: assessment of user needs, hardware limitations of computers, personal vs. group use of computers, computers as personal aids vs. access to computers, and selecting a computer based on application needs. The workshop covered adaptations for users with physical disabilities, communication-related disabilities and sensory disabilities. Like the current OT FACT Workshop series, the Computer Access Workshop was self-supporting, with revenue derived from attendee fees.

The most recent workshops were held in 1990. A workshop in Toronto on April 6-7 drew 95 participants; one in Madison, Wis. on May 4-5 drew 63 participants. The Computer Access Workshop series is no longer being held.



Map showing locations where Trace Center workshops have been held

Service Delivery Programs

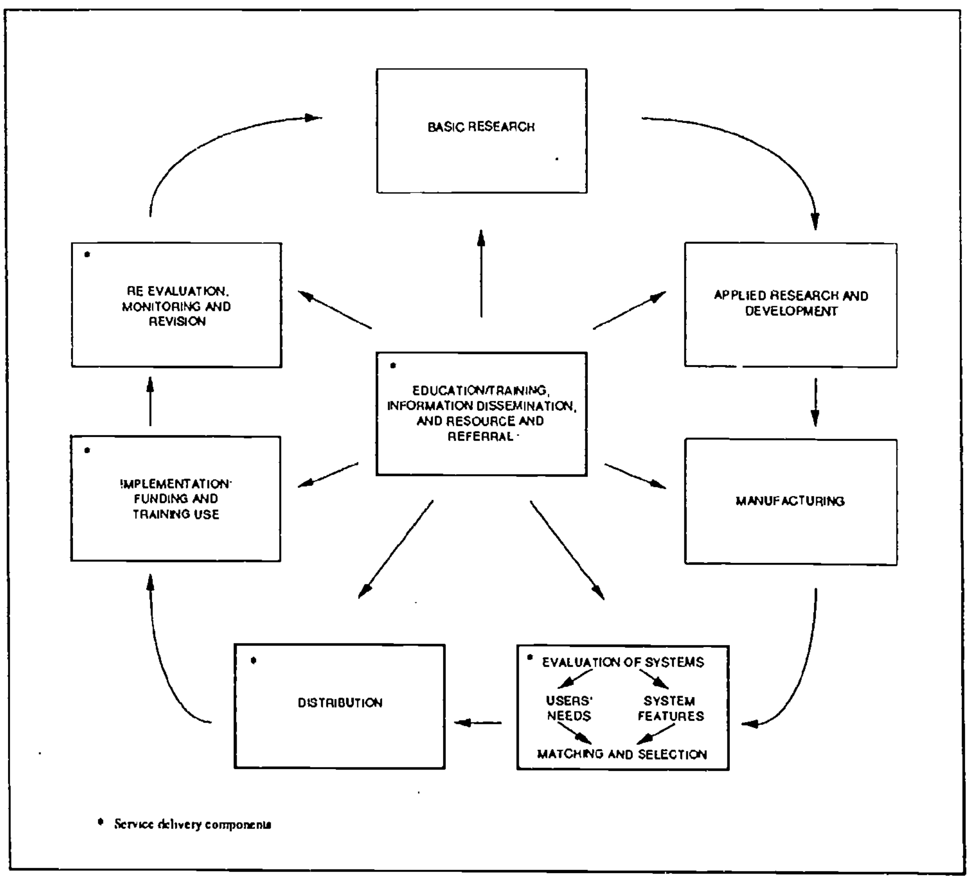
In addition to its research, development, information and training programs, the Trace Center is connected with clinical service delivery programs. These programs deal directly with the types of technology in which the center specializes.

The center's ties to clinical programs are important for several reasons: (1) so that research and development project staff can directly observe consumer needs and decide which could be met by new devices, techniques, and standards; (2) so that the Trace Center can share its technical expertise directly with service delivery programs; and (3) so that researchers and developers can see the actual implementation of systems and analyze real-life problems.

This last issue is particularly important, as there are many factors in design besides the basic need for a system which affect a consumer's ability to obtain and use it. These include price of a device, ability to obtain funding, ease of use for the consumer, ability for family members and other support people to operate the device, frequency and cost of repairs, and the need to customize the user interface.

The Trace Center's connections with clinical programs fit into an integrated model of assistive and rehabilitative technology activity (see figure). This model shows how "service delivery" actually extends into several areas of the total activity in the field. Although activities such as "education/training" and "evaluation of systems" have been funded as separate projects at the center, clinical programs are frequently involved in all of these activities at the client level.

The Trace Center has two major clinical programs.



Model of assistive and rehabilitative technology activity (from Rehabilitation Technology Service Delivery: A Practical Guide *[RESNA Press])*

The Communication Aids and Systems Clinic (CASC) provides augmentative communication and computer access evaluations and follow-along services. Regular therapy services are also available to those in the Madison area. The CASC is program of the University of Wisconsin Hospital and Clinics and is administered by the Trace Center. The Communication Development Program (CDP) is a county-based, county-funded consultative service delivery program for augmentative communication and computer access.

In addition to the CASC and the CDP, the center provides direct services through its Rehabilitation Research Services and Client-Based Research programs. These programs allow the center to provide its technical expertise for development of modifications to clients' systems. It can also entail the development of prototype or unique systems for clients, in which case the project serves the dual purpose of client service and research and development.

Communication Aids and Systems Clinic

Clinic Team: Joni Nygard, MS, CCC-SLP; Blair Panhorst, MS, CCC-SLP; Andrea Johnson, OTR/L; Jamie Klund, MS, OTR; Roger O. Smith, PhD; Gregg C. Vanderheiden, PhD; Bonni Caparoon

Background

The Communication Aids and Systems Clinic (CASC) serves people who need additional ways to communicate because of severe impairments that affect speech. Causes of such impairments include: cerebral palsy, progressive neuromuscular diseases, head trauma, paralysis and cognitive limitations. The clinic assists clients in selecting and developing a means of augmentative communication—a form of communicating that supplements or replaces speech. In addition to serving needs related to conversational communication, CASC assists clients in developing systems for writing, environmental control, and accessing computers.

Clinic services

CASC provides a variety of services, including evaluation, equipment selection, consultation, training and therapy. In providing evaluations, clinic staff assess a client's current capabilities and potential, determine the optimal augmentative communication system, and work with the client to make sure it will be implemented successfully. For individuals having significant physical impairment, evaluations frequently entail assessment of seating and positioning, location of effective physical control sites, and assessment of communication skills. Appropriate electronic or non-electronic devices are tried and recommendations are made. The clinic adapts or fabricates equipment for clients when necessary, and helps clients develop a communication training program, performs follow-up, and advises clients in obtaining funding for equipment and services.

CASC uses an interdisciplinary team to provide evaluation and therapy services. The team members include:

1) Speech-language communication specialists: Examine a person's language, cognitive and interactive skills as they relate to using an augmentative communication or writing system.

2) Interface specialists: Address motor, sensory and perceptual barriers which prevent the effective use of communication aids and computer access interfaces.

3) Seating and positioning specialists: Work to maximize a person's physical abilities by providing them with optimal support and positioning in their wheelchair. CASC coordinates with equipment vendors and rehabilitation engineers to provide this service to clients.

CASC clinician assesses a young client's ability to use an electronic aid

Administration and funding

CASC is a clinic of the University of Wisconsin Hospital and Clinics, and is managed by the Trace Center. The clinic's operations are free-standing and self-funding, not requiring grant-funded personnel. This situation has two benefits: the separation of fiscal accountability (research and clinical) and the assurance that CASC practices can be replicated at centers not having a research and development center on-site.

Funding primarily follows a medical model, making use of private insurance, HMOs (referral required), Medicaid, and Katie Beckett. Other methods of funding are school districts, vocational support agencies, and community support funds. The clinical team assists clients in finding funding for equipment by providing the necessary documentation.

Communication Development Program

Clinical Team: Julie Gamradt, MS, CCC-SLP; Carla Lynch, MS; Jamie Klund, MS, OTR; Joni Nygard, MS, CCC-SLP; Gregg C. Vanderheiden, PhD

Background

The Communication Development Program (CDP) is a community-based service delivery program serving residents of Dane County, Wisconsin who have severe communication impairments. Program staff assist clients in developing functional augmentative communication systems. The CDP works directly with clients and families, and also provides assistance and training to staff of community agencies which serve individuals who have severe communication impairments.

The CDP has been in existence since 1976. It serves preschool children (0-3 years) and adults (18 years and older). The CDP also works directly with the school system, when necessary, in order to provide transition for clients entering and leaving the educational system. The program has seen a steady increase in the number of clients requiring services, indicating a strong need for the program in the county.

CDP clinician Julie Gamradt works with a CDP client on his system for communication and computer access

Services of the program

Nine major services are provided by the CDP.

1) *Provision and maintenance of materials and communication aids:* CDP staff assist clients, family members and service providers in developing, assembling, using and updating communication aids. This includes provision of communication boards and books, displays for electronic communication aids, calendars used for communication about current events, "mini-boards" (topic-specific displays with limited vocabulary), and specialized symbol displays such as tactile displays for blind individuals.

2) *Training for use of communication aids:* CDP staff provide training to clients, family members, and service providers.

3) *Sign language:* CDP staff evaluate its potential effectiveness for particular clients and provide training.

4) *Use of technology:* When appropriate, CDP staff assist clients with more extensive technology needed for communication, such as computers and portable electronic communication aids. Services cover equipment selection and training.

5) *Equipment maintenance, repairs and support services:* The CDP assists clients in troubleshooting problems they experience with equipment.

6) *Funding:* Part of the augmentative communication services provided by the CDP is to provide documentation required by funding agencies for augmentative communication equipment.

7) *Coordinating client services with other programs:* The CDP

actively interacts with numerous other agencies within Dane County for purposes of training, coordinating services, providing materials, and consultation. The goal is to integrate different aspects of meeting clients' needs.

8) *Inservices and group training:* The CDP provides training to clients, family and service providers. This builds a broader base of assistance for the client in day-to-day successful use of a communication system.

9) *Presentations and public awareness activities:* Increasing public awareness of the needs and abilities of individuals who use augmentative communication systems is one of the priorities of the CDP. Activities include classes, presentations and an open house.

In addition to these services to individuals in the county, the CDP also provides training experiences to students studying augmentative communication. Students serve in clinical affiliations with the clinic.

Administration and funding

The CDP is funded through a grant from the Adult Community Services division of the Dane County Department of Human Services. It provides services in cooperation with the Communication Aids and Systems Clinic. The program also assists clients in obtaining funding from other sources where possible and appropriate.

Cooperative and Consultative Efforts

ABLEDATA (Newington, CT)—Development of Hyper-ABLEDATA and transfer of Trace Center database information to ABLEDATA.

ACS Technologies, Inc. (Clinton, PA)—Software for compatibility of RealVoice communication aid with keyboard emulating interface.

American National Standards Institute: ANSI (Washington, DC)—Development of a standard for control of power wheelchairs from communication aids and other intelligent controllers (also cooperative project with International Standards Organization).

American Occupational Therapy Association (Rockville, MD)—Development of system for integrated reporting of occupational therapy functional assessment (OT FACT), including development of commercially available software package.

Ameritech Foundation—Accessibility of TDDs for individuals with multiple impairments.

Apple Computer, Inc.—Uploads of database information related to computer access; assistance in preparation of electronic and non-electronic information materials; support in handling technical information requests; technical assistance with implementation of accessibility features for computers and operating systems.

Apple Computer, Inc.—Development of OT FACT (Occupational Therapy Functional Assessment Compilation Tool) software for Macintosh environment.

Berkeley Systems, Inc. (Berkeley, CA)—Development of auditory-tactile computer interface for blind users, including development of software tools for allowing special access hardware to address operating system of Apple Macintosh computer.

Computers to Help People, Inc. (Madison, WI)—Direct access by persons with disabilities to information on assistive technology services: a model interstate cooperative database.

Consumer Care Products (Sheboygan, WI)—Evaluation of design of adjustable workstation table.

Crestwood Company (Milwaukee, WI)—Design of a portable communication book.

Disability Access Committee on X (coordinated by Trace Center)—Joint effort to develop disability access capabilities in the X Windows graphical user interface. Several vendors and researchers involved, including Trace Center, Georgia Tech, MIT, Digital Equipment Corporation, Sun Microsystems, IBM Corporation, Berkeley Systems, Inc., Bell Atlantic, Bellcore, and AT&T.

Disability and Business Technical Assistance Centers - DBTACs (various regional centers)—Development of Cooperative Service Directory software.

Don Johnston Developmental Equipment (Wauconda, IL)—Evaluation and testing of KE:NX adaptive input system for Macintosh computers.

Electronic Industries Association, Assistive Devices Division of Consumer Products Group (Washington, DC)—Cooperation in development of guidelines for the design of consumer products to increase their accessibility to persons with disabilities.

Forum on Information Networking in Disability: FIND (Columbia, SC)—Development of a common base taxonomy for disability related services.

Franklin Electronic Publishers, Inc. Consultation on disability interface design for mass-market talking dictionary/thesaurus device.

General Services Administration (U.S. Government)—Development of information materials on computer accessibility standards.

Hugh MacMillan Medical Center (Toronto, ON)—Assistance in development of evaluation protocol.

Hugh MacMillan Medical Center (Toronto, ON)—Further development of Trace Center long range optical pointer technology.

IBM Corporation (White Plains, NY)—Development of IBM-environment assistive technology databases.

IBM Corporation (White Plains, NY)—Development of AccessDOS package of disability access features for DOS, for IBM PC and PS/2 computers.

Industry-Government Initiative on Computer Accessibility (A nation-wide ad hoc group)—work on document: "Considerations in the Design of Computers and Operating Systems to Increase Their Accessibility to Persons with Disabilities."

InfoLine (Los Angeles, CA)—Development of a common base taxonomy for disability related services.

Information Technology Association (Washington, DC)—Development of software design guidelines for the application software industry.

International Committee on Accessible Document Design (various organizations)—Development of formal and informal standards for interchange of electronic documents in forms usable by people with disabilities.

International Standards Organization: ISO—Development of a standard for control of power wheelchairs from communication aids and other intelligent controllers (also cooperative project with American National Standards Institute).

Macro International - ABLEDATA (Silver Spring, MD)—Upload of ABLEDATA information on assistive technology products into Trace Center's Hyper-ABLEDATA and DOS-ABLEDATA software.

Microsoft Corporation (Redmond, WA)—Development of Access Pack for Microsoft Windows: a set of disability access features for Microsoft Windows operating system (IBM PC and PS/2 computers).

Microsoft Corporation (Redmond, WA)—Technical assistance with implementation of disability access features in Windows, DOS, Windows NT and Microsoft-at-Work.

Prentke Romich Company (Wooster, OH)—Ongoing consultation regarding interfacing communication aids to computers. Commercial transfer of Trace Transparent Access Module (T-TAM).

RESNA (Washington, DC) and **National Information System** (Center for Developmental Disabilities, U of SC)—Development and maintenance of distributable service delivery databases. Development of a common base taxonomy for services.

Technology Act Programs (More than 30 state programs)—Development of Cooperative Service Directory software.

Unicorn Engineering (Richmond, CA)—Transfer of source code and information to assist Unicorn in design of expanded computer keyboard.

University of Arkansas, Learning Express and **ICAN** (Little Rock, AR)—Development of software for DOS-ABLEDATA database of products for people with disabilities.

Wheelchair Standards Committee (RESNA, Washington, DC)—Development of standard for serial interface for control of wheelchairs.

Words+, Inc. (Lancaster, CA)—Evaluation and consultation on a variety of products, including the Augmentative Communication Evaluation System (ACES). Commercial transfer of Trace Transparent Access Module (T-TAM).

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