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AAAS Office of Opportunities in Science

Science, Technology and the Handicapped

Edited by
Martha Ross Redden
Wayne Schwandt



American Association for the Advancement of Science

1776 Massachusetts Avenue, N.W., Washington, D. C. 20036

AAAS Report No. 76-R-11, August 1976

AAAS OFFICE OF OPPORTUNITIES IN SCIENCE

THE MAJOR PURPOSES OF THE OOS ARE:

- * to increase the number of minorities, women and the handicapped in the natural, social and applied sciences;
- * to increase the kinds of opportunities available to these groups;
- * to increase the participation of minority, women and handicapped scientists and engineers in policy-making, advisory and managerial positions.

TO FULFILL THESE PURPOSES, the OOS is involved in many programs and activities. It functions as a *clearinghouse* on information concerning women, minorities and the handicapped; it acts as *liason* with other professional organizations to help coordinate equal opportunity efforts; it works with the *Scientific Manpower Commission* on problems dealing with the recruitment, education and utilization of women, minority and handicapped scientists; and *within the AAAS* it encourages the increased participation of these groups and the consideration of issues concerning them in all programs and activities of the Association.

UNDER THE GUIDANCE OF ITS ADVISORY COMMITTEE AND PANELS, the Office has developed numerous programs to implement its objectives. *Science Education for Minorities: A Bibliography* is an inventory of projects undertaken since 1960 which have been aimed at improving the quality of science education for minority students. The "*Conference of Minorities in Science*", held as part of the AAAS Annual Meeting in Boston, February 19-21, 1976, assessed this country's efforts to bring about an adequate representation of minorities in the sciences. Proceedings will be published. The *Project on Native Americans in Science* is investigating the problems and developing strategies for improving the science education and opportunities available to Native Americans. It is also developing programs on ethnosience and ethnomedicine, and on altering the attitudes of the general public and educators that are detrimental to Native American progress in technical fields. The *Project on the Handicapped in Science* seeks to improve the status and participation of handicapped scientists and to improve science education available to handicapped youth. One activity is to make professional meetings completely accessible to the physically disabled, as it recently did with the AAAS Annual Meeting. *Rosters of Minority and Women Professionals*, published in 1975, is an assessment of the uses and benefits of rosters as tools to achieve equal opportunity.

The OOS welcomes ideas, suggestions and help from all who are interested.

SCIENCE, TECHNOLOGY AND THE HANDICAPPED
PROCEEDINGS AND ACTIVITIES
SPONSORED BY
THE PROJECT ON THE HANDICAPPED IN SCIENCE
AAAS ANNUAL MEETING
BOSTON, MASSACHUSETTS
1976

Edited by
Martha Ross Redden
Wayne Schwandt

American Association for the Advancement of Science
1515 Massachusetts Avenue, N. W.
Washington, D. C. 20036

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The activities of the Project on the Handicapped in Science at the 1976 AAAS Annual Meeting in Boston which lead to this publication were supported in part by the Rehabilitation Services Administration, Department of Health, Education and Welfare, Grant No. 16-P-56803/3; the Du Pont Company; and the Exxon Corporation.

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FOREWORD

One of the least desirable traits of the human condition is our propensity to avoid those among us who are afflicted with overt physical disabilities. While this may be an inherent psychological carryover from those days of survival of the fittest, it is more likely we do not wish to have a reminder that we are potentially and continually eligible to join them. As a result, we hide our disabled veterans, our accident victims and those suffering from birth defects in institutions of one sort or another depending upon the severity and/or aesthetic nature of the defect. The consciences of many seemingly healthy persons are eased and indeed reinforced as credit is taken for monetary support of the handicapped whether through taxes, individual donations or contributions to the disease of the month drives. Such gifts are assumed to be an obvious indication of "we care."

But do we? In general this process is patronizing and may reduce potential and valuable human resources to social burdens even though modern training methods have increased the probability of successful rehabilitation. A real indication of "we care" would be the provision of entry level positions to the qualified handicapped and advancement to higher positions as work skills, wisdom and knowledge increase. At present, many of the disabled are underemployed at low pay without any real possibility of promotion.

For the past few years, I have been concerned about how the overt physically disabled person fares in industry. Even though profoundly deaf I have reached a relatively high level of management, but I don't see many others at any level. As a scientist, a so-called knowledge worker, I find this somewhat strange, for physical capability, no matter how desirable it may be, is relatively unimportant in the business of science. The governing factor in the employment and utilization of scientific personnel should not be the appearance of the package, but the quality of the contents.

Because of these impressions, I began to promote the cause for the employment and advancement of the handicapped scientist. Fortuitously and fortunately, two events occurred which insure the eventual success of the venture

The first was the passage of The Vocational Rehabilitation Act of 1973 by Congress. This bill, introduced by my district Congressman, John Brademas (D, Ind.) included provisions for equal opportunity and affirmative action programs for the handicapped. The second was the active involvement of the Office of Opportunities in Science of the American Association for the Advancement of Science (AAAS) in the crusade.

Dr. Janet Brown, the director of that office, was quick to understand the magnitude of the problem and the need for a centralized effort to combat the prejudices. She helped arrange our first presentation--The Physically Disabled Scientist: Potential and Problems--at the 1975 Annual Meeting of the AAAS in New York City. The program was designed to increase the level of sensitivity within the technical community to the needs of the physically disabled. She followed this up by the assignment of a staff member, Ms. Martha Redden, to develop and administer a program for the physically disabled scientist.

Ms. Redden promptly organized an Advisory Group of handicapped individuals, rehabilitation experts, interested scientists and Dr. Brown. Now, attendance at scientific meetings is one of the more important mechanisms through which scientists advance their careers. Such meetings provide for scientific, social and political contacts which can contribute much to one's personal success. The committee believed that the majority of the physically disabled scientists were unable to take advantage of this opportunity for professional advancement because of the difficulty in overcoming formidable environmental obstacles. Ms. Redden was given the challenge to make the 1976 meeting accessible to all.

Not only did she make the meeting accessible to all, but she also played an important role in arranging a special program on "Science, Technology and the Handicapped." These Proceedings are the official record of that session. They contain both reports of technological innovations which will make life somewhat easier for certain of the physically disabled and discussions on why physical, educational and career barriers to handicapped scientists must be overcome. The information is, of course, invaluable to those intimately concerned with the problem. The value of the volume would be substantially increased if it became required reading for those policy makers and prime movers in government, education and industry who should be concerned with the

care, maintenance and development of human resources, but who, for some reason or another, overlook the potential of that most neglected minority group--the handicapped. So, for the handicapped, I suggest they do themselves a favor--make sure people who can help know these proceedings are available.

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PREFACE

The symposium Science, Technology and the Handicapped held at the 1976 AAAS Annual Meeting in Boston explored the technological advances being made for the handicapped, the ways in which architectural, transportation and career barriers are being overcome for the handicapped scientist, and implications for action by professional associations. The symposium drew attention to research data and dramatic technological advances and related these to policy priorities, legal requirements, educational needs and needs for further research and development. Scientists who are themselves disabled participated with design and development engineers and policy and educational specialists. The overall goal of the symposium was to emphasize the need to involve science and technology so that handicapped persons may reach their full potential.

In addition to the symposium, the AAAS Project on the Handicapped in Science arranged other activities at the 1976 Annual Meeting to focus the attention of the science community on the concerns of the handicapped and to make the meeting fully accessible. These activities included: A resource and information center; exhibits at Science International 1976, "Science Education, Research and Technology"; a luncheon concerning perspectives on the education of the handicapped, "A Natural Partnership"; a breakfast, "Rehabilitation Research on Disability: New Horizons"; a news conference, planning meeting and reception. This publication contains the proceedings of the symposium and the speeches presented at the luncheon and breakfast. The report of the planning meeting, a list of the exhibits, and a description of the Project on the Handicapped in Science are appended.

ACKNOWLEDGMENTS

The staff of the AAAS Project on the Handicapped in Science wishes to acknowledge the contributions of other individuals who participated in the Project activities at the AAAS Annual Meeting in Boston, February 18-24, 1976 and those who assisted in the preparation of this manuscript.

We deeply appreciate the assistance of the symposium arrangers and presiders, Richard H. Bolt, John A. Swets, Barry Unger and Edward Keller, Jr. whose assistance in deciding the scope of the symposium and selecting the participants was invaluable. We also wish to thank Richard Goldberg and the Massachusetts Rehabilitation Commission for arranging the breakfast; Edward Keller, Jr. for organizing and presiding at the planning meeting and Mark N. Ozer for conducting the planning session; Kay Moore for arranging interpretation services at each activity; John Gavin and Roger Revelle for their leadership and opening comments at the luncheon; each person who presented a paper; the persons who arranged for and took part in the exhibits; and Janet Brown whose guidance made the whole Project possible.

We acknowledge the assistance of other staff of the AAAS: William D. Carey, Executive Officer, for his continuous support through all phases of this project; Arthur Herschman, Elizabeth Zeutschel and Jim Mears, of the Meetings Office, for their advice and patient guidance both prior to and during the meeting; Carol Rogers, Public Information Officer, who advised and assisted in publicity for the Project activities; and Hans Nussbaum for his interest and support of the Project and for sharing his talents to add a song to the reception. We would also like to thank especially Gail Green for her work on the final typing of this document.

A special thanks is due also to others who directly or indirectly assisted in the meeting activities: Andrea Schein, coordinator of volunteer services and the many volunteers for their indefatigable assistance; members of the Massachusetts Council of Organizations of the Handicapped who gave generously of their time to advise and help us before and during the meeting; John Driscoll of the Rehabilitation Services Administration, Regional Office, who helped contact persons in Boston knowledgeable about local resources; Joe Fenton, Project Officer of the Rehabilitation Services Administration, who gave helpful advice throughout the Project.

Three very special groups of people deserve our heartfelt thanks: The Project on the Handicapped in Science Advisory Group, the AAAS Boston Advisory Committee, and the AAAS Board of Directors. The Project Advisory Group has given unselfishly of their time from the first planning meeting in September 1975 and continuing throughout the meeting in Boston. The Boston Advisory Committee cooperated with the Project staff to facilitate the arrangements for all special meeting activities for the handicapped. The AAAS Board of Directors, especially Margaret Mead, Roger Revelle, and Richard Bolt, who have supported the Project since its beginning.

PROJECT ON THE HANDICAPPED IN SCIENCE Advisory Group

Dr. William Bean	Dr. Arthur Livermore
Mr. C. Warren Bledsoe	Mr. Ed Lynch
Dr. Elizabeth Boggs	Dr. Kalisankar Mallik
Dr. Janet Brown	Dr. Doug McFarland
Mr. Leslie Cole	Dr. Georgia McMurray
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Dr. Robert Henze	Dr. Nansie Sharpless
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The Kurzweil Reading Machine
A Technical Overview

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This paper discusses the Kurzweil Reading Machine from two perspectives: first, why we selected the approaches that we did; and second, how the machine works--a description of the sequence of processing steps that cause information to be converted from text images to speech sounds.

The reading machine converts ordinary printed material, such as typed letters, books, and memoranda in a wide variety of type styles, to comprehensible, full-words, synthetic English speech. It is intended as a reading prosthetic aid to enable blind persons to read, at rapid rates, the diversity of material available in inkprint without significant strain or extensive training.

Physically, the device consists of three, reasonably compact units. The Reading Unit, upon which the printed material is placed, is about the size of a selectric typewriter--two feet by two feet by eighteen inches high. The Electronic Control Unit, which contains a mini-computer and other special-purpose electronics, is about a two foot cube. The Control Box is about the size of a desktop calculator--six inches by six inches by three inches.

The user places printed material face down on the glass plate which forms the top surface of the Reading Unit. The user then instructs the machine to begin reading the page by pressing the "PAGE" button on the Control Box. The printed material is automatically scanned by a small, electronic camera moving on an X-Y mover beneath the glass plate. The camera converts the printed image into an electronic image which is preprocessed by special-purpose electronics and then transmitted to the minicomputer in the Electronic Control Unit. The computer analyzes the electronic image to locate the letters, to recognize them, to compute the sequence of speech sounds, and finally to generate control signals for a set of special synthesizer circuits to produce the artificial speech. The computer also controls the movement of the camera on the X-Y mover.

Through the use of the control buttons, the user can control the sequence of reading. For example, to halt the machine and direct it to repeat a line or section of text and to skip rapidly forward to skim text. The machine can be directed to go slowly--one word at a time, to locate a particular word that was unclear, and to spell out that word. With these and other controls, the user is able to take an active rather than passive role in reading. In addition to absorbing the content of the reading material, the user is making decisions--to examine a word more closely, to repeat a line, to skip a section, to skim.

In order to facilitate the discussion of the techniques utilized in the reading machine, it would be useful to separate the Print-to-Speech problem into two component problems: print-to-grapheme string and grapheme string-to-speech, each of these component problems representing a rather different technology. Print-to-grapheme string conversion, which we also can call Optical Character Recognition, requires: (1) scanning the printed material to convert the print image into an electronic image; (2) analysis of the electronic image to locate and separate out contiguous subimages suspected of being characters; and (3) identification of the character forms based on shape, position, and context.

Before discussing this process in more detail, I would like to examine several questions of approach. The most basic is, "Why is Optical Character Recognition required in the first place?" Briefly, there is an alternative to Character Recognition, that of transmitting the unprocessed visual signal to another sensory channel. For the tactile sense, such a device would provide a stimulus or impulse picture of each letter as it appeared on the page for the user to touch and recognize. For the auditory sense, each printed letter would be converted to sound with the vertical and horizontal dimensions of each letter converted to pitch and time, respectively. Such devices, called Direct Translation Devices, exist. The problem with the Direct Translation concept is the basic incompatibility of the different human sensory channels. Computer input channels do not have this problem. Different computer input channels use basically the same codes, and information can readily be converted from one media to another without necessitating a complex conversion. Human sensory channels, on the other hand, process sophisticated patterns of information, and the types of patterns that provide optimal communication for one sense are not cognized easily or rapidly by another. A dramatic example of the basic incompatibility of the perceptual domains of different human senses is human speech. Speech is readily perceived by the auditory sense, yet when pictorial representations of speech, through Spectograms or other methods, is presented to the visual sense, even with extensive practice, identification of words spoken by different speakers is virtually impossible. The practical experience with Direct Translation reading aids, from tests of both the Optacon, a tactile Direct Translation device, and the Stereotoner, an auditory Direct Translation device, is that users can learn to recognize letters, but the process is difficult and reading rates attainable are very slow. Theoretical considerations as well as the experimental evidence yield the

conclusion that, to attain rapid reading rates comparable to sighted readers, the information must be presented using patterns optimal for either the tactile or auditory sense. This requires the reading device itself to recognize the letter sequence rather than leaving this task of recognition to the user.

A second issue concerns the handling of multiple type styles. There are four ways this problem might be approached: (1) restricting the input to a single style of type; (2) restricting the input to a limited number of type styles, (3) reprogramming the device for each different type style (each time the user changed the type style); and (4) providing a system that handles different styles of type without reprogramming. The first two approaches severely limit the range of reading material that the device would make available. This is especially true since so-called "cold" typesetting techniques recently have resulted in a proliferation of new type styles. The third approach requires the user to identify the type style being read, to know when the type style is changing, and to what style. This would be difficult for a sighted reader. For a blind reader, it would require the regular intervention of a sighted assistant who could make these identifications. To maximize both the independence of the blind reader, as well as the diversity of inkprint material that could be read, the fourth approach, known as multifont character recognition, is necessary.

Having established the basic requirements for the "Print" half of a reading machine, we come back to the three functional steps of print-to-grapheme string conversion: scanning, character separation, and identification. Scanning is perhaps the simplest step conceptually, but not one to be overlooked easily in reading-machine design. The problem is basically mechanical, moving the camera horizontally and vertically using a system that is both reliable and inexpensive. Recognizing that electromechanical projects often fail in the mechanical department, we invested considerable resources in developing a reliable design. Our experience thus far with the X-Y mover that we developed indicates that we have achieved the goals of economy and reliability. A key design parameter in developing an inexpensive yet reliable X-Y mover was to sacrifice high degrees of positional accuracy which the software, being reasonably flexible, does not require.

The camera itself contains a Charge-Coupled-Device scanning array, with 500 light-sensitive elements arranged in a straight line. For each sampling period of two milliseconds, the scanning array transmits a thin, vertical slice of the image to the preprocessing electronics. The camera moves in a horizontal direction (both left-to-right and right-to-left), so that multiple samples allow the computer to build a two-dimensional image in its memory. Every second, 500 samples of 500 points, or a quarter million points in all, are transmitted by the scanning array. These quarter million points are preprocessed by special purpose electronics to enhance contrast and to reduce storage requirements before being transmitted via a Direct-Memory-Access channel to the computer.

Once the image is transmitted, the computer discards "noisy" images suspected of being pictures and other nontextual material. Images that have basic horizontal-vertical ratios and positional relationships associated with text are then separated into discrete characters. The basic algorithm for character separation is the contiguity rule, based on the observation that printed characters generally do not touch one another. There are exceptions to this rule, however, especially in poorly printed material. A module called "Split Analysis" is responsible for analyzing contiguous images where the vertical-horizontal ratio exceeds that for normal characters. The Split Analysis module identifies likely "split" points for touching characters, and then separates merged letters into discrete images. The Disambiguator module, which I will discuss later is responsible for the reverse process of reconnecting examples of broken letters.

Once the image has been separated into individual character forms, the computer identifies the letter and replaces the real-time image of the character with its identification. It is important that this be done rapidly to free the extensive amount of memory required for each character image. There are, in fact, never more than two or three character images in memory at one time.

There are two ways in which this identification problem can be approached. The first involves storing a digitized picture of every character in the identification set in memory, comparing a scanned image to each stored picture, and selecting the stored image that correlates most closely. This is known as Template Matching and is a successful technique, provided that the size of the identification set is restricted. It works well for a single type style or a severely restricted set of type styles, but deteriorates rapidly when the identification set is expanded to include a large number of type styles. Template Matching does not, therefore,

achieve the goal of automatic recognition of the wide variety of fonts in use today. There exist variations of Template Matching, called Minimal Property Extraction, which involve storing linear or simple functions of images rather than entire digitized images. Minimal Property Extraction has some advantages over Template Matching in terms of storage requirements, but has the same font limitation.

The technique we employed to recognize letters in a wide variety of type styles without excessive storage requirements was to define letters in terms of properties that are relatively invariant across the types of changes that occur between type styles. Through extensive experimentation, we have found that the type of properties that provide the greatest invariance are geometric properties--lines, vertices, loops, concavities, and their relationships. In this type of classification, an upper-case "A" without serifs would be defined to have: (1) a loop; (2) a loop extension starting on the west side of the loop headed south (a west-south loop extension); (3) an east-south loop extension; (4) a north-central to south-west line segment; (5) a north-central to south-east line segment; and (6) one south concavity. If the line segments in the upper-case A were thicker or thinner, or if the angle at the north-central vertex were larger or smaller, the same set of topological properties would be extracted. Most of the changes across type styles involve vertex angle sizes and line thickness, and the "high-level" properties we have implemented provide the necessary invariance across these types of changes.

One type of change between type styles does not provide invariant results for these properties--the arrangement of serifs. Serifs add additional line segments, vertices, and sometimes even additional concavities. This is handled by defining the serif and sans-serif form of each character separately. Sometimes, several serif form definitions are required due to different possible arrangements of the serifs for a particular character. Substantially different character forms are handled the same way. There are, in fact, in our character definition table, an average of five different property sets for each character in the identification set. Since the properties are binary and require very little storage for each property set, the entire character definition table, with approximately five property sets for each character, requires less memory than a single set of templates defining a single type style.

The topological analysis described above analyzes only the shape of each character. Shape alone is not always sufficient for a final identification, and the output of this "Shape Recognizer" is frequently an "Ambiguity Code" indicating one of several possible final identifications. For example, a vertical bar could be a lower-case "l" [el], an upper-case "I" [eye], or the number "1" [one]. Similarly, the shape associated with a serified lower-case "l" could be a lower-case "[el]", a lower-case "[eye]" (if there is a dot above it), or the number "[one]". The final identification for such ambiguity codes is made by the "Disambiguator" module, which takes into account positional factors such as north and south boundaries in relation to nearby characters, letter size, the presence of dots above or below the character, as well as contextual cues. As an example of a contextual cue, a vertical bar with a space to the left and a consonant to the right is probably a capital "[eye]" rather than a small "[el]" because words starting with "[el]" do not have second-letter consonants.

Occasionally, one of the possible final identifications for a particular Ambiguity Code is a letter fragment. If a possible letter fragment is next to an ambiguity code with a possible matching fragment, the disambiguator will merge the two fragments into a single, final identification. In this way, at least some broken letters are identified as single characters.

The output of the Disambiguator is a set of final character identifications, in Ascii code, and that completes the print-to-grapheme string conversion process.

We now come to the "Output" process--or grapheme string-to-speech conversion. Again, we should consider several questions of approach.

First, why speech? For the auditory sense, other options would be Morse code, spelled letters, and so-called "phonetic" speech consisting of concatenated letter sounds. Morse code and spelled letters require extensive training and result in relatively slow reading speeds. Phonetic speech is also difficult to comprehend, requires extensive training, and results in slow reading rates for most users. In a conference report in 1971, Franklin S. Cooper and Patrick W. Nye of Haskins Laboratories reported:

Initial studies compared the readability of several non-speech codes with natural speech sounds. The results of this research indicated, on empirical grounds, that only a device

which could produce spoken English would provide high reading rates and easy comprehension. Moreover, because speech output requires no training and a far smaller investment of interpretive effort than any other form of acoustic or tactile display, spoken material has a substantially greater chance of being successfully used by a commanding segment of the blind community.¹

There has been a number of other studies comparing different auditory outputs, but there is little point in belaboring the issue--it has been clear for several years that full-word speech is necessary to achieve rapid reading rates, as well as minimal training requirements.

A braille output would be optimal for the tactile sense. We did not select a braille output because (1) only a relatively small percentage of blind persons use braille extensively or at all; (2) many blind persons do not have the tactile sensitivity to use braille; and (3) while some persons can read braille at speech rates (and even higher rates), the average braille reading speed is less than one-half of speech rates. It was clear to us that a full-word speech output would provide rapid reading rates to the widest possible segment of the blind population. A braille output is, however, a feasible attachment to the Kurzweil Reading Machine, all that is required is a braille printer.

Having decided on a full-word speech output, there is still one question of approach. The principal technical problem associated with full-word speech is determining how words are pronounced from the way they are spelled, which we will call grapheme-to-phoneme conversion. One approach is to store a pronunciation dictionary in the computer's memory, storing the phoneme string for each word in the main corpus of 100,000 English words. Another approach is to store only roots of words, stripping off prefixes and suffixes, and splitting apart multi-root words. This type of morphological stripping of words prior to their entry is a dictionary cuts down the number of entries required to some extent. Both of these approaches, however, require a substantial amount of computer memory to hold the dictionary and are not practical approaches for a compact and affordable device using available memory technologies.

The approach we have taken is to implement a set of phonetic rules which define the relationship between spelling and pronunciation in the English language. A set of approximately 1000 rules accurately defines this relationship for most words. We have found it necessary to include a dictionary of exceptions to the rules, but since the dictionary requires no more than about 2000 entries, and since the rules themselves are quite compact (only about 4000, 16-bit words of storage), the entire system including the exceptions is practical for a small minicomputer-based system.

The rules define the sequence of phonemes associated with different sequences of graphemes and their interactions. As an example, if "sch" is followed by a consonant, the "sch" is generally soft, as in the name "Schneider" or the word "schnapps." If followed by a vowel, the "sch" is generally hard, as in "school," "scheme," or "schizophrenia." In addition to the rules and the exception dictionary, the speech system includes a morphological analysis to strip off prefixes and suffixes to increase the applicability of the rules and dictionary.

The speech system also includes a simple syntax analysis to provide a stress contour across each sentence. The speech is not, therefore, a monotone. These prosodic features or variations in stress level are intended to reduce listener fatigue by making the speech more pleasant to listen to.

One type of processing not attempted by the machine is the resolving of so-called "ambiguous" words--for example "read" as in "can you read" and "have you read," or "lives" as in "one hundred lives were lost" and "he lives down the block." This type of disambiguation is quite feasible but would add significant cost and complexity to the device. There are surprisingly few ambiguous words--less than twenty--and the disambiguation can be achieved by the user from context quite easily, once the user is made aware of the necessity to do so. This was one area, therefore, that we felt a wise compromise dictated leaving the problem unsolved.

Once the grapheme string has been converted to a list of phonemes with associated stress levels by the morphological analysis, phonetic rules, exception dictionary and syntactical stress analysis, control signals are generated to direct a set of electronic synthesizer circuits to produce the speech sounds associated with each phoneme.

Part of the speech system is a 300-character circular grapheme buffer, which stores the last 300 recognized characters. With the buffer and the set of user controls, the user is able to repeat sections of text, locate particular words and have them spelled, simulate skimming functions, and so on. The rate of speech as well as the pitch and volume are also controlled by the user.

I would like to play for you a recording made several days ago of the machine. The tape is a recording of the machine reading the text of the Gettysburg Address. The sheet it was reading contained eight different type fonts, and I have copies of it for those who are interested. While this was recorded, the machine was directed to read the first three lines twice, then to repeat it a third time at a faster rate, and finally a fourth time going slowly word by word, occasionally spelling out a word.

Before I play the tape, I would like to point out, that the speech output requires a little getting used to. Our experience thus far indicates strongly that virtually everyone attains a high degree of comprehension after several hours of exposure. Extensive training is not, therefore, required to comprehend the speech at rapid rates. Without any exposure, listeners vary in their ability to comprehend, although some people can understand it with little or no experience.

After about five years of preliminary investigation--feasibility studies, analysis of different algorithms, component reviews, literature searches, etc., Kurzweil Computer Products was formed about two and a half years ago to develop and perfect a working machine. Over a year ago, the first working model was completed that could convert printed text to full-word speech. We have been perfecting and improving the device since that time, and now have the fifth system or version of the reading machine completed.

The emphasis now is to test thoroughly the machine in the field in a wide variety of user situations and improve the device based on the feedback we expect to receive. There currently are two field-test programs--one funded by DHEW's Bureau of Education for the Handicapped will place units of the reading machine at the Perkins School for the Blind and the Boston School System; and the second, a human engineering study of the reading machine to be conducted by the National Federation of the Blind will place reading machines in a variety of user situations. It is our hope that at the conclusion of these field tests the machine will meet as closely as possible the reading needs of blind people and rapidly can be made available to the broadest possible segment of the blind population.

NOTE

¹Franklin S. Cooper and Patrick W. Nye, "Plans for the Evaluation of a High-Performance Reading Machine for the Blind" in Evaluation of Sensory Aids for the Visually Handicapped, a report on a conference sponsored by the Subcommittee on Sensory Aids, Committee on Prosthetics Research and Development, National Academy of Sciences, 11-12 November 1971.

Bringing the Disabled User Into the Design Process:
Improving New Technology for the Disabled

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It is commonplace to suggest that potential consumers of new programs or products ought to be able to influence their development and design. Indeed, in an age when social scientists dwell on how cultural biases and lack of understanding of the perspectives of others inhibit our efforts to solve social problems, few scientists would question the concept of getting input from those who will be serviced by their research. This would seem especially true in the design of technology for the physically disabled. Such technology is generally intended to facilitate personal and individual activities such as mobility and reading which require significant man-machine interaction. Its design therefore should require considerable input on user preferences and needs.

Unfortunately, attempts at involving users--disabled or not--have not fared well in practice. In many cases, efforts at user involvement have only resulted in misunderstandings and little apparent contribution to product excellence.

This paper will discuss the problems associated with involving the user, particularly the physically disabled user, in the process of technological innovation and will present a strategy for facilitating productive user-designer interaction. The prescriptions contained in this strategy will be illustrated with examples from the development and dissemination of the Kurzweil Reading Machine for the blind.

I believe that the failure of efforts at user involvement may be due more to the ways the concept has been applied than to any fault in the concept.

Operational questions that face the designer or government policy-maker attempting to facilitate user involvement include the following:

1. To what degree should potential users be involved? What influence over what decisions should the user be given?
2. At what stages in the research and development process should the user's input be sought? In what specific content areas should this input be solicited?
3. Finally, how should such relationships between designers and users be created and structured? What informal contract should the scientist and user have with each other regarding their respective roles? On a day-to-day level, what kinds of involvement activities are appropriate?

To answer adequately these operational questions and thus attempt to maximize the potential of the user-involvement concept, we need to understand this concept in the context of broader views of the innovation process and to analyze the specific problems encountered in attempts to apply it.

CONCEPTUAL APPROACHES TO INNOVATION

By studying the general literature on innovation, we may be able to combine the user-involvement concept and other approaches in a way that maximizes the likelihood of good innovation.

One view of invention and innovation--one particularly advanced by Dr. Jacob Rabinow, Chief of the Office of Invention and Innovation of the National Bureau of Standards--is that a nation's reward structure, set through conscious government policy, is a key factor in determining the type and amount of innovations that occur.¹ For example, Dr. Rabinow believes that changes in patent law and changes in government policy that would make it easier for high technology enterprises to get loans together would increase technological innovation. In a more direct way, the government can also put research funds into areas of new technology it wants to encourage. For example, in the case of the Kurzweil Reading Machine for the blind, the interest of the Bureau of Education for the Handicapped in seeing early models built and tested has been very important in getting this technological innovation off the ground.

To go a step further concerning the role of the government, through such tools as its guidelines for contractors, the government can, if it wishes, influence the way research is carried out. For example, although I do not necessarily recommend this, the government could create legal requirements for user involvement in technology projects that it funds.

A second and more systems-oriented view, which we can call the rationalist approach, sees invention and the innovation that builds upon it as a process which can be managed, analyzed into its component parts, and made subject to rational controls. In its purest state, without qualifying attitudes, the rational view emphasizes a process which is goal-oriented, orderly, and a process in which it is clear ahead of time in which discipline or technology the answer falls. Innovation is seen as basically a cut and dried matter, a follow-up on an initial good statement of research goals.

In analyzing the failure of innovative attempts, members of the rationalist school thus are likely to criticize the lack of clarity of innovative goals, the lack of specification of steps in the development and implementation process, and the absence of solid evaluation and monitoring along the way. Certainly there is much truth in this criticism. We have all experienced poorly directed projects and/or projects with poorly stated goals.

The remedy, according to the rationalists, is for the innovator to choose a clear goal (perhaps through marketing analysis, perhaps through the personal perceptions of an inventor) to identify the appropriate technology beforehand, and then to plan and schedule an orderly process for the application of this identified body of knowledge. An application of this approach has been the space programs of the U.S. government, where planners painstakingly figure out, before any major project begins, the performance characteristics of each component and the technical innovations to be implemented, and then produce a stage-by-stage development program.

There are limitations, however, to unbridled application of the rationalist approach. Problems as well as opportunities that arise in the process of invention cannot be predicted or planned in advance. Furthermore, needs and goals, on the one hand, and new technology, on the other, often determine one another in the course of development. Neither can be fully determined at the outset. Often, a new technology is so radical or unexpected, or provides previously unimagined capabilities, that uses for it can be proposed only after the technology is at least partially developed. When this is the case, it is unlikely that a priori marketing analysis or a survey of needs would have indicated a need for it. For example, it is unlikely that a market analysis in the days of the horse and buggy would have indicated the need for an automobile because the idea of the horseless carriage was not a matter of fact but rather a radical idea outside the experience of most people of that time.² We realize, in fact, that invention and innovation involve highly creative processes including intuition, emotion, and analogous application of developments in parallel fields, and often work backward from and exploit intriguing phenomena that have been discovered as a part of basic research following other goals. Clearly, a rationalist ordered approach, although helpful in planning details of the innovative process, is not enough by itself. This limitation is important in determining the optimal points in the research and development process at which to facilitate user involvement.

PROBLEMS WITH USER INVOLVEMENT

With the above discussion in mind, we can now examine the specific problems connected with user involvement as an approach to improving technological innovation.

A first problem is that the concept of user involvement is very broad and may be endorsed by people for reasons other than its direct value in improving the quality and the relevance of a product. Thus some people see user involvement as a moral imperative in itself that people should have a voice in decisions which affect their lives. Others emphasize that the appearance of participation in decisions buys the internal commitment of potential customers and these advocates of user involvement therefore tend to emphasize appearance over reality. Either of these approaches can generate ambivalence or cynicism about the effectiveness of user involvement and a lack of clarity about what it should constitute.

Even where both designers and users appear to have a genuine commitment to users actually influencing the design process, problems still occur.

If one party feels relatively unable to influence the other party, this feeling can inhibit dialogue and decrease the likelihood of a constructive outcome. If the user perceives himself as less influential (something often although not always related to perceptions of inferior status or economic means), there is frequently an expectation that the designer will ignore the user's recommendations. Social psychology laboratory

studies³ in fact confirm that the greater the perceived influence differential in a situation, the more negative will be attitudes of the perceived less-influential party toward the more influential.

Thus disabled users who may perceive themselves at a disadvantage to a designer--typically a government agency or manufacturing corporation--are likely to be distrustful of its offers of cooperation, or to be too intimidated to make constructive criticisms.

From the viewpoint of the designer organization that considers itself relatively more powerful than its user counterparts, there is a tendency to see the user as not wanting to voluntarily cooperate or to accept intelligent compromise. Again, studies in the social psychology of attribution indirectly confirm this explanation.

Obviously, the two attitudes can reinforce each other. When such feelings exist, both designers and users are less likely to believe in and spend the energy in confronting--i.e., clarifying and exploring--and resolving the differences between them. If users feel that there is no point in stating their opinions and if designers feel that users do not want to be reasonable, then issues will either not be confronted in a helpful way or will be avoided entirely, and the quality of a program or product will suffer.

Another reason for ineffective interaction is that effective problem-solving requires considerable interpersonal skills in the giving and receiving of feedback. Designers often become defensive and unable to listen to constructive criticism by users. Although this defensiveness is readily understandable in terms of the real psychological commitment designers have put into their efforts, such defensiveness can prevent designers from hearing valid suggestions and can reinforce users' stereotypes of them as unresponsive. Users, for their part, often tend to aggravate the situation by making their suggestions, in nonconstructive ways that imply a judgment of the designer's intelligence or intent.

These tendencies toward ineffective behavior may be reinforced on the designer side by corporate organizational norms of avoiding the open airing of disagreement and on the user side by norms (possibly borne out of the internal politics of consumer organizations) that encourage unproductive, deliberately critical attitudes toward corporate and government designers, or what is sometimes claimed to be "grandstanding."

Small wonder, then, looking at such interpersonal and organizational barriers, that there is often lack of trust and rigidity on both parts, and ineffective contributions to development. Social scientists such as Argyris and Schön and Bolman have demonstrated that these relationship qualities appear to be true across a wide variety of professional-client relationships such as those between school administrators and parents, and between city planners and community groups.

Beyond the interpersonal issues, however, another difficulty is that users often do not have enough information or expert knowledge to effectively criticize designs and to contribute suggestions or the money to purchase such expertise. For example, one of the reasons community groups have had difficulty in influencing city and highway planning officials is that the community groups usually have not had the expertise nor been provided funds to hire staffs with the technical expertise to intelligently collaborate with and/or confront the official experts.

A final problem with user involvement is that it is usually not coordinated with the timing of the innovation process as described above, a process with unpredictable as well as orderly aspects. On one hand, user involvement is frequently seen only in terms of using market analyses to generate ideas for new products. Because of the unplanned nature of major advances, this approach used alone may in some cases actually construct creativity. On the other hand, other designers limit user influence to a yes or no vote by viewing involvement primarily in terms of final consumer approval tests at the tail end of the development process. In contrast to both these views, we can see that between the beginning of a project and its dissemination, there is specific research and development that is susceptible to rational, ordered planning and a clear statement of goals. Here, the minigoals represented by user needs and preferences would be helpful input, but, alas, user involvement is rarely structured into this "nuts and bolts" stage of the design process.

To summarize, ineffective user involvement can be caused by such factors as organizational politics and poor relationships, lack of information and technical expertise by users, and the lack of a clear purpose and sensible structure for fitting the involvement of potential users into the ongoing processes of innovation.

PRESCRIPTIONS FOR PRODUCTIVE USER INVOLVEMENT

I come, however, not to bury the concept of user involvement but to specify and to improve it. On the basis of the preceding discussion, we can specify a normative strategy for user involvement in the design process and then look at examples of its application.

1. The first element of such a strategy is that a designer should not solicit user involvement unless there is a genuine commitment to users actually influencing the design in the belief that this will increase product quality or relevance. To do otherwise is to invite cynicism, even if the designer has "honorable" intentions.
2. Second, the best points for users to participate in the design process are those at which users can provide design objectives--e.g., the provision of controls on the Kurzweil Reading Machine to allow the blind user to repeat and spell out words when desired--for the orderly programmable parts of the design process; or where users can evaluate proposed alternative designs for meeting their needs; or where users can help in modifying the device to improve its usability.
3. Subject matter and the plan of activities for user involvement should be agreed upon in advance by both parties. User input should emphasize what needs to be done more than how to do it. For example, a designer would not expect users, disabled or otherwise, to improve electronic circuits or write new computer programs, but would desire input from disabled users on the relative priorities they would assign to certain features of a product and the usage needs they would anticipate, such as the kinds of page formats they want a reading machine to handle.

Activity specifications might include frequency of meetings, what kinds of reports if any, length of relationship (indefinite or short-term), and so on. These understandings are not ironclad commitments naturally and are subject to later modification, but nonetheless can form the basis for each part's expectations of the relationship.

4. A necessary but not obvious matter in structuring user involvement is defining first whom we mean by "potential users." Rather than the word "user," which has narrow connotations of only those who will physically operate a device, it is better to use the broader concept of "clients." I define clients as "those who will be affected by the innovation, directly or indirectly." Thus, for example, clients of technology for the physically disabled typically will include disabled adults, the rehabilitation specialists who work with them, disabled children, their parents, and their teachers. Each of these groups will have its special perspective, self-interest, and need, and thus each can provide useful input into the design process.

Of course, user involvement will be less formal in its beginnings; here, general purposes for a project or program are just being developed and it is often unclear which groups will be served or affected by it.

However, when projects require less radically new technology, and when an intended user population can be identified from the start, it may be both meaningful and feasible to involve users earlier and more formally in the specification of design objectives.

5. Mechanisms should be built into the program which will provide for or allow the user to have enough information and expert knowledge to discuss intelligently alternate designs and their cost benefit trade-offs and implications for the user.
6. In light of the considerable potential for organizational and interpersonal difficulties, designers and users should work toward creating an interpersonal climate where differences can be surfaced, confronted, and responsibly resolved--with plenty of give and take by both parties. Specific steps in this direction can include informal advance planning of the relationship; the appointing of specific representatives from both parties to monitor the user-involvement program; the engagement of neutral third-party consultants, and the provision of structures as detailed below to increase the influence of users in the relationship.

Each of these suggestions, incidentally, has analogues in the emerging research and prescriptions for cooperation in such diverse areas as police-community and university-public school relationships.

EXAMPLES FROM THE KURZWEIL READING MACHINE

We can now discuss these ideas in terms of the development of the Kurzweil Reading Machine and the two testing programs Kurzweil Computer Products ("the company") is engaged in.

First, we can look at the timing of user involvement over the history of the machine.

In the late 1960s Raymond Kurzweil, then an undergraduate at MIT, without the constraint of a specific planned application and as a part of a basic interest in pattern recognition, studied the problems of character recognition. Over time, specific and unique approaches to property extraction were conceived, and a plan for implementing them partially worked out.

After several years of theoretical work, efforts were made to look at how the technology that had emerged--low-cost, high-level property extraction of multifont characters--might be applied. The new technology seemed appropriate to the needs of blind people to read efficiently the great variety of type styles seen in ordinary ink-printed books, typewritten letters, and other printed communications. At this time, around 1973, the reading needs of the blind were examined both in terms of the approaches already in use and from the viewpoint of potential users. This was accomplished through reading papers by and discussions with rehabilitation professionals and blind persons. This rather informal stage of user involvement, both indirect and direct, influenced the general strategy for the configuration of a device using the new technology as well as the specific development objectives for the next three years.

Now, three years and a major stage later, the company has a reliable working prototype and users are again involved--this time more formally and specifically with regard to maximizing the usefulness of the device. The reading machine must be able to interact with users and respond flexibly to their needs. To achieve this, the design process requires information on the needs and preferences of those who will use the equipment--input on the nature, design, and arrangement of user controls; the physical configuration of the machine, text material specifications, and other factors. Most of these questions cannot be answered in advance but must be answered through a testing and modification program in conjunction with potential users of the device. The company is therefore implementing two programs of client input.

The first program, a contract with the Bureau of Education for the Handicapped, which is part of the U.S. Department of Health, Education, and Welfare, demonstrates the wide definition of "client" as those who will be affected by an innovation, directly or indirectly. Under this program, test units of the reading machine, which are currently being constructed, will be placed at the Perkins School for the Blind and in the Visually Handicapped Program of the Boston School System. Extensive tests will be conducted aimed at improving the reading machine on the basis of the observations and experience of blind school children, their teachers, and their parents. Data will be collected on reading comprehension levels achieved on different reading materials and on factors that affect this level, with a view toward maximizing both overall comprehension and the diversity of materials that can be read.

The second program is a human engineering study to be conducted by the National Federation of the Blind ("NFB") in collaboration with the company. Under this program, the NFB will place six models of the reading machine in a variety of user situations--in the office of a blind executive, lawyer, engineer, or scientist, in a rehabilitation center and so on--evaluate and determine how to improve the device.

Although both programs are important to further development of the Kurzweil Reading Machine, I will emphasize examples from the NFB program because it concerns adult blind users, and therefore is more elaborately structured for user involvement.

This program demonstrates many of the above ideas about the dynamics of collaboration with users. The NFB, with more than 50,000 members, is the largest organization of blind people, and explicitly describes itself as a consumer organization. Each party in the relationship can realize gains from it: from the company's viewpoint a better, more marketable product; from the NFB's viewpoint the opportunity to influence and improve something that

will have a significant impact on the lives of blind people. This increases the likelihood that each party is listening and responsible.

The subject matter of the interaction and plan of activities has been spelled out in a twenty-four page memorandum of intent. I will summarize the activities as follows: after users have begun their exposure to the machine, questionnaires on user experience will feed into periodic status reports. These are to be used as advance inputs to informal technical meetings between the program staff and the company's designers. These meetings will seek to integrate the ongoing data with the design of improvements to the machine in such areas as performance and control configuration. The agenda for these meetings will include discussion of the research results gained from users, categorization of the problems that are thus identified, the development of possible options for their remediation, the setting of priorities for such options with regard to both cost considerations and the needs and preferences of blind users, and, finally, recommending solutions. Additionally, between technical meetings NFB's technical staff and the Kurzweil staff will monitor the changes that have been introduced.

There are significant advantages for a designer to work with an organization such as the NFB rather than with unaffiliated, individual users. Users belonging to a recognized organization are more likely to have confidence in the ability of their organization to influence the design and therefore are more likely to express their opinions and confront differences. The same benefit of working with organized users is seen in the Bureau of Education for the Handicapped program where clients will interact with the company as part of the Boston School System and the Perkins School for the Blind.

A large user organization, incidentally, is likely to represent a spectrum of needs, preferences, and user characteristics. Strong support of the project by the organization's leadership, as is the case with the client organizations the company is working with, also increases the likelihood that individual members will be seriously committed to the project.

The funding structure for the NFB-company program also facilitates the autonomy of the user group in the relationship. The NFB supports its role from funds directly contributed to it for this purpose by private foundations. From this budget, the NFB is purchasing the six machines and hiring the specialists to manage the testing and the NFB's input into the modification process.

This budgetary arrangement is interesting in light of recent research findings by Derr and Demb.⁵ They studied several federally funded projects aimed at developing collaboration between prominent university graduate-education departments and nearby big-city public school systems. The more productive relationships--measured in increased perceived relevance of university courses and amount of consultation rendered to the urban school system--resulted when the urban school systems were given management control of the budget by the government, and thus had more perceived autonomy.

Because of the importance of users either having or being supplied with expert knowledge, the NFB's budget for the project allows it to employ individuals from within as well as from outside its membership, people with skills in such areas as engineering design, computer science, human-factors psychology, and the analysis of cost: benefit trade-offs. Two prominent experts with expertise in the engineering, configuration, implementation, and evaluation of equipment and devices for the disabled have been engaged as program director and program associate. Both men also happen to be blind and have been in the forefront of those advocating a greater role for the blind consumer of new technology. Other assistants and technical consultants--both blind and sighted--also will be hired.

Finally, we can look at how the formal relationships between Kurzweil and its clients have developed and are being facilitated. The company has had discussions over the last two years with the NFB, the Visually Handicapped Program of the Boston School System, and the Perkins School for the Blind, and these discussions have led to the present programs. In the company and in these organizations, specific individuals have taken responsibility for developing and continuing to monitor these relationships. In addition, because the NFB and the company both feel that the quality of the relationship is important to its effectiveness, together they have agreed to have their work facilitated by an independent social scientist. Through private interviews and direct observation of the technical meetings, this consultant will gather data on how the relationship is working out. The data will be compared and interpreted by him and used to facilitate the development of changes where relevant.

In conclusion, the purpose of these examples has been to provide some indication of how the user-involvement concept can be made operational. It is my hope that by finding and following the conditions that most favor productive user involvement, we may be able to learn more about its true potential for increasing the relevance and quality of innovation--especially new technology for the disabled.

NOTES

¹"Is American Genius Being Stifled?: Interview with Jacob Rabinow, A Leading Authority on Patents," U. S. News and World Report, December 23, 1974.

²Donald Schon, Technology and Change: The New Heraclitus, 1966.

³L. Solomon, "The Influence of Some Types of Power Relationships and Game Strategies Upon the Development of Interpersonal Trust," Journal of Abnormal Social Psychology, 61(2)1960; M. Mulder, et al., "Illegitimacy of Power and Positivity of Attitudes Toward the Power Person," Human Relations, November 1965.

⁴J. W. Thibaut and H. W. Riecken, "Authoritarianism, Status and the Communication of Aggression," Human Relations, 8(1955):95-120.

⁵C. Brooklyn Derr and Ada Demb, "Building Collaborative Relationships, A Study of University-Urban School System Interactions," June 1973. (Mimeographed.)

Using a Computer to Help Teach Deaf Children to Speak

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Between one and two children out of every one thousand are born deaf, or suffer profound hearing loss during the first few months of life. For these children the development of fluent speech is an extremely difficult task.

Among the techniques that have been applied to the problem of teaching speech to deaf children is that of providing them with visual or tactual representations of speech sounds as substitutes for the missing auditory information. No completely satisfactory way of representing speech visually or tactually yet has been developed; several efforts have been made to use visual and tactual displays of specific aspects of speech in training situations, however, and these efforts have met with varying degrees of success.

Recently, we made an attempt to apply computer technology to the problem of teaching speech to deaf children. There are two main reasons for believing that building a system of speech training aids around a computer makes sense. One is the flexibility that is gained by doing so: not only does it become feasible to incorporate in one system many of the types of aids that have been implemented as separate devices in the past, but changes to displays that would require hardware modifications in special-purpose devices can often be realized by program changes in a computer-based system. Another is the fact that the computer's speed makes it practical to perform analyses on the speech signal that would be difficult, if not impossible, to accomplish in real time otherwise, and to display the results of these analyses in a very large variety of ways.

CHARACTERISTICS OF THE SPEECH OF DEAF CHILDREN

The thing that is likely to be most apparent about the speech of a deaf child when one listens to it for the first time is that it is very difficult, perhaps impossible, to understand. Familiarity with the speech of deaf persons in general, and with that of a specific individual in particular, may increase its understandability considerably; however, it is safe to say that poor intelligibility tends to be a characteristic of the speech of persons who have been profoundly deaf since birth or shortly thereafter.

Although the speech of no two deaf individuals is exactly alike, any more than is the speech of any two hearing individuals, it is possible to specify some ways in which the speech of deaf persons tends to differ from that of hearing persons in general. Such specific information is important for scientists and teachers who want to help improve the speech of the deaf; by itself, the knowledge that speech is not very intelligible provides little guidance regarding how to provide the necessary remediation. The following brief summary of the types of deficiencies that tend to characterize the speech of the deaf is a condensation of a fuller discussion of the topic (Nickerson 1975). The grouping of problems is a somewhat arbitrary convenience.

Timing and Rhythm

The speaking rate of deaf persons is typically much slower than that of hearing persons. The durational differences between stressed and unstressed syllables tend to be too small. (In particular, unstressed syllables tend to be too long.) Pauses are inserted at inappropriate places (e.g., within phrases). Some speech sounds (e.g., fricative consonants, closure period of plosives) are sometimes inappropriately lengthened. Certain transitional articulatory movements are often poorly timed. Overall speech rhythm is often poor--a consequence perhaps of the other timing deficiencies.

Pitch and Intonation

A common problem is inappropriate (typically too high) average pitch--falsetto voice; another is insufficient pitch variation--monotone voice. Some children fail to produce the fall in pitch that typically occurs on the final syllable of a declarative sentence. Others are unable to produce a terminal rise in pitch such as occurs at the end of some questions. Some produce erratic pitch changes that bear little relationship to normal intonation patterns.

Velopharyngeal Control

Many deaf children have great difficulty controlling properly the velum or soft palate.

that acts as a gate between the oral and nasal cavities. Some leave it down (thereby leaving the passage between the cavities open) when it should be up, thus nasalizing sounds that should not be nasalized (e.g., b, d, g). Some have it up when it should be down, thus failing to nasalize sounds that should be nasalized (e.g., m, n, ng). Many have difficulty gaining the fine, temporal control of the velopharyngeal opening that is necessary to produce abutting nasal and stop consonants, as in center, an utterance requiring that the velum be raised to produce the nasal consonant (n, in the example), and then lowered very rapidly so as to permit the build-up of the pressure within the oral cavity that is needed to produce the plosive (t).

Articulation

Inability to produce certain speech sounds (e.g., s) is a common problem, as is the failure to differentiate between sounds. Failure to distinguish between voiced and voiceless consonants is an example of the latter problem. Other articulatory difficulties include: reduction of vowels to the neutral schwa (as in about); difficulty with diphthongs, and with blends (sp, fl, ks); omission of arresting and releasing consonants; and insertion of adventitious sounds.

Voice Quality

One finds many references in the literature to the distinctive quality of the voices of deaf persons. It seems to be the consensus that there is something distinctive about it, but there is relatively little agreement regarding what the basis of the distinctiveness is. Among the more commonly used descriptors are the following; breathy, nasal, monotone, tense, and harsh.

Interrelatedness of Problems

It is apparent that the problems mentioned above are not independent. They are interrelated in numerous ways. Certain classes of speech problems are probably the result of inappropriate postures of certain articulators such as the larynx, or inappropriate control of the respiratory system during speech. While it is possible to focus on an individual problem during speech training, the teacher cannot safely ignore problems other than the one being focused upon, because the result of attempting to change the speech in one respect may be to change it, and not necessarily for the better, in other respects as well.

The Relationship Between Specific Speech Characteristics and Intelligibility

Unfortunately, not very much is known about the relationship between the objectively measurable characteristics of speech and its intelligibility. Consequently, it is not always clear what specific aspects of the speech of a given child need to be changed in order to realize the greatest intelligibility gains. The need for more research on this issue is great.

AN EXPERIMENTAL SYSTEM OF SPEECH AIDS

The system that will be described was built at Bolt Beranek and Newman, under the auspices of the Bureau of Education for the Handicapped, and has been in operation at the Clarke School for the Deaf in Northampton, Massachusetts, for three years. Figure 1 shows the system being used by a student in a tutorial situation. We stress that this is an experimental system, still in the process of being developed. The assumption with which we started was that the best (if not the only) way to develop a system that would be a useful aid for speech training was to build something, get it into the hands of users quickly, and then work closely with the users to evolve it in accordance with the insights they gained by using it. Of course, the original design reflected our best initial guesses concerning what capabilities such a system should have, but we expected that some of these guesses would prove to be wrong, which they have. The following description of the system, as it now exists, is adapted from several earlier reports, most particularly from Nickerson and Stevens (1972, 1973) and Nickerson et al. (1976).

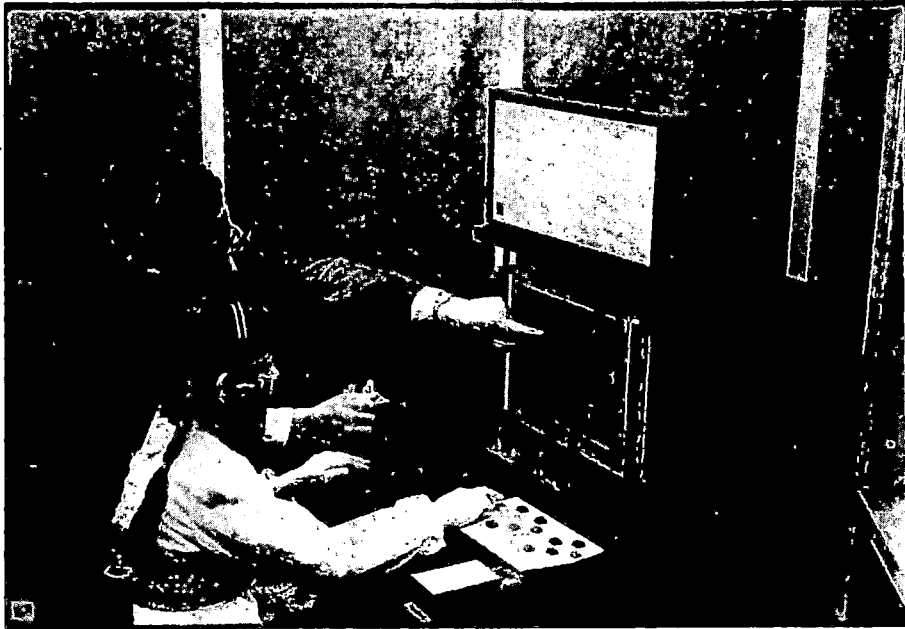


Fig. 1. Student and teacher seated in front of the display and control panel for the system.

A simple block diagram of the system is shown in Fig. 2. Speech information is obtained by means of a miniature accelerometer attached by double-stick tape either to the throat or the nose and a voice microphone, as shown in Fig. 3. When the accelerometer (which weighs less than two grams) is attached to the throat, its output is fed to a circuit that measures pitch periods. When attached to the nose, the circuit that receives the output measures the vibration on the nasal surface, which is used as an indication of the amount of acoustic coupling to the nasal cavity through the velopharyngeal port (Stevens et al. 1975). The output of the voice microphone is fed into a filter bank that determines the amplitude in each of nineteen frequency bands within the range 100-6560 Hz.

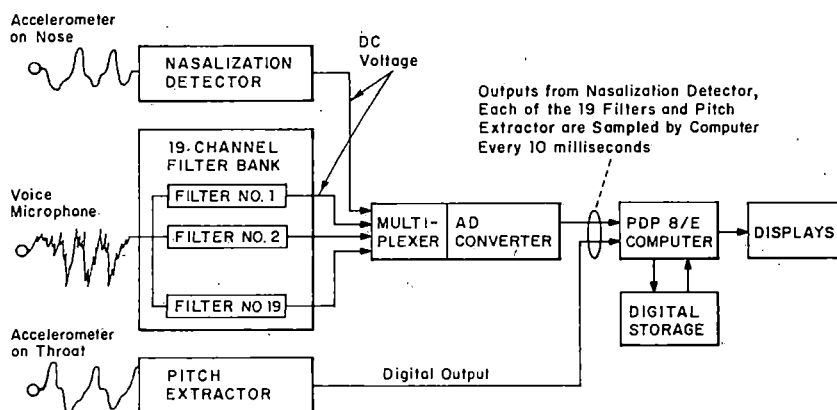


Fig. 2. Simplified block diagram of the system.



Fig. 3. Head-mounted microphone and miniature accelerometer that are used with the system of speech-training aids.

If the ball is either too high or too low to go through the hole, it bounces from the wall back to the starting position, and the child may try again. Both the height of the hole in the wall and its width are adjustable by the teacher. Such adjustments are made by turning appropriate control knobs.

In a more complicated version of the ballgame display, a second wall may be added to the left of the first one (see Fig. 4b). By adjusting the distance between the wall and positioning the holes to different heights, the teacher can define a task in which the child must make his pitch rise or fall by specific amounts within a certain time interval in order to be able to get the ball into the basket. The positions of the holes and their widths (in Hz and fractions of an octave, respectively) and the distance of each wall from the starting position (in milliseconds) are displayed on demand.

*All of the figures representing displays in this report were made by taking Polaroid snapshots of a "slave" oscilloscope that shows a duplicate, in miniature, of the display at the teacher-student station.

Data from the pitch extractor or nasalization circuit and the filter bank are sampled by the computer 100 times per second, and used to generate a variety of visual displays. These data are stored in a ring buffer that has a capacity of 200 samples; thus the system preserves a running record of the last 2 seconds of speech. This record can be "frozen" at any time, and the captured data can be used to maintain a display for leisurely inspection or for the making of measurements. An audio tape loop, which also records the last 2 seconds of speech, can be stopped and replayed on command. Control inputs from the user are given to the computer via a set of push buttons and knobs.

Displays

Displays are generated by four independent programs, which we refer to as: (1) ballgame, (2) vertical spectrum, (3) cartoon face, and (4) time plot.

Ballgame

The intent in developing the ballgame program was to implement a display that would motivate a young child and permit him to develop some speech-related skills in a game-like situation. The game starts with several balls positioned in the lower left corner of the display. When the child starts voicing, a ball begins to move at a fixed rate toward the "wall" at the right of the display, its height being determined by the value of some parameter of the speaker's voice, for example, its pitch. The child's task is to make the ball go through the hole in the wall. If he succeeds, the ball drops in the basket that is positioned to the right of the wall, and a smiling face appears in the upper right corner of the display (See Fig. 4a).*

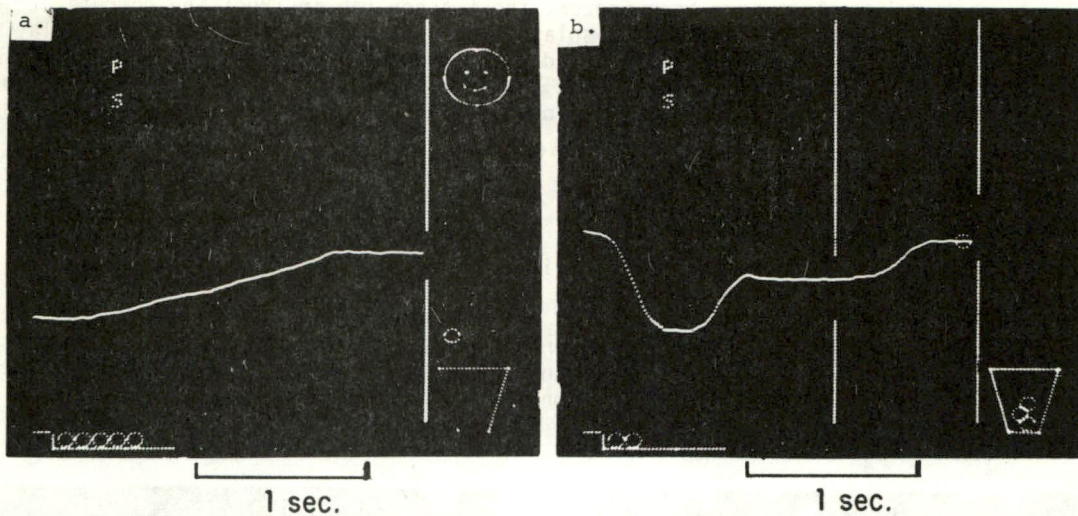


Fig. 4. Ballgame display. Left: successful attempt with one-wall display. Right: fourth success about to be achieved with two-wall display. The P and S at the upper left of each display indicate that the parameter that is being displayed is pitch and that the speaker who is producing the display is the student.

The operation of the vertical-spectrum display is illustrated in Fig. 5. Each shape in this figure is determined by the frequency spectrum of the sound from which the shape is generated. The width of the shape at a given height is proportional to the energy (on a logarithmic scale) within a specific band. Voiced and voiceless sounds are distinguished by the presence and absence of the horizontal lines, respectively.

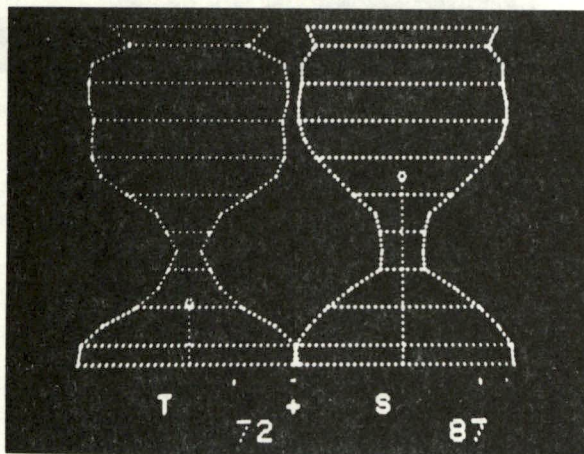


Fig. 5. Vertical spectrum display. Left and right figures produced by male and female speakers, respectively, during utterance of the vowel /i/ in the word "be." The T and S below the shapes identify the teacher's and the student's displays, respectively.

The pitch of the speaker's voice is represented by the length of the "lollipop" rising from the center of the base. Note that in the example shown in Fig. 5 the two shapes, both of which represent the vowel "eye," are quite similar in spite of the fact that the left one was produced by a male speaker with a fundamental frequency of about 100 Hz, and the one on the right, by a female speaker with a fundamental frequency of about 210 Hz.

The right-hand shape in this display changes continuously as the student speaks, unless he is sustaining a steady sound. The shape on the left may be used as a standard that the student may be asked to match. In order to generate a standard, the teacher makes a sound and freezes the display by pressing a button when he has produced the desired shape. The student's (right-hand) display may also be frozen; and it may be transferred to the left side of the display where it can serve as a standard for future attempts at matching.

Whenever these displays have been frozen, the teacher can instruct the computer to replay either stored speech sample, and to redisplay it as it is being replayed. The replay can itself be frozen at any given point and inspected frame-by-frame, if that is desired. The numbers below the shapes in Fig. 5 indicate that the replay in this case was frozen with the teacher's display on frame 72 and the student's on frame 87. The total number of frames in each sample is 100.

Cartoon Face

The cartoon-face display is illustrated in Fig. 6. The idea here was to develop a display in which several aspects of speech could be represented simultaneously in a single integrated scene. The presence of an "Adam's apple" on the throat signifies the presence of voicing, its height indicates the fundamental frequency of the voiced sound, loudness is represented by the size of the mouth, and the detection of an "s" or "z" is indicated by the appearance of the letter "s" or "z" in the cartoonist's balloon.

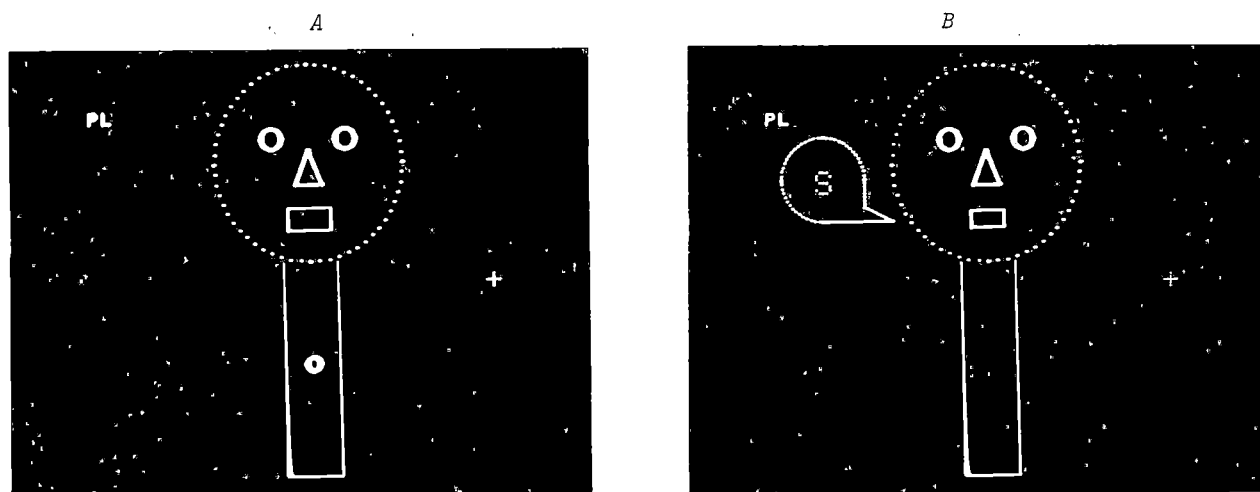


Fig. 6. Cartoon-face display. A: responding to a voiced sample of speech, showing the "Adam's apple" at the position related to the most recently sample pitch, and the mouth opened proportionally to the "loudness" of the voice signal. B: the display during an unvoiced sample meeting the criterion for the "s-detector." The PL indicates that the display is responding to pitch and loudness: the plus sign (+) indicates that the program is ready to accept more speech input.

Time Plot

The time-plot program, which has been used most extensively to date, has the capability for displaying several aspects of speech as functions of time. Pressing a specific button causes a "menu," such as that shown in Fig. 7, to appear on the display. An option may then be selected by pressing another button. The menu shown in Fig. 7 represents the functions that are currently implemented in the time-plot program.

If the user selects the first option on the menu, speech amplitude, or what we loosely call "loudness," is displayed as a function of time. This display indicates the fluctuations in amplitude from one syllable to the next, with minimal during the consonantal intervals and maximal during the vowels.

Selection of the second menu option would result in a display of fundamental frequency, or "pitch," as a function of time. The top trace in Fig. 8 shows this display for the utterance "It's a pencil," spoken with normal intonation; the bottom trace represents the same utterance, but spoken in a monotone voice. Segments of the display for which no points are plotted represent either voiceless sounds or silent intervals. Figure 8 also illustrates the fact that the time-plot program provides for the possibility of representing two utterances on the display simultaneously. Typically, this feature is used for the purpose of providing the child with a pattern to match. The teacher makes an utterance and freezes the resulting trace on the top

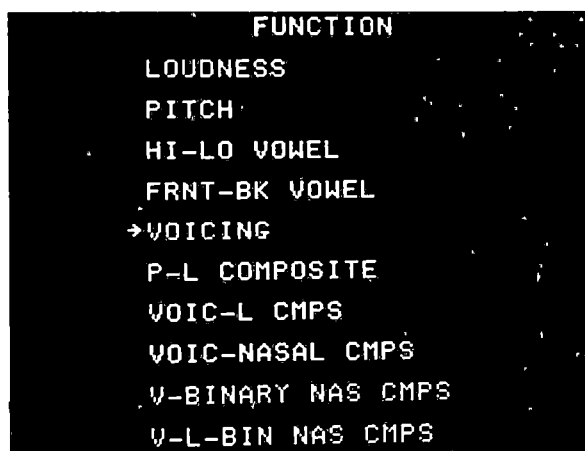


Fig. 7. Time-plot program: function menu.

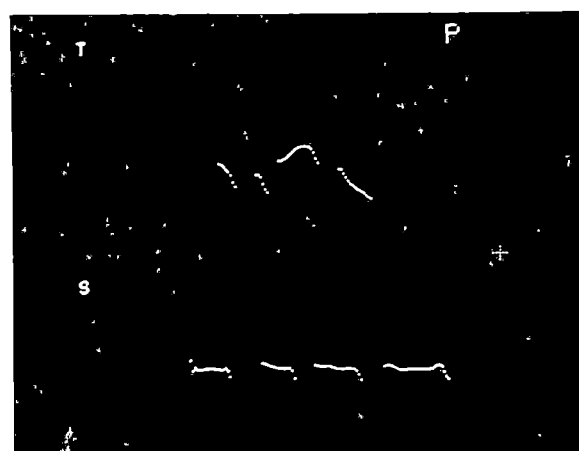


Fig. 8. Displays of fundamental frequency, or "pitch," of the voiced segments of the utterance "It's a pencil," with appropriate intonation (top); with monotone voice (bottom). The T and S identify the teacher's and student's display areas, respectively.

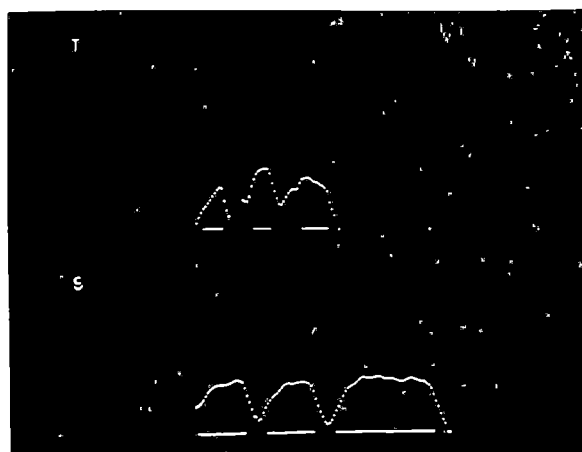
half of the display. The child then attempts to make the same utterance and to match the teacher's trace with one of his own on the bottom half of the display.

The next two display options shown on the function menu, high-low and front-back, were developed originally for use in a system to aid in the teaching of correct pronunciation to learners of a second language (Kalikow and Swets 1972). The high-low function is related to the frequency of the first formant, and the front-back function similarly is related to the frequency of the second formant. The first- and second-formant frequencies are known to be related to tongue height and to the front-back position of the tongue body, respectively (Peterson and Barney 1952). Therefore, these displays indicate approximate tongue position in both the high-low and front-back dimensions.

The voicing display shows a horizontal line whenever voicing is present, and nothing otherwise. This display can be used with suitable utterances to represent timing and rhythmic properties of speech. Typically, voicing is not shown by itself, but in combination with other parameters such as loudness or nasalization as will be explained below.

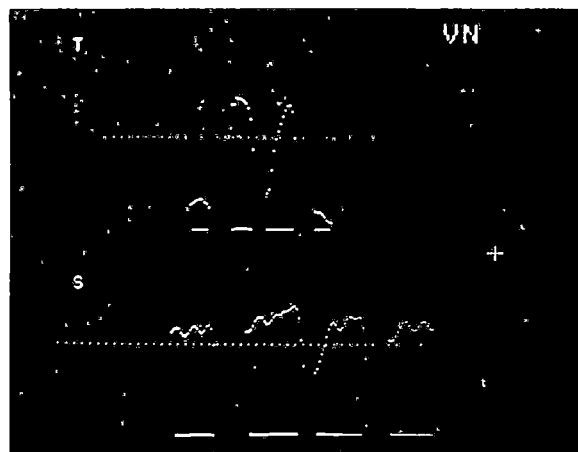
Each of the time-function displays described so far represents a single aspect of speech in isolation. The program provides the user also with several displays of combinations of features. Figure 9 is an example of a display that represents voicing and loudness in combination. The phrase is "the teacher," spoken with a normal temporal pattern (top) and with a slower than normal tempo such as is often found in the speech of deaf children (bottom). This display can be used to show patterns of timing of articulation. Missing or adventitious sounds, and in some cases speech-sound substitutions, often can be seen fairly clearly. Confusions between voiced and voiceless speech sounds also may be detected in this display.

The displays shown in Fig. 10 combine representations of voicing and of nasalization. The nasalization function illustrated distinguishes quite well between nasalized and nonnasalized sounds produced by speakers with normal hearing. The traces shown in the figure represent the phrase "You can drink it." The top trace shows how the display looks when only the nasal consonants and the preceding vowels are nasalized. In the utterance represented by the bottom trace, all the vowels are nasalized. The solid lines below the nasalization functions represent voicing in these displays. The horizontal dotted lines represent "criterion values" that can be adjusted by the teacher. In this example, the contours lie above the criterion line for nasalized vowels and below the line for non-nasalized vowels.



1 sec.

Fig. 9. Voicing-loudness composite displays of the utterance "the teacher," spoken with normal timing (top) and with abnormally slow tempo (bottom).



1 sec.

Fig. 10. Voicing-nasalization composite display, for the utterance "You can drink it," spoken with proper velar control (top) and with all of the vowels nasalized (bottom). Concerning the horizontal dotted lines, see text.

Other combinations of attributes are possible, of course. Figure 11 shows a display that combines loudness, voicing, and nasality, each of the latter two attributes being treated in a binary fashion. A single horizontal line indicates voicing; double horizontal lines bracketing the voicing line indicate nasalization, and the curved traces represent loudness. The nasalization lines appear whenever the nasalization function exceeds a criterion that has been set by the user. Figure 11 represents the same utterance as does Fig. 10 ("You can drink it"), and the criteria were set as indicated by the horizontal dotted lines on Fig. 10. Thus, the bracketing horizontal lines shown in Fig. 11 are associated with those segments of the speech for which the nasalization traces in Fig. 10 rise above the criterion lines.



1 sec.

Fig. 11. Voicing-loudness-binary nasalization composite display for the utterances represented in Fig. 9. The nasalization criteria were set as indicated by the horizontal dotted lines in Fig. 10.

There is little doubt that the features represented in the various time-plot displays that have been described play important roles in the production and understanding of speech. There is a degree of arbitrariness, however, concerning the ways in which these features have been encoded in these displays. The use of time functions has a certain face validity inasmuch as speech is describable in terms of a set of time-varying properties. Moreover, representing time spatially means that the display has a "memory," which makes quite distinct some short-lived aspects of an utterance that might be difficult to detect in a display that represented properties of the speech only for the extent of their duration in real time. A disadvantage in the use of time functions is the fact that many features can be represented simultaneously in an integrated fashion. Showing several time functions in parallel on the same display is a possibility; it is not clear, however, that the viewer can make effective use of such a display. Experimentation will undoubtedly be required not only to determine the relative utility of various types of information for speech training but also to determine optimal ways of encoding that information for visual, or perhaps tactual, presentation.

USE AND EVALUATION OF THE SYSTEM IN A SPEECH-TRAINING PROGRAM

Although the system was developed primarily for use in speech training, it has also been applied to the diagnosis of speech deficiencies, the evaluation of training effects, and the collection of normative data regarding the characteristics of the speech of both deaf and hearing persons. The usefulness of the system for these applications stems from its ability to make quantitative measurements on various aspects of either live or recorded speech. Each of the display programs described above has the capability of producing, on request, values of the speech parameters that are currently being displayed. An additional program has been written for the purpose of analyzing recorded speech.

About 40 students have been given speech training with the aid of the system, usually on a daily basis (20-minute sessions) for periods of 7-14 weeks. The system is used both in tutoring situations in which a teacher instructs a child with its help, and in unsupervised drill sessions in which a child works with it by himself. Tutorial sessions consist of various types of exercises graded in difficulty. The exercises that are used with a given child depend, of course, on what aspect of his speech is being emphasized. In general, however, they include both (1) "vocal gymnastics," in which the student practices such activities as sustaining certain vowel or consonant sounds, producing simple nonsense syllables or sequences of such syllables; and (2) production of meaningful utterances of various lengths, selected to contain the speech gestures of interest. Emphasis is placed on procedures that will help the student to generalize the learned speech skills to new utterances without reference to the display. Use of the system in self-instruction mode is attempted only by students who have had some experience in the tutorial sessions.

We stress again that we do not view the system as a finished product. We expect it to continue to evolve as users gain further insights into how to apply its capabilities to the training problem. We have collected some evaluative data, less for the purpose of establishing the effectiveness of speech training with the system per se, than for that of providing an objective basis for eliminating displays and training procedures that are not effective and for improving those that show promise.

The types of evaluative data that have been obtained include daily and weekly records maintained by the tutors concerning the objectives and accomplishments of the children during individual training sessions, subjective evaluations by each tutor of the overall progress of his students over the course of his training program, objective data on relevant acoustic characteristics of test utterances, listener judgments concerning specific speech features, and measures of intelligibility.

Some of the resulting data have been presented elsewhere (Boothroyd et al. 1974; Boothroyd et al. 1975; Stevens et al. 1974). Briefly, they show that the training that has been done with the help of the system was effective in improving the students' speech in objectively measurable and perceptually detectable ways. Specifically, improvements were obtained in timing (including reduction in the durations of pauses, shortening of the durations of unstressed vowels, and increases in syllable-production rate), in velopharyngeal control, in pitch control (including lowering of pitch range, production of pitch fall at the end of an utterance, reduction in incidence of inadvertent pitch jumps), in voice quality, and in some articulatory skills. The amount of improvement obtained varied considerably from child to child and was greater for material that was used during training than for unrehearsed material

and spontaneous speech. Measurable improvements in overall intelligibility of unrehearsed speech were not demonstrated for most students. We attribute the failure to obtain noticeable improvements in intelligibility in part to the relatively short period of time that was spent with each child, and in part to a lack of understanding of how specific speech features must be modified to realize such improvements. Ultimately, of course, the value of such a system will be judged in terms of its ability to help improve intelligibility and overall speech quality.

On balance, we consider the results encouraging and generally supportive of the idea that the computer represents a potentially powerful tool to apply to the difficult problem of teaching speech to the deaf. It is clear that how effective any speech-training aids will be in practice will depend very much on the specific ways in which they are used. Moreover, as technical developments provide increasingly sophisticated methods for the analysis of speech and the generation of displays, pedagogical uncertainties are likely to come more and more to the fore as the factors that really limit what one can expect to accomplish with speech-training aids. It also seems clear to us that the flexibility of a computer-based system provides opportunities for the type of exploration that is likely to be required to make progress on these types of problems. The sort of close collaboration between researchers and teachers that we have attempted to maintain in this project is also essential, we believe, if efforts to evolve effective training aids are to have a reasonable chance of success.

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The Tufts Non-Vocal Communication Program

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Summary: This paper describes the efforts of the Biomedical Engineering Center in conducting both research and applied studies in the area of non-vocal communication for the severely physically disabled.

Introduction

The application of technology to the field of Rehabilitation Medicine has offered the promise of restoring or assisting physical functioning of a severely physically disabled person. A major area of concentration of the Biomedical Engineering Center has been that population which is prevented from normal communication because of a profound motor dysfunction. The lack of speech and writing skills due to muscle incoordination, weakness, or paralysis is evident in disorders such as cerebral palsy, ALS, traumatic head injury, and stroke. While each of these is medically different, the resultant absence of communication is commonly devastating in terms of the person's social, educational, and vocational life.

The Biomedical Engineering Center (BMEC) has staffed its nonvocal communication project with three engineers, an occupational therapist, and a special educator. The goals of the project are to identify technological means of assisting a person to better communicate, and work within the community in the application of assistive devices.

At the present time, the BMEC is under contract to the Massachusetts Bureau of Special Education to work with special needs programs throughout the state providing this type of technical support. As of this writing, twenty-two special education classrooms have been equipped with electronic devices developed by the BMEC. At the same time, the BMEC is working with other agencies and institutions in examining the communication needs of other disabled individuals. Older people who may have been educated before an accident or the onset of a disease do not require educational support, but may require a faster, more powerful device than would a child who is disabled from birth and is learning language in spite of his disability.

A very difficult situation is the older cerebral palsied person who may have been entirely missed by the educational system. He may be extremely intelligent while lacking the formal language skills necessary for effective use of an assistive device.

In order to meet the needs of a varied population, the BMEC has begun to develop a series of communication devices that span the entire range of communication possibilities. This effort will give the individual a choice of which machine (if any) he wishes to use. The remainder of this paper describes the developments of this program.

The TIC and Related Devices

The Tufts Interactive Communicator¹ (TIC) has been designed as a single switch input typing device that can be operated by a single grossly controllable muscular movement. The need for such an easily operable unit was identified early in the project. While many nonvocal individuals can operate more complex interfaces, the single switch feature finds extensive use with the most severely disabled. The user selects the characters from a visual keyboard that offers rows of characters by successive illumination. A single switch closure chooses the illuminated row, and commands the TIC to scan the characters in that row. A second switch closure chooses a single illuminated character. Once selected, the letter or number is printed on a hardcopy medium, and is displayed electronically. In this way messages are constructed on a letter-by-letter basis.

The TIC that is now in use differs only slightly from that which was developed over 5 years ago. The method of letter selection has proven to be effective and hence is unaltered. The visual keyboard has been rearranged to take advantage of the rank order of characters in the English language. This represents an approximate 30% speed improvement over an alphabetically ordered visual keyboard.

Recent developments in low power electronics have offered the potential for battery operation of the TIC. Since funding for redesign of this device was not readily available, the program staff proceeded cautiously, looking for an appropriate time for a design change.

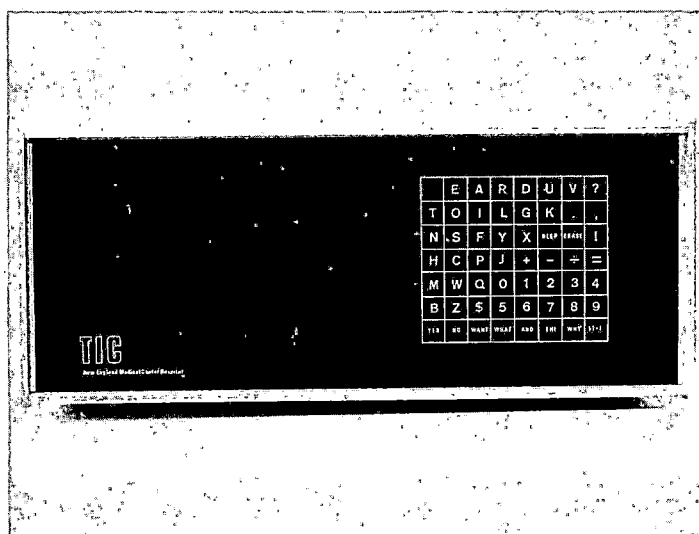


Fig. 1 Front Panel of the TIC

The current equipment modifications are actually taking place in two directions. The present TIC offers a 32 character electronic display, and a paper strip printer. These functions are being transferred into a smaller, portable unit with an operating life of eight hours before recharging is necessary. The existing TIC, for which a large price has been paid for tooling development, will simultaneously be upgraded into a more powerful communication tool. This device will offer a complete video display that can be edited and modified by the user. The corrected text can then be "dumped" onto a typed page. This will provide the flexibility required for academic and vocational activities.

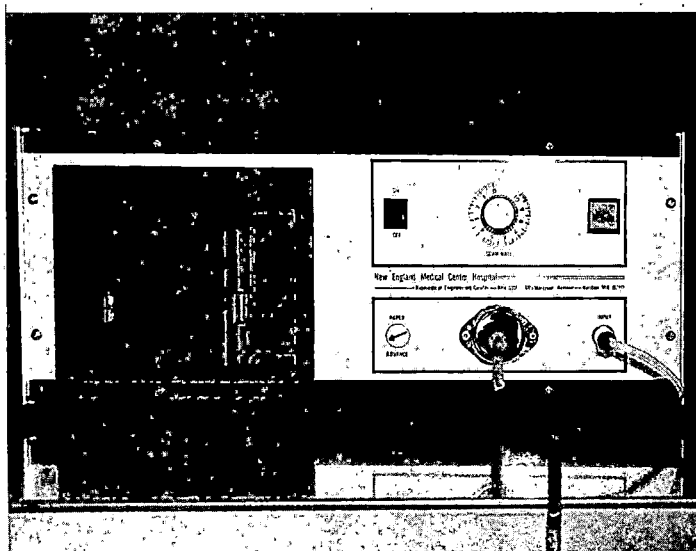


Fig. 2. Rear Panel of the TIC

The Dictionary

Each person who communicates through written or spoken language tends to use a vocabulary that is smaller than that actually at his disposal.² This may be evident in conversational idioms, or in key words or phrases (i. e., jargon) of a geographical location, or business environment. Part of the Non-Vocal Communication Program's activities has been to identify ways of shortening the user's time involved in transmitting a message. The method chosen has been to incorporate a dictionary of 400 words or phrases that can be custom programmed into a personalized TIC. The new circuit card can accommodate four increments of 1000 letters. Therefore the complete dictionary will consist of no more than 400 entries whose total length is no longer than 4000 letters. While this provides an average of 10 characters per entry, the actual word or phrase lengths will be independently set.

The selection of such a large number of entries offered a challenge in the design of a visual keyboard. The magnitude of a 456 entry keyboard (400 words + the standard TIC keyboard) would prevent efficient use due to long scanning times. An encoded method was determined to be the desirable approach. The bottom row of the TIC keyboard is designated with the numbers one through eight, indicating dictionary page numbers. Each character of the existing keyboard will represent a different word on each page. Selection of a word is accomplished by first choosing a page number, and then the appropriate keyboard character. The desired word will be taken from the dictionary memory and displayed on the output device.

Anticipatory Communication

An important consideration in the application of a communication device is the speed with which its operator can make an output. The rate of output is limited by both the user's input time response, and the size of the scanned visual keyboard. Although the vocabulary and verbal skills of the user are expected to improve with training, the physical input cannot be expected to do the same. Disabilities such as cerebral palsy do not generally change dramatically and will most likely require the user to use the same grossly controlled input motion for his lifetime. ALS is a progressive disease and will result in a loss of motor control over time.

As can be understood from above, the easy solution of "speeding up" the scan rate is impractical. Improvement cannot be found in reducing the keyboard size since the TIC keyboard contains essential entries for alphabetic and numeric output as well as punctuation and arithmetic symbols.

A major effort of the BMEC has been to study the application of language redundancy to this rate problem. Results of the project have shown a theoretical improvement of approximately 50% over the standard TIC. Present studies are focusing on the display techniques that will maintain this level of improvement when the device is used by a human operator.

Based upon knowing no prior characters $p=.19$
 Based upon knowing 1 prior character $p=.28$
 Based upon knowing 2 prior characters $p=.40$
 Based upon knowing 3 prior characters $p=.51$

Fig. 8. Probability of Correctly Predicting the Next Character to be Typed

The current state of the research has yielded a prototype device appropriately named the ANTIC (Anticipatory TIC) which predicts the six most likely letters to follow the letter most recently chosen. This prototype is being studied with the assistance of a high-level spinal cord injured client who is providing valuable information on its acceptability as a working design. In order to reach the 50% improvement, the statistics on letter frequency will be based not upon the single prior choice, but upon the three previous selections.

Symbol Communication

All of the above devices require that the user have the ability to spell, or at least recognize words from the dictionary. Within the Nonvocal Communication Project there has been

identified the need for a less sophisticated device that will identify locations rather than character symbols. The solution to this need has been a small relatively inexpensive device that offers the user the choice of 8 or 48 squares. Filling these squares will be symbols, letters, or pictures attached to small plastic clips. The same type of switch as is used in the TIC or ANTIC can stop the scanning at a particular symbol and cause the light to flash as an indication of choice. The Symbol TIC or SYMTIC scans the eight squares in a linear fashion, or scans the 48 in a row column manner. There is no printout provided in the unit. The SYMTIC is envisioned as a teaching tool for early intervention with nonreaders and can be used with various teaching systems such as the Peabody Rebus Reading Program⁴, or the alternative language programs like the Bliss Symbolics.⁵

Symbol Printing

The principal difficulty encountered with the SYMTIC is its lack of a printed output. This prevents the user from communicating independently since his listener must remain within viewing distance.

The BMEC is trying to rectify this situation by developing a printing unit that will reproduce graphic symbols. The Cryptographic TIC or CRYPTIC will initially be programmed for use with the Bliss Symbols and will be assigned to the Vermont Achievement Center in Rutland, Vermont.

Electronic Letterboard

The devices described throughout this paper have been operated by a single input switch. Many nonvocal individuals are capable of greater interaction with a machine. Letterboards have been commonly used by those clients who have some residual pointing ability or the use of a headpointer. Letterboards⁶ have the advantage of being inexpensive and entirely flexible since they are only paper on which a teacher or clinician writes words and letters or draws pictures. The locations of these objects can be determined according to the physical abilities of the user. Midline crossing problems, hand preference, or varying dexterity can be minimized by the proper placement of the symbols.

Electronic conversion of these letterboards has not been able to offer the same flexibility. Expanded typewriter keyboards offer a fixed arrangement that

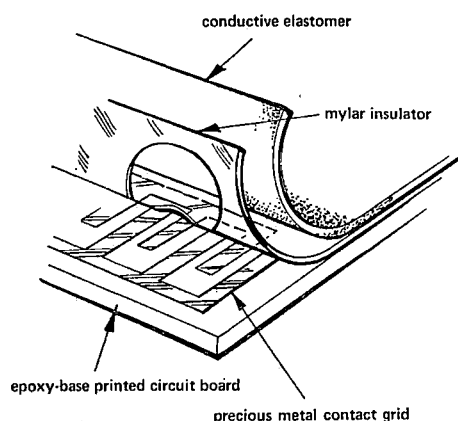
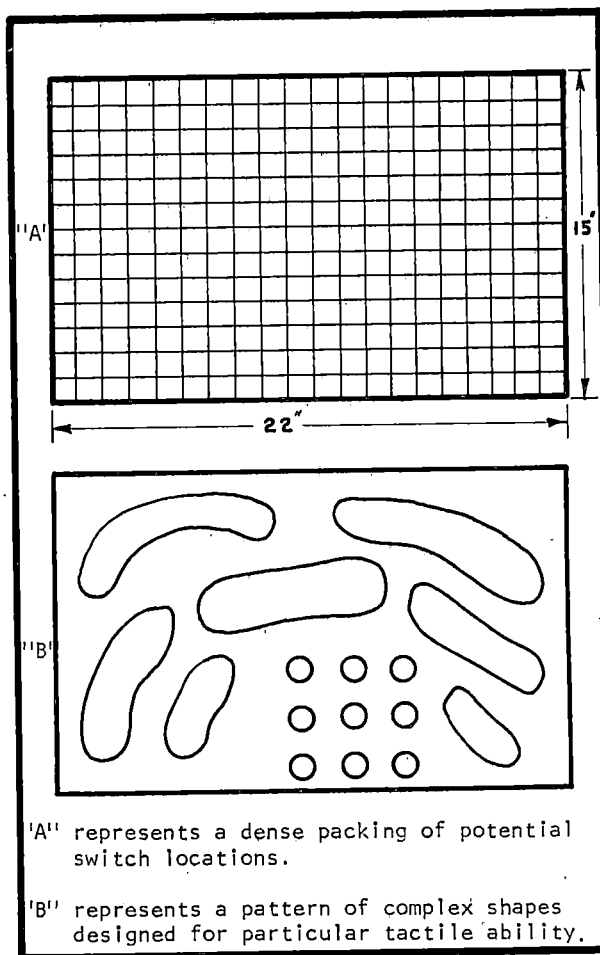


Fig. 4. Elastomeric Switch Structure



'A' represents a dense packing of potential switch locations.
'B' represents a pattern of complex shapes designed for particular tactile ability.

Fig. 5 Samples of Complex and Custom Tactile Communicator Layout

may often be unsatisfactory to a user. Varying the size of that keyboard or even changing the size of the switches becomes a major mechanical task. The Autocom⁷ from the University of Wisconsin offers an attempt at flexibility with several optional arrangements of the magnetic proximity switches.

The BMEC has contracted with the Flex Key Corporation of Gloucester, Massachusetts for the fabrication of a flat switch panel that measures 22 inches by 15 inches and contains 4000 switch contacts arranged in a honeycombed grid. The Flex Key Corporation has graciously donated the engineering time required in the design of the switch panel.

The switching mechanism is a proprietary process owned by Flex Key and utilizes the properties of a conductive elastomer. The entire panel consists of a large printed circuit card and a layer of elastomer separated by a mylar insulator. The entire panel is approximately 1/8 inch thick.

The switch contacts are 0.25 inches in diameter on 30 inch centers. Assuming that the smallest object pointing to the panel will be a human finger, at least one of the switches will be closed when the panel is touched. Once the switch closure is made, the X and Y coordinates of the contact will be detected by external circuitry. The force required to register an input is less than 10 ounces. The switch movement is 0.005 inches.

The external circuitry is now being developed and will allow the teacher or clinician to define clusters of switches as words or letters. In this way a totally flexible letterboard surface may be custom designed to meet the user's needs. The logic circuitry will identify the appropriate input and operate the same type of printing devices as are already in use in the TIC.

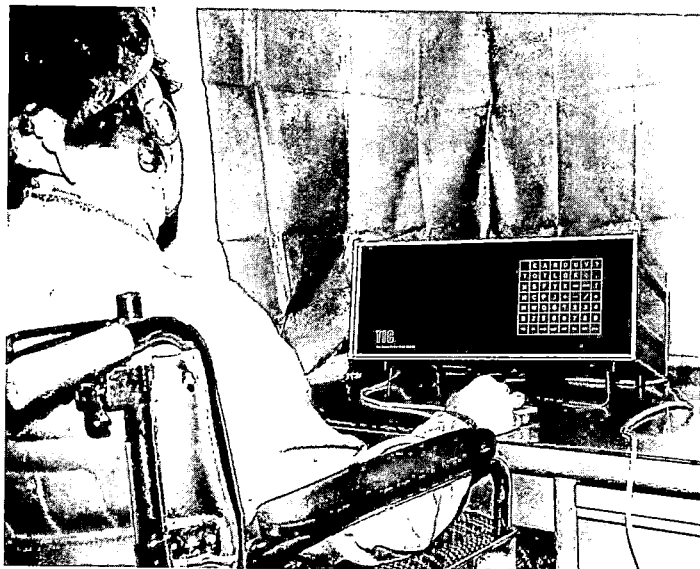


*Fig. 6. Tufts Interactive Communicator
in Clinical Setting*

Technology Utilization Project

The Biomedical Engineering Center has felt an obligation to make available the results of its research and development. This has already been evident in the project within the state of Massachusetts. Other devices also have been made available to individuals and institutions for use in their own programs. The BMEC tries to maintain contact with these sites and provide any possible assistance. All devices have been offered as a service of Tufts-New England Medical Center and are made available on a non-profit basis.

Acknowledgement

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Research Needs Related to Science and Technology
for the Handicapped

Max W. Mueller
Bureau of Education for the Handicapped
United States Office of Education
Washington, D. C.

The importance of science and technology for the handicapped is demonstrated amply by the level of interest in evidence at this symposium, and with the growing interest and activity relating to this area. It is critical that research and development activities keep pace. What follows are personal perceptions that have not yet been translated into research plans or, more importantly into the funding policies of the Bureau of Education for the Handicapped (BEH). My own background necessarily limits my comments primarily to educational research needs in terms of technology and the handicapped. Keeping these two limitations in mind, this paper will note the data sources from which these perceptions are drawn, identify a few major issues, discuss several overarching needs, and mention a couple of non-needs.

In terms of data sources, my perceptions have grown from conferences, research integration projects, ongoing projects supported by BEH and other federal and nonfederal resources, interactions with experts, and the analysis of proposals that the BEH receives. Over the past year the BEH has sponsored five major conferences designed to establish what research needs to be done to provide better education to the handicapped. The participants in these conferences were, in addition to researchers, practitioners and consumers. By bringing these people together, BEH hoped to develop many ideas directed at the primary needs in education of the handicapped. In each conference technology and science emerged as important issues. Additional input came from federal projects that we call "research integration projects," and analysis of ongoing projects identified additional needs. Another kind of input we seek consistently is the opinions of experts in the field. This continuous input is received not only from experts in technology, and special education research but also from teachers, counselors, and from the handicapped themselves. Finally, one of the best ways to identify needs is to look at proposals received by BEH. Overall, a wide range of experts consistently provide input in terms of ways to get the most out of federal program money directed to technology for the handicapped.

Five major issues relating to science, technology, and the handicapped can be identified in almost all of these sources of input. The first is the need for better science education for the handicapped, particularly for the mentally retarded, who for many years have been considered incapable of learning in any science. Today, BEH supports research and curriculum development in science for the mentally retarded. Blind or orthopedically handicapped children frequently have also been at a disadvantage in science education because of the lack of adequate tools, instrumentation, and so forth. This appears to be a fairly significant need.

The second issue that emerges is career opportunities in science and technology. We are studying occupational opportunities, the limitations of certain occupations on certain disabilities, and the occupational training of the handicapped in a much broader range of fields.

The third area we identify is delivery of service. Here there is need for more coordination, research, and development in terms of the various technological assists to delivery of educational services to the handicapped. The Boston educational television station has been one of the leaders in providing special programs for the deaf. The BEH currently is supporting a variety of projects in telecommunication techniques in the delivery of educational as well as other services. I understand that the National Institute of Education and the National Science Foundation also are interested in supporting this work. The fourth issue is the use of technology for classroom use vs. individual use. Cost is a major factor. Devices for institutional use may be possible and economically feasible in a fairly short term, where as individual use may take longer. We need to look closer at the feasibility of modifying or adjusting technology so that it is useful both in the classroom and to individuals.

A fifth major dimension of need in terms of technology and the handicapped is the application of technology to circumvent a disability that might develop into a handicap. Three major areas of this type of technology have come out of our research planning as areas that need further work: (1) Reading machines appear most promising for the visually handicapped including those that are visual to tactile, such as the Optacon and Argonne Braille Translation and Storage machines; visual to auditory, such as The Kurzweil and the Stereo-Toner; and visual to visual, such as Randsight. Since the vast majority of visually handicapped persons are not completely blind, additional work on designing a Closed Circuit TV unit for very low-vision persons, design and testing of better overhead projection-type devices as reading aids, and even new development in the area of lenses is necessary. Also for the visually handicapped, mobility devices need additional work. (2) For those with hearing impairment, additional technology and training is needed in visual presentations of speech such as the efforts of Bolt Beranek and Newman, Inc.; tactile presentations; and better use of residual auditory techniques or auditory skills that use technology. (3) In assessing the needs of the orthopedically handicapped, areas that need attention are aids in mobility, communication, and environmental control, a little broader issue for which many of the communication devices are well adapted.

Overarching these issues are five major needs relating to full implementation of technological advances in services for handicapped persons.

(1) Coordination. These needs relate to coordination among researchers, developers, providers of services, and consumers. Too often researchers and developers, in trying to get appropriate input, have left out the important element of personnel who serve the handicapped such as special education teachers, rehabilitation counselors, speech therapists, occupational therapists, etc. Often developers may have very good input from a blind person when in reality they are developing a machine or technology that has to go through a teacher of the blind, a dimension frequently ignored. Another area that is critically important is coordination among developers. This perhaps is illustrated by the example that was mentioned: if you carry it to its simplest level, most of the devices require some kind of input, technical processing, and this results in various kinds of outputs. The TIC, the Autocom, and the Cybercom are designed to meet similar needs of similar populations. Rarely can the best input from a given device be matched to the processing of another one and further matched to the best output from another. Coordination among developers so that one developer's work on input could be more directly related to another's output would be advantageous. There also is a need for coordination among federal agencies. In addition to BEH, technology for the handicapped is funded by the National Institute of Education, the National Institute of Neurological and Communication Disorders and Stroke, the Rehabilitation Services Administration, the National Science Foundation, the Veterans Administration, and probably others.

(2) Cost analysis. We need to look carefully at cost factors in terms of all research and development activities. We should not get too far into development, no matter how promising, unless long-range cost effectiveness can be judged favorably. Cost analysis also is essential in the allocation of research and development resources.

(3) Marketing. First, the cost of devices designed for the handicapped must be reduced so that they are within the reach of institutions and individuals. A better system for making known the availability of devices also is needed. The BEH is developing a marketing program to assist developers in reaching appropriate markets. There are several institutions around the country where a fairly large sampling of available hardware-type devices is available for both rehabilitation counselors and teachers and the handicapped themselves to see and try out. But on the whole, very little effort goes into marketing at this time.

(4) Training. It appears from the information available that technology is far outstripping the ability of both the handicapped themselves and teachers of the handicapped to make optimal use of it. The need may be as great for better teacher training and student training techniques as for refinements in the technology.

(5) Adaptation of technology. There is a need to adapt teaching technology related to hardware technology rather than to start over from scratch at every point.

Finally, I want to close with three things which I see in my role as federal reviewer of proposals for funding. First, we get many proposals for gadgets for serving the handicapped which the handicapped don't perceive as a need at all. I think one of the needs among developers is to look at that audience/community very early in the developmental stage rather than somewhat later. Many developers of technology for the handicapped fail to do this. Secondly, we see many efforts which are focused on too small a need. Using the reading machines for the blind as an example, imagine a blind student getting to college. He may need a Kurzweil reading machine in order to read textbooks. When he goes to the bulletin board he needs a Stereotoner to read that material. If he has a hearing loss he may wish to change to the Optacon for the purpose of reading and on and on until the cost of hardware is prohibitive. I see many solutions listed for various minute sorts of things where a total educational program for handicapped persons might require twenty or thirty different devices when in reality a few general purpose ones would serve the same purposes. Finally, let us look at one "non" need in the field of education of the handicapped. We should take a very careful look at any of the kinds of things that we do with technology to assure that they do not further stereotype the handicapped person. Each advance must be to his advantage educationally, economically, and psychologically.

Policy: Where Do We Go From Here?

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Dr. Mueller touched on most of the points I intended to cover, so I need only enjoy myself with you. So, first, with respect to the accent of the Kurzweil reading machine which has been demonstrated and referred to by Dr. Mueller. It is clearly Swedish and that is appropriate given the role of Sweden in our time as a leader in social planning and societal order.

Second, I'd like to tell you a story told by Elting Morison in a book called Men, Machines and Modern Times. Its relevance to technology for the handicapped may not be immediately apparent. It had to do with the introduction of continuous-aim firing in the U. S. Navy. When two ships are going in different directions, at different rates of speed, up and down at different frequencies, and one of them is trying to hit the other with a gun, how does one ship's personnel keep the gun trained on the other ship? In Teddy Roosevelt's time the Navy had a quite complicated and very heavy set of gear machinery and a highly trained gunnery crew. Behind the gunnery crew stood a more highly trained and very prestigious gunnery captain who shouted out orders "10° to the right, 3° to the left--Fire!" And once in a while the shell hit an enemy ship. In the Pacific sector, there was a Commander Sims, who put together two existing elements. One was: "let's take advantage of the inertial movement of the ship--the fact that it's already moving," and the other was: "let's let the moving parts of the gun move through the sight so that you can put your eye to the sight." There was a sight on the old device, but no sailor would put his eye to it because of the recoil. Combining these rather simple technologies, Sims was able to produce a device that one man could operate alone. One person, in the Pacific theatre, with his eye against the sight, increased the firing accuracy by 300%. Sims was so delighted with this development that he wrote by special messenger to the Naval Department, in Washington, D. C. and received no answer. He wrote again; and again, no answer. This might have disappointed lesser mortals but it did not disappoint Sims because he was a rather peculiar character. He was ornery, persnickety, took to authority very badly, and was disorganized and hard to manage. He used the informal system; he was a sort of organizational criminal. He so harassed the Navy Department that it agreed eventually to test his device. It was taken to Washington and strapped to a solid block and, of course, deprived of the inertial motion of the ship it failed. This proved to the Navy's satisfaction that continuous-run firing did not work. Sims contacted Teddy Roosevelt who was intrigued with the device and rammed it vertically down the Navy's throat. As a result it was adopted in both Atlantic and Pacific theatres and there achieved the 300% increase in accuracy.

The question that Elting Morison asks about this is why the Navy resisted this obviously sensible technology? His answer is that it was not due to Bourbon distemper of the military mind, but that in fact the Navy was quite sensibly attempting to conserve something absolutely crucial to the organization of the ship, namely its hierarchy and structure. When one replaces a prestigious gunnery captain and a highly trained gunnery crew of eleven people with a piece of simple technology that one man can operate, the effect is a massive onslaught on the hierarchy, the structure, the theory, and the morality of the Navy. The Navy was in effect protecting itself, by what seemed like stubbornness.

The dilemma is that the sensible self-maintenance that keeps any organization from falling apart amounts to stupidity in the long pull. And the question is, how is it possible for organizations to adapt to new technological capacities without flying apart at the seams.

Let me make a bridge to the field of the handicapped. Some of the veterans who came back from the European theatre of World War II were blind. Many of them were parachutists who had been blinded by a shot in the head; some of them were sent to Valley Forge. They were young, and vital. The concept of blindness at the time of World War II, and the blindness technology associated with it, has been described by Robert Scott in The Making of Blind Men. A blind person was regarded as someone with limited ability to move and to interact with others; he employed a heavy, white, wooden orthopedic cane.

At Valley Forge there was a young physical education instructor named Richard Hoover. Hoover's interest in increased mobility for the blind led him to invent a long cane, more like an antenna than a supportive orthopedic device. It was a measuring instrument which, when oscillated in front of a moving person, was capable of feeling out and sending back information about the environment. Hoover invented that device in response to the needs of GI's back from the war who pounded on the commanding officer's table with their wooden canes and demanded a degree of mobility and freedom that was not then within the lexicon of responses to the blind.

The antenna-like device was an invasion of the blindness system which, like Morison's ship up to that time, had protected itself against technological innovation. The invasion was provoked, on the one hand, by World War II with its new crop of blind sassy demanders and, on the other hand, by an outsider and physical education instructor, who was not bound by the lexicon of possibilities for the blind.

I think the pattern of technological innovation is basically a pattern of warfare because there is no such thing as a technological vacuum. The new technologies that are being developed are not being put into vacuums. They are being put into technological plenums, and in those plenums they are replacing and driving out other technologies. Therefore, this is a kind of technological war we are seeing. The basic pattern of the war, I think is illustrated by the Morison story and by the Hoover story, that is, that technological innovation generally occurs by invasion and subversion. But certain prices must be paid for this. For example, technologies have a hard time getting in and getting out. In both cases, inertia is the penalty that society pays.

The most interesting question is that of alternatives to technological innovation as a war game played by innovators and resisters. It would be interesting--it may be even necessary--to try to convert the process of technological innovation and development into a process of inquiry among those concerned with the process rather than the guerilla warfare it now appears to be.

If it were such a process of inquiry, what would be the central questions that it would have to confront?

One question I think is "For whom?" Ideas about the population of the blind die hard. In the field of blindness, which is the one area of handicap that I've studied, there was a stereotyped view that the blind were all of working age, with the single handicap of total blindness. But in the period between 1960 and 1970 it became clear that the legally blind were, for the most part, over the age of fifty-five and, were for the most part, women. They tended to have handicaps other than blindness; almost all of them could see, and therefore approaching them in terms of the stereotype of the totally blind was rather dramatically mismatched to the properties of that population.

So there was a kind of inertia characteristic of self-maintaining systems, in which technologies hit the system, but also with respect to beliefs about the characteristics of those it presumed to serve.

The second question is, "To what end?" The Hoover cane is a very simple piece of technology. Its elegance consists not in the complexity of its components but in the elegance of the idea. I would argue that the major technological aids for the blind in the last fifty years have been the cassette tape and the Hoover cane. I am not sure that everyone would agree with that. But if I am right, those two technological aids raise some questions about what it is we want to achieve with technological development. I think there is a two-fold problem. One has to do with the concept of technological imperative; scientists and technologists tend to want to develop science and technology because of the imperatives embedded in their own disciplines. Much of that work is understandable in terms of a very simple set of ideas. I think these technologies are concerned with the conversion of information from one medium to another. For example, the mapping of tactile marks upon visual domains; the mapping of visual domains upon auditory domains; and the mapping of kinesthetic or motion information upon visual or auditory domains--this is what this technology is about. And it is no accident that scientists and technologists are able to contribute at that level because of what is happening to information processing technology, mark-sensing technology, and communications technology at this time in our history. So there is a meeting of two imperatives: on the one hand, what scientists and technologists find it exciting to do, and on the other hand, what has some relevance to the needs of the handicapped.

But it does not follow that the technological imperative is necessarily the imperative of use, nor does it follow that the imperative of use requires high technology. This is a major question. The problem is rather like the problem of technology for developing countries. If we want to provide technology for Colombia, should we ship them our most sophisticated tractors and agricultural and chemical fertilizers on the theory that what is good for us is good for them? Or, as has been suggested, should we send plastic washing machines that women can take down to the river and use?

The dramatic example is the computer versus the lap tray. I really liked the lap tray. I do not want to cast aspersions on the computer, but I thought the lap tray was really first-rate. In terms of its simplicity, its low cost, it would be interesting to compare the marginal benefits to the user from what was achieved with lap tray technology alone from what was added with high technology and electronic backup. Now I do not have an answer to that question and I am not arguing for the lap tray to the exclusion of the computer. But sometimes very simple pieces of technology have the benefits of replicability, ease of use, reliability, and are in harmony with existing technological systems. For those reasons they have a lot going for them and ought to be compared carefully with higher technology.

The other component of the question, "To what end?" is the problem of assessing needs. I think "need" is the second most nefarious word in the English language because it suggests that there are such things, and there are not. If in the period of horse transportation you were looking at "needs for transportation," you would have discovered needs for horseshoes that lasted longer and needs for hay that went further and needs for horses that could run three stations rather than two, but you would not be likely to discover needs for automobiles. A person's ability to express a need is a function of the person's structuring of the world. One's structuring of the world influences his idea of what things are. When we ask him to formulate needs, we are asking him to make an implicit judgment about the state of technology. Why should we expect him to be able to do that? We are really asking him to make an invention without saying that. It is an interesting idea to ask users to make inventions but it is different from asking them to reflect on what their needs are. In general, people can only say what they need in terms of what they have already. But the sense of "need" which could lead to a real discovery or to a technological development, is very questionable. I do not mean that as a nihilistic comment. What it argues is that there is a joint inquiry that ought to take place between various actors involved in the lives of handicapped people--the handicapped themselves, first of all; those involved in trying to help them; and those involved in inventing for them. Those transactions should aim at getting beneath the experiences, try to describe the experiences of living. The mere description is an extraordinarily difficult and complex task, and ought not be reduced to the simplicity of looking for needs. That in itself is a major challenge to research in this field.

There is a third question, "Who shall get it?" Could we live out a national policy based on the assumptions underlying the investments that we are now making? That question is interesting because of what it implies about the goals and our assumptions about people implicit in the technological work itself. For example, what assumptions are we making about the kind of independence that we want to produce through the technology that we develop? Are we assuming that we wish to help people become independent of anyone? Are we assuming that we want to help people become more effectively dependent upon some? Are we assuming that we do not want to change in any way the dependence of the people we are trying to help?

What is the trade-off between funding more sighted readers and providing more reading technology? What is the trade-off between providing more sighted guides and more mobility technology? That question should be answered and the spectrum of answers to the the question of dependence and independence be examined. I have the feeling that these simple questions can have a massive and radical impact upon the courses of technological development that we choose to pursue.

Eliminating Architectural and Transportation Barriers

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Architectural and Transportation Barriers Compliance Board
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According to Albert Einstein, "All that is valuable in human society depends upon the opportunity for development accorded the individual." In the case of disabled individuals anxious to enter the scientific professions, this opportunity for development means an accessible environment in which employers too are free of attitudinal barriers.

The U.S. Department of Health, Education, and Welfare (DHEW) estimates that there are 41 million handicapped people in the United States today to whom such opportunity is potentially limited. This is approximately 20 percent of the population. According to DHEW, a handicap is a "chronic or permanent defect representing a decrease in or loss of ability to perform various functions, particularly those of the musculoskeletal system and sense organs." However, this definition by DHEW does not include those who suffer a temporary disability.

In 1971 an estimated 62 million Americans (30 percent of the population) had an accident in a car, in an office or factory, or in the home that prevented them from functioning in a "normal" manner. Ironically, this means our environment is designed for the elite 70 percent of the American population--the "normal" men and women.

The "normalness" of the environment is most evident in university and college settings. Students are a special group of the general population with respect to age, residence, socioeconomic status, nutrition, and intelligence. Additionally, they probably are physically superior to the general population and they span a narrow age range, most frequently in the late teens and early twenties. This poses important questions regarding the middle-aged who return to school to retrain for a third or fourth career, and this group promises to be a predominant element in our post-industrial society.

Age, capabilities, and capacity for tolerance are becoming increasingly diverse. These factors, coupled with an environment designed for the 70 percent "normal" population, create a multiplicity of circumstances that make participation and enjoyment difficult for many and impossible for an all-too-large percentage.

The Architectural and Transportation Barriers Compliance Board (ATBCB) views its responsibilities in terms of alleviating the adaptation required of the individual to function in an environment. The ATBCB was created by Congress in 1973 as an enforcement mechanism and compliance agency to ensure implementation of and adherence to existing statutes which require federally funded buildings constructed after 1968 to be accessible to all. Additionally, the ATBCB is responsible for researching innovative approaches to environmental design for all persons. Congress intended the ATBCB to be the major national force for eliminating environmental barriers that severely impede and prevent the mobility, employment, education, recreation, and thus the contribution of millions of physically limited individuals.

The ATBCB is a quasi-independent agency composed of the heads of nine co-equal federal agencies. The Secretary of Health, Education, and Welfare serves as permanent chairman; other members are the Departments of Transportation, Housing and Urban Development, Labor, Interior, and Defense, General Services Administration, United States Postal Service, and Veterans Administration.

There is a permanent staff to support and activate the mission and role of the Board, including a legal counsel. Major divisions include Research and Planning, Compliance, and Public Information.

The AASS has assumed commendable initiatives in its ongoing program to make scientific professions accessible to handicapped persons, including making this meeting place accessible and sponsoring this symposium, providing interpreters for the deaf, publishing conference proceedings in braille, surveying agencies for suggestions in overcoming employment barriers, and many other activities. We would like to encourage the continuation of these efforts and offer our expertise to ensure an effective program.

Within the Board's mandate there are three major areas in which the AAAS could interact with our staff: regulatory, catalytic, and facilitative. In its regulatory capacity, the Board aims at establishing a consistent, comprehensive system for monitoring federally supported construction. The compliance mechanism is designed to ensure that all construction receiving federal financial assistance provides for accessibility to and use by all disabled individuals. To carry out our duty of enforcing standards, we are authorized to investigate any federally financed construction and issue orders necessary to ensure compliance with the law. An order of compliance issued by the Board is final and binding and may include withholding or suspension of federal funds. Through our regulatory capacity, we encourage a federally coordinated approach in developing research, policies, and standards related to environmental barriers.

As a catalytic agent, the Board provides an awareness of the needs and rights of handicapped individuals. By its structure, the Board is able to maintain a broad variety of forums for exchange and interaction between consumers and public and private agencies and organizations. As a catalyst, the Board has the capacity to "spark" the private sector, over which we have no legal sanctions, and we encourage states, municipalities, localities, and private segments to implement the innovations our research produces. In this way we have established permanent working relationships with such organizations as the American Institute of Architects (AIA), National Association of Home Builders, Amtrak, Airport Operators Council International (AOCI), the American Association of Physical Plant Administrators, and the Building Research Advisory Board of the National Academy of Sciences.

The Board is authorized to conduct national public hearings on any subject affecting handicapped individuals. In this way it provides a forum for exchange of ideas from consumers, professionals, and disabled persons, as well as from representatives of the private sector whose task it is to create barrier-free transportation, housing, recreation, education, employment, and in general, living environment.

Further, the Divisions of Public Information and of Compliance of ATBCB have been actively providing, upon request, technical assistance for policy and program development to such organizations as the President's Committee on Employment of the Handicapped. The National Center for a Barrier-Free Environment (which represents the barrier-related concerns of the AIA, Goodwill Industries of America, National Congress of Organizations of the Physically Handicapped, National Paraplegia Foundation, National Rehabilitation Association, Paralyzed Veterans of America, and National Easter Seal Society).

The Board also has a very important obligation as a facilitator. This is accomplished through the identification and supply of supportive policies and activities in both the private and public sectors, financial aid, technical assistance, coordination, consumer representation, legislation, and information. All of these functions are resources essential to significant effectiveness by the handicapped community and its supportive organizations.

The Board completes its facilitating role in part through legislatively authorized investigation, evaluation, and development of alternative solutions to the architectural, transportation, and attitudinal barriers confronted by physically limited persons. We are concerned particularly with barrier problems in public buildings and monuments, parks and parklands, transportation, and residential and institutional housing. We are able to draw on the member agency most responsible and either work with that agency's existing resources or direct it to perform the given task.

The Rehabilitation Act Amendments of 1974 provided for the establishment of a consumer advisory panel, "A majority of the members of which shall be handicapped individuals, to provide guidance, advice, and recommendations to the Board in carrying out its functions." The members of this National Advisory Committee on an Accessible Environment have been assembled and will convene for the first time in May. This panel will facilitate input into the decision-making process by persons most affected by barrier-free design and will provide information, ideas, and experience between consumers and change agents in the federal government.

Major recent activities by our staff may serve to illustrate ways in which the Board and AAAS may work together. In June 1975 a hearing in Chicago was aimed at helping people understand that concerted efforts can effect positive changes toward the removal of barriers to handicapped persons. The hearing created a greater awareness and fostered the development of a permanent relationship between the Board and consumer and industrial organizations. A wealth of information was obtained from the testimony which has been compiled into a two-volume report entitled Freedom of Choice. This report has been submitted to Congress and to the President, and includes major legislative and administrative recommendations. Major among these is a proposal for a national policy to meet the housing needs of the nation's handicapped.

The Board's second annual report also has been completed and we plan to publish it through a local or college library. It summarizes the activities of member agencies and staff aimed at eliminating barriers and ensuring compliance with existing architectural-barrier legislation.

The Board also has been active in Bicentennial planning and transportation. Our Bicentennial-related role is that of a consultant providing advice, guidance, technical assistance, and direction whenever requested. We have reviewed and approved the planned

renovations to the Lincoln and Jefferson memorials and the incorporation of access provisions to Constitution Gardens, and we have identified needed internal alterations to the Washington Monument. The Board also provided guidance in removing site and facility barriers to the handicapped in both the White House and Ellipse areas.

We also have established and maintained contact with government and private officials regarding the establishment of a National Children's Bicentennial Island on Kingman's Island in the Anacostia River near Washington, D.C., to ensure that the park is completely accessible to and usable by disabled persons. Our staff has consulted with the D.C. Bicentennial Commission and with the architect in the development of this facility.

In the area of transportation, an extremely beneficial working relationship has been established between the Board and the AOCI, an organization representing approximately 90 percent of the airports in this country. Recommendations and suggestions were made to the AOCI on how existing airports can be made accessible to handicapped travelers. The AOCI was extremely receptive and has cooperated generously. The AOCI, in cooperation with the Board, agreed to conduct a comprehensive accessibility survey of all its member airport terminals. Our staff assisted in developing and testing an instrument to be used in conducting the survey. The AOCI will supply the information needed to prepare a comprehensive resource book about accessibility provisions at the nation's airports.

Members of our staff have functioned in a consulting capacity with Amtrak officials. Of approximately 435 new cars, 20 percent were to be Amcafe (restaurant) cars which Amtrak officials promised would be accessible to handicapped persons. Subsequent to public viewing, it was discovered that they were not. Working with the Board, Amtrak will redesign and renovate the Amcafe cars and the restrooms so as to provide accessibility. Amtrak officials also indicated that they will work to make all stations on the Eastern Corridor (Washington to Boston) accessible, and include in future grants provisions to ensure accessibility in station facilities.

Many of the Board's activities of the past year are relevant to increasing the accessibility of learning, working, traveling, and meeting environments essential to opening the scientific professions to handicapped persons. Both the Board and the AAAS seek to bring together, coordinate, and share information to make all Americans aware of and concerned about barriers. The Board serves as a catalyst to accelerate efforts throughout the nation to remove and prevent barriers. We are anxious to cooperate with or assist any individual, organization, or agency--public or private.

Ultimately, the Board's objective is an accessible nation where the "opportunity for development accorded the individual" harbors no partiality.

Career Barriers: Discrimination Against the Handicapped

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The history of mankind is the story of triumph of reason over superstition, of knowledge over belief, of fact over prejudice; and the progress of mankind is but the result of that triumph. In every area of human endeavor advancement has come only with the crumbling of the barriers of ignorance. It has been so with science, with religion, with industrial technology, and with human relations; and it is still so today. The struggle for enlightenment and justice has been and is the great issue of the age.

The civil rights movement, which grew in the 1950s and reached its peak in the mid 1960s, and the women's rights movement, which began in earnest somewhat later and is only now reaching maximum crescendo, have popularized the term "discrimination" and focused national attention on human problems long ignored. The historians will note that this was indeed an era of social change, represented by the crumbling of traditional stereotypes and myths and characterized by much less rigid customs and expanding social roles.

Without question, these forces of social change at work in our society have impacted on the lives of each and every citizen--rich or poor, black or white, male or female, young or old. If they have accomplished nothing else, they at least have helped us to be more receptive to new concepts and more suspicious of old notions. It is upon this mindset, this willingness to explore in a quest to discover unknown truths that we place our belief in the future.

I suppose that it is only human for each of us to feel that our particular situation is unique and that our problems are not generally understood by the rest of society. Recognizing this, therefore, I hope you will pardon me when I observe that probably no group has been more victimized by myths and misconceptions than has that group which society generally refers to as "the handicapped."

Since I am blind and since I represent the National Federation of the Blind (a national membership organization of the blind, created, directed, and controlled by the blind themselves), much of what I am about to say will be drawn from the field of blindness, but I think the arguments to be advanced have a much broader application.

To begin with, I contend that the real problem facing the blind today is not blindness, and, in a broader sense, the real difficulty which the disabled confront is not their disability. This is a simple enough thing to say, but how can it be so?

Some insight can be gained by a brief look into our past. The heritage of the blind and the disabled is indeed revealing. In ancient times disease and disability were commonly ascribed to possession of the body by evil spirits, and those stricken were often thought to have given up their souls. The impaired or the seriously ill were considered in some groups to have lost their status in the community and could be destroyed with a clear conscience.

Even in the golden age of classical Greece, the disabled fared little better. Both Plato and Aristotle approved the casting out of impaired children. Among the Spartans, they were left to die in mountain gorges, and in Athens the condemned infants were deposited in clay vessels and abandoned by the roadside.

In ancient Rome the citizens openly sanctioned the practice of drowning defective children and baskets for this purpose were sold in the marketplace. If, by accident, blind Roman children survived into adulthood, they could expect to be sold into bondage--girls as prostitutes and boys as gallery oarsmen.

It is reported further that in 1771 at the annual fair of St. Ovid, in Paris, an innkeeper had a group of blind men attired in a ridiculous manner, decorated with peacock tails, asses' ears, and pasteboard spectacles without glasses, in which condition they gave a burlesque concert for the profit of their employer. This sad scene was repeated day after day and greeted with loud laughter by the gaping crowds.

While we have obviously advanced far beyond such unhappy characterizations, our progress is definitely not in the truest sense complete. We are today still victims of yesterday.

For example, review with me the dictionary definition of blindness. In addition to sightless, Webster notes other common uses for the term: "Blind--lacking discernment; unable or unwilling to understand or judge; made without reason or discrimination, as, blind choice; apart from intelligent direction or control, as, blind chance; insensible, as, a blind stupor, hence drunk."

Virtually all of the connotations of the word "blind," in short, are those of inferiority, incompetence, and even downright stupidity. Since language habits carry revealing associations of unconscious attitudes and values, it is of no little significance that society continues to speak of an unreasoning choice as a "blind choice," and of an insensible stupor as a "blind stupor."

Of course, if this were merely a problem of semantics, we could leave it with the linguists and the lexicographers, but such is unhappily not the case. The barrier is more than one of language and it extends from the far reaches of our distant heritage into the present age of enlightenment and scientific advancement. Do I exaggerate? I think not. Perhaps a case study will prove the point.

Several years ago, when I served as president of our student division, I witnessed a graphic illustration of the attitudinal barriers at work. The case involved a young undergraduate who had applied to Stanford University to do graduate research in the field of history. His name was Frank Graff. His grades were good, and he clearly had the intellectual capacity necessary for a rigorous academic program.

According to Stanford, however, such credentials were not sufficient--not sufficient, that is, if the applicant is blind. The rejection letter which Graff received is a classic. It reads:

Dear Mr. Graff:

I am sorry to have to tell you that the department of history has recommended that you be denied admission to Stanford University for graduate work. I think that I can best indicate the department's reason by quoting directly from the note on the report. "Mr. Graff is a young man of superior courage and quite possibly superior intellect as well. But blindness in a research historian is virtually an insuperable handicap."

The basic problem, of course, is that work on the graduate level involves scanning thousands of pages of material during research work, whereas that at the undergraduate level is more nearly confined to a reasonably manageable body of standard histories and monographs. Your experience as a student in undergraduate history courses is not an accurate indication of the kind of problems that you will face as a graduate student.

I can assure you that the committee in the history department took full account of your statement, including your explanation of how you intend to surmount your difficulties. I am very sorry indeed to disappoint you after what is undoubtedly a gallant achievement on your part, but those involved felt that in this case the kindest path was to prevent frustrations before they occurred, and I myself concur in their views.

Sincerely yours,

How is one to respond to such arrogance? Blindness in a research historian is considered an insuperable handicap. Note the artificial barriers. The basic problem, says the Dean, is that the blind cannot scan vast bodies of printed material, and the assumption obviously is that the sighted can. Never mind the fact that there are thousands of blind persons already competing successfully in the various research professions; this evidence is somehow conveniently ignored.

Beyond that, note the presumption of "superior courage"--this is a common barrier erected in the path of the disabled. The prevalent thinking seems to be that persons with disabilities (while able to perform certain routine and repetitive tasks) are definitely not able to compete with others when it comes to more complex than normal work activities. Hence, ordinary accomplishments--such as graduating from high school or earning reasonably high marks--are met with exclamations of praise and talk of "gallant achievements."

The blind, for example, often are considered marvelous by the sighted when they perform successfully such superhuman miracles as crossing a relatively quiet city street. This thinking imposes on the disabled an unimaginable handicap. If, for example, a prospective employer is overwhelmed when a blind applicant arrives at the scheduled interview at the right

place and on time, and if he begins the discussion by expressing his amazement in great gushes of passionate praise, the blind applicant might just as well dismiss the session as a learning experience because there will probably not be an offer of a job. Consider, if the employer seriously questions the blind person's ability even to get to the job site, he will most certainly have more serious doubts about the actual performance of the work involved.

With this in mind, Professor Jacobus tenBroek (in his own time, himself a scholar in constitutional law and legal history and coincidentally the principal founder of the National Federation of the Blind) replied to Stanford University on Graff's behalf. His letter reads in part:

Graff got in touch with me because though I am blind, I have been in the academic world for thirty years. He has consulted me about the problems of a blind person seeking to enter and to make his way in that profession. I have advised him that there is no reason why he can't do the work, including work in history.

Working with the use of readers undoubtedly presents some problems not experienced by an academician working with the use of his own eyes. The point you particularly mention--the ability to scan--is in some cases a big one. Lots of my seeing friends in the profession, however, can't scan either and proceed very much at a pace that I achieve. Indeed, by necessity the plodder may do more careful work.

In terms of production, I have been able to hold my own with most of my colleagues, having authored or coauthored four books and roughly fifty articles in the journals. Most of these have been on constitutional law and legal history. Nor do I reply solely on my own experience. There are literally dozens of blind persons teaching and researching in the colleges and universities of this country. I am personally acquainted with a good number of them. Some of them are productive; others not so much so, as in the case of our seeing colleagues. Productivity and competence to do research and writing are not, I am firmly convinced, functions of visual acuity but of mental perceptiveness and habits of labor.

I know nothing about the extent to which Frank Graff possesses these latter qualities. Indeed, I would not only be content that you should apply your usual standards, but would insist that you do so. Exclusion on grounds of blindness alone, however, is by everything that I know about blind people and about myself altogether unwarranted--if you will permit me to say so.

Professor tenBroek's response lay bare the actual issue. The question is not whether the blind can scan (or for that matter, whether anybody else, blind or sighted, can scan). The question more legitimately is can we do the work, and the only way to answer it is to offer the opportunity to try.

What Professor tenBroek is arguing is that the Stanford deans have imposed a requirement on the blind which is not imposed on others. Indeed, in the academic world this is a common barrier which arises. When considering the credentials of an applicant who is blind or those of a person with some other disability, the admissions officers undoubtedly reflect on their own methods and attempt to place themselves in the positions of the prospective candidate. This, of course, is unreasonable since these officials seldom, if ever, have any background in the alternative techniques which might be available to the disabled to perform fully the duties of the work involved. The result is the unconscious imposition of a double standard. This done, the only action which seems rational is to reject the application. In fact, according to Stanford, this act of rejection was not only rational, it was morally right, or as they put it, "the kindest path."

Unfortunately, the decision in this case was neither rationally sound nor morally justified. Even so, one does not often like to admit the error of his ways, and those who inhabit the academic world are no exception to his general human characteristic. Thus the dean of the department of history at Stanford replied to Professor tenBroek. In his letter he argued that Graff's rejection had turned on a number of considerations, only one of which was Graff's handicap. On that score, though, the dean stood firm. Here is what he said:

We do believe . . . that an inability to glance through bodies of material is a substantial disadvantage to a man working in history and that it is more of a disadvantage in history than it would be in other academic fields. In some ways Mr. tenBroek's own achievements, which we recognize and salute, are proof of his own personal indomitability and in no sense a reason for discounting the importance of the handicap.

I would observe that the plot indeed thickens. In the first instance, the blind were required to scan substantial bodies of printed material while their signed colleagues were only expected to do the work, no mention of methodology attached. Now we are required not only to scan printed matter, but also to be "personally indomitable," and do I have to point out that personal indomitability is not a condition imposed on our seeing colleagues? The barriers are truly not physical, but they are substantial.

The Stanford response also contains another argument commonly used to support the traditional attitudinal barriers. The contention is that any particular field (whichever one is being discussed) is more impractical for the disabled than most others. Using this line of argument, the potential employer or the admissions officer can tell the disabled candidate to go elsewhere and feel that he has done the poor soul a favor. Of course, what he fails to account for is the virtual inevitability that somewhere there is someone competently performing the task he thought impossible, and thereby proving his apprehensions to be groundless.

These are the thoughts that Professor tenBroek carried in his mind as he responded to Stanford in a final letter. In part, this is what he said:

Professor vanSlyke argues that inability to scan bodies of material is a substantial disadvantage in history, and that it is more of a disadvantage in that field than in others. I concede the first point, but doubt the second. Vast bodies of material must be covered in all the social sciences. In law, the reading is particularly heavy. Even though one is not doing legal research, the practitioner, the professor, and the judge all must keep abreast of the work of innumerable courts, and success in any given lawsuit may well depend upon research competence. Yet there are somewhere between one to two hundred blind persons practicing law in the United States--at least a dozen judges from trial courts to the Supreme Court and a handful or more teachers and scholars. So even though we should admit the disadvantage of inability to scan, it does not follow that this is such a disadvantage as should or does rule blind persons out of the research professions.

What is even more critical in my point of view than the fact that the department decision rests on preconceptions about blindness rather than on actual knowledge is the fact that a test is applied to Graff which is not applied to other applicants. The history department, I am sure, does not examine students in terms of their ability to scan before it admits them. To my certain knowledge there are lots of professors in the social sciences on the Berkeley campus who have a very poor ability to scan, and some of these are in our history department. The same surely must be true of graduate students here and elsewhere.

If, in a meeting of a department in the social sciences or in history, a faculty member should propose to establish a scanning test for all graduate student admissions I think I would be opposed to it on general grounds. The question really isn't can a student scan; it is can he do the work, and this is dominantly a question of intellectual capacity. If he actually produces, who cares what his methods are. But in the absence of a department's adopting any such test to be applied to all students, there can be no justification whatsoever for applying it to particular students, and especially for selecting the students to whom it is to be applied on the basis of general misimpressions about the nature of blindness and its limitations.

I am flattered by Professor VanSlyke's characterization of me as personally indomitable. This is a mode of argument which has always plagued the task of opening employment opportunities for blind people. First, their prospective employer says that it may be possible for blind persons to work in somebody else's field, but not in mine. Then he explains the successful blind people in his field by pointing to their unusual qualities. As a matter of fact, as I have pointed out before, blind people have succeeded and do succeed as teachers and scholars in history, and other social sciences, in law and in many more fabulous fields. A blind person of my acquaintance, over the disbelief and resistance of the faculty, took a Ph.D. in chemistry and is now a research chemist. Another blind person of my acquaintance did the same in nuclear physics. The argument is always the same: it may be that they can succeed somewhere else. What is overlooked in using the argument about exceptional blind persons is the number of them there are and the variety of fields in which they have succeeded. But, in addition, if the successful blind are to be explained away in terms of their particular qualities, would it not make sense for the prospective employer to test for those qualities in the newly appearing blind persons? For example, does the Stanford history department have any reason to suppose that Frank Graff is not personally indomitable?"

As a postscript, I should say that Frank Graff was accepted for graduate work in history at another prominent university, and so far as I know, he has made his way in his chosen career. The issues, though, in this case study are much more general than the personal advancement of one blind student. On trial at Stanford were the blind and, in a broader sense, anyone not possessing the physical characteristics arbitrarily considered requisite to success in typical academic pursuits. Among other lessons contained therein, the Stanford experience validates the theory that truly the handicap of blindness lies not so much in the physical fact as in the misconceptions of sighted people about it and the exclusionary actions which they take on the basis of those misconceptions. Does a blind person really have any ability? Usually, the presumption of society is that he does not, that his disability drives out all ability, that blindness is not only inconveniencing but incapacitating. This time-honored presumption, to be sure, flies in the face of all forms of evidence available. It contradicts the record of experience, defies logic, and ignores the findings of science, both natural and social, and all too frequently, it prevails.

Here is yet another example. On October 16, 1975, an undergraduate blind student majoring in the biological sciences wrote to the Director, Program in Physical Therapy, University of California at San Francisco. His letter was brief and to the point, setting forth academic qualifications and incidentally mentioning his blindness.

Back came the answer, and here is is:

Dear Mr. Mitchell:

Thank you for your correspondence of October 16, and your interest in this physical therapy program.

I do not know what you have been told regarding this program; however, I would not encourage your continued interest in this particular program. This is an intensive "crash" type program which requires a heavy amount of reading and the rapid assimilation of concepts. Certainly, your aims for your baccalaureate degree are sound and would be good preparation for physical therapy education. However, I cannot urge you too strongly to investigate the other programs within the state such as at California State University at Northridge and Fresno. These programs are much less intense and demanding by virtue of their consuming more time in the delivery of their programs. The equipment utilized in physical therapy and in this program is not modified for the necessary assistance to a blind student. I am sure you would find the unusually fast pace of this program and the adjustments necessary to be quite demoralizing.

If you wish to see me personally, I will be happy to discuss the conditions with you. But at this point in your studies and with time to redirect to a less demanding program, I think your time would be better spent investigating the possibilities within the programs mentioned above.

Sincerely yours,

Once again the traditional stereotypes are operative. "While the blind can probably compete somewhere else, our program is altogether too demanding for them." "The pace is too fast here." "Concepts must be assimilated rapidly." "The reading is too heavy, and our equipment is not modified."

Plainly, the barrier is up on the campuses and written across it are the words of rejection and disbelief. In this instance, with no information to go on other than the knowledge that the student is, in fact, blind, the judgment has been handed down, a decision rendered, and the blind as a class have been found guilty, tried in absentia.

This has often been characterized as an age of progress and enlightenment, but of many superstitions and misconceptions which have barred the way to progress, perhaps none has been more firmly entrenched or has more stubbornly resisted the light of reason than traditional concepts about blindness. These two case studies reveal that the blind have been considered a group apart, a helpless and hopeless lot. They have been relegated to positions of social isolation, subjected to legal discriminations, and denied the most fundamental right of all men, the right to work for their daily bread and to earn their

self-respect. In the best Christian tradition, they have been entitled to the protection of society but not to participation in it. They have been expected to submit cheerfully, even gratefully, to the patronizing custody of a system which, while giving them charity out of kindness, has robbed them of the opportunity to exercise their individual talents and capacities. They have been thought of not as unemployed but as unemployable.

These are the time-honored notions, the traditional concepts, but even the most respectable of fallacies cannot withstand truth forever. The barriers have at last begun to crumble, and we are beginning to emerge from our long subjugation. In this effort we believe that the scientific community in America can and will play an important and leading role. Without question, it has often been the scientists both natural and social who have led in the advancement of new ideas, and often they have done so at their own peril. In the sixteenth century, narrow-minded religious leaders persecuted Gallileo for his new theories of the universe. In the twentieth century we, the blind and the physically disabled, are calling the scientific community to join with us in the cause of abandoning superstition and prejudice and replacing them with the truly rational concepts of equality and opportunity. Let the word go out from this day forward that a new era has been reached in the affairs of mankind--an era in which men will be judged not on their disabilities but on their abilities, for this is truly the scientific spirit.

Science Education for the Handicapped in
Special Education and Mainstream Settings

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We are at a watershed in the field of special education for handicapped students. Changes are occurring that involve a renegotiation of arrangements--a new policy--aimed at more inclusive arrangements and broader opportunities for education of handicapped persons. I believe that in the past--and to a large extent even today--the procedures for schooling of the handicapped often have created special barriers to handicapped students whose bent is toward science and other fields that require strong and specialized instruction.

Historical Perspective

The history of education for handicapped children, if told from their point of view, is a simple story of massive neglect, denial, and rejection. For every Laura Bridgeman and Hellen Keller, tens of thousands of other handicapped children were doomed to constricted lives because it was believed that they could not be taught or were not worth teaching. In a sense, the development of special education can be recounted as an assault on this discriminatory attitude. It began in the early nineteenth century with a handful of dedicated pioneers: Samuel G. Howe (1801-76), who started the first school for the blind in the United States and proved by his work with blind and deaf Laura Bridgeman that the blind could be educated; Thomas H. Gallaudet (1787-1851), who organized the first school for the deaf in this country; and Louis Braille (1809-52), the inventor of the system of writing that bears his name.

Formal arrangements for the education of exceptional children in the United States can be divided into four periods as follows:

<u>Rough Time Periods</u>	<u>Model Programs Format</u>
1. Late Nineteenth Century	Residential School
2. Early Twentieth Century, about 1900-45	Prototype Community-based Programs--the special class and special school
3. Mid Twentieth Century	Explosion of the simple "special class" model
4. Late Twentieth Century	Negotiations for more inclusive arrangements: The period of "least restrictive alternative," "mainstreaming," or "progressive inclusion."

Nineteenth Century: Residential Schools

The first institutions organized in the United States for the education of blind and deaf children were residential; they became the models and set the dominant early pattern for special education in the United States. The institutions tended to be narrowly categorical in orientation and, since colleges and universities were not yet involved in relevant professional training programs, teachers were necessarily prepared for their specialized work by on-the-job training. The roles of teachers, therefore, were defined categorically as of the "blind," the "deaf," or the "retarded."

Although most states established residential schools for the children of residents and numerous private schools also were founded, not all exceptional children could be accommodated in the institutions. Facilities were limited in state-operated schools and private ones were too expensive for many families. Some parents considered the removal of their children more onerous than depriving them of educational opportunities; while children with multiple handicaps often were not eligible for admission to any school.

Residential schools are still in existence but more and more they are being used only for selected, profoundly handicapped individuals who are thought to be best served there.

Early Twentieth Century: Community Prototypes

Some distinctive community-based programs for the education of handicapped children began to appear at about the turn of the century as special classes and public day-schools.

In their earliest forms, these programs were dependent on residential schools for leadership, curriculums, and teacher preparation. Gallaudet College in Washington D. C., for example, which was then serving deaf children started a teacher-training program in the 1890s.

At their best, these early community programs never did more than tolerate handicapped children and the movement developed slowly. For the first half of the twentieth century, most handicapped children were in schools for minimum periods only.

Until comparatively recently, of course, public schools had never seriously tried to serve all children, and especially not those who were difficult to teach. Indeed, during the first decades of this century, most children attended school only long enough to acquire a basic education. Consequently, school systems were not prepared physically, philosophically, or financially to operate far-reaching programs for exceptional children. Special education is costly by definition because of its emphasis on individual problems and needs. When school budgets were limited, as during the Depression of the 1930s in particular, special class programs were not expanded.

Mid Twentieth Century: Explosion of Simple Models

As if to make up through one large effort the neglect of centuries, a remarkable surge of activities in behalf of handicapped children began shortly after World War II. Our largest states launched programs to serve the handicapped in the public schools on a broad scale and numerous colleges and universities organized programs to train teachers in special education.

The change that occurred over the quarter of a century is best reflected in statistics. In 1948, 442,000 children were enrolled in special education programs, in 1963, 1,666,000 and, according to estimates of the Bureau of Education for the Handicapped, during the 1971-72 school year, 2,857,551 handicapped children were receiving special education services. These data reflect more than a six fold increase.

The increase in training programs for teachers of the handicapped was almost as great. About seventy-seven colleges and universities were providing training sequences for special education teachers in one or more categories in 1948; by 1954, the number was 122 and by 1973, over 400.

Although it is impossible to determine all the influences which brought about the sudden development of public school programs for exceptional children, three can be recognized. They were new on the educational scene.

1. Parents of handicapped children formed a number of organizations, such as the National Association for Retarded Children (chartered in 1950, now the National Association for Retarded Citizens), which became socially and politically active. They influenced state legislatures and the Congress. Because of the activities of the politically aggressive parent organizations, the federal government established a national program in the field of special education. In 1957, support was provided for research and leadership training in the area of mental retardation; in 1963, the support was extended by Congress to cover virtually all areas of handicaps; and in 1967, the new Bureau of Education for the Handicapped was established to administer the burgeoning new programs.
2. Many state legislatures, in response to pressures from parents' groups, passed new legislation that mandated instruction in the schools for many categories of exceptional children. The legislatures provided excess cost aids in one form or another to local school districts that launched new programs. Because of the financial assistance provided by state legislatures, and later by the federal agencies, many school districts found that the operation of special education programs not only permitted the provision of services for exceptional children but also helped to improve the services for the school population as a whole.
3. As the nation became aware of and made necessary provisions for the rehabilitation of World War II and Korean War disabled veterans, facilities in Veterans Hospitals were enlarged and new research programs to aid further these veterans were established in various institutions and agencies. In colleges and universities, departments of clinical psychology, speech pathology, and physical medicine were expanded through federal rehabilitation funds, and the influences of investigations in behalf of veterans spread

to include research and training for exceptional children. For example, because blinded veterans rejected isolation and dependency as their fate, programs for mobility and occupational training were begun for them at Veterans Hospitals. Some of the national leaders who participated in carrying out these programs were also involved with schools. Consequently, some transference of expertise took place that was reflected in programs for blind children. Many school systems found that these children could function in day-school programs based on a resource room model, that is, programs in which the children spend only part of the day away from the regular classroom. These programs forced serious examination of the past practices of automatically referring blind children to special schools or classes.

It should be noted that the sheer quantitative leap in programming for exceptional children between 1945 and 1970 cannot be attributed to any great technological or ideological advances. There were some innovations, such as the development of low-vision and individual electronic hearing aids and methods for rapid reproduction of printed materials (including expanded prints), but they are of limited account in the context of massive changes that occurred in the broad programs of special education. In the main, the period can be said to have been one of rapid development based on simple models of the past.

This is not to imply that the two and a half decades were totally barren of new ideas; in fact, some of the trends that are discussed in the next section were generated during these important years. A few examples should suffice.

As part of the studies stimulated by President John F. Kennedy in the mid-1960s, a great many U. S. special educators were able to investigate developments in the field in other parts of the world. Visitors to the Scandinavian countries encountered what is known as the process of "normalization," that is, educating the handicapped in and for the "normal" environment of the nonhandicapped to the maximum feasible extent. This viewpoint requires major development of community-based support systems for the handicapped.

The boundary lines of the categories of handicapped children began to be seriously examined, and strong pressures were developed to extend special education services to students who were obviously very much in need of specialized forms of education but were yet unserved.

Late Twentieth Century: Negotiating for More Inclusive Arrangements

I believe that quite fundamental changes are in process in the 1970s; they involve a renegotiation of boundaries between regular and special education and between community-based and residential schools. Perhaps the period can be summarized under the rubric "least restrictive alternative" or "mainstreaming," in a broad meaning, or "progressive inclusion."

But before proceeding beyond the brief, historical statement covering the first three periods and leading into the current scene, a summary conclusion is in order. The theme in the brief, historical sketch above is that the whole history of education for handicapped children can be told in terms of one steady trend described as "progressive inclusion." Handicapped children have come, in a period of less than two centuries, from total neglect, first into isolated residential schools (for just a few) then into isolated community settings (mostly in the form of special classes) and now into more integrated arrangements for many children. At this moment we are in the midst of what will undoubtedly be recorded in future histories as a remarkable reversal of a negative cascade by which handicapped children were sent off to isolated classes and centers. The agendas of local school boards all across the country in the early 1970s reflect the influx to the community of handicapped children, earlier sent off to hospitals and residential centers; and on the desks of virtually every school principal are difficult questions concerning the accommodation of more handicapped children in regular classrooms.

The current mainstreaming trend is not, I believe, a minor pendulum swing or a temporary enthusiasm. There has been a steady, progressive, inclusive trend in special education from the beginning: from unconcern--to distal--to proximal arrangements. It would be naive simply to assume a straight-line, uncomplicated, and continuing trend; but there are fundamental forces at work, I believe, which support the general trend toward more inclusive arrangements for the education of children who have special needs. Administrative arrangements are seen increasingly as dependent variables, as modifiable to meet individual human needs, rather than as well-designed, impermeable niches for children diagnosed or "carved by nature" to fit a particular slot.

Mainstreaming is rapidly becoming perhaps the single most conspicuous trend in the field of education. In a recent open-ended survey conducted by a writer for The Council for Exceptional Children, special educators were asked to list the changes that they anticipated in the field for the next decade. Mainstreaming was listed more often than any other single topic. Although the specific predictions took a variety of forms, the central element of each was that children with exceptional needs will be referred less often out of regular classes for treatment in special classes and centers. The action required for this change to be successful will be mainly in the area of the regular classroom, making it a broader, more flexible and resourceful place.

Where the mainstreaming movement is taken seriously, attention is given to a number of implications. One is that regular classroom teachers need training and assistance to become more resourceful in accommodating exceptional pupils. This idea is not new. Wallin, in 1935, reported that "... for countless generations the public school education of handicapped and maladjusted children ... has been placed squarely upon the regular grade teacher, although they have never been required to qualify for this ... work by earning one credit on appropriate courses."¹ Lately, many college faculty and local supervisors have begun to take seriously the matter of better and broader preparation of regular educators, and several states have mandated courses on exceptional children for all teachers.

A correlative activity is the rapid change over of many special education teacher preparation programs to provide broadly trained resource or consulting teachers who can help to bridge gaps between regular and special education.

Many special educators now think of their field as involving a broad continuum or cascade of administrative and instructional arrangements, ranging from regular class placements to resource room plans, itinerant teaching plans, part-time special classes, full-time special classes, local day schools, residential schools, treatment centers, and hospitals. In the past, exceptional children tended to be "rejected" to special stations with the most seriously handicapped rejected down through all levels to the end-of-the-line residential centers. What clearly is happening now is that the negative cascade is reversing along the whole continuum. Residential schools are emptying back to the community and special stations back to regular classes. At its worst, this trend is a cruelty if no decent arrangements are made to retrain personnel and reorder programs; at best, the trend permits the thrilling discovery of how the mainstream schools can indeed accommodate many exceptional pupils and become part of broad, community-support structures for children who have special needs. This involves making of the mainstream classroom into something broader than it has been in the past and new supportive roles for many special educators.

Conclusion

There is virtually no chance that children of high ability who are also handicapped will have full opportunities for development if they are shunted aside to special classes and schools for all of their elementary and secondary education. Even less will there be opportunities for them if insurmountable barriers are encountered in college and graduate schools.

Time has run out on "set aside" programming. There is a vast movement in early education and in elementary and secondary schools to remove physical and other kinds of barriers to the appropriate education of all handicapped students. This trend is undergirded by the aggressive concerns of parents, by students themselves, and by many professionals; it also is undergirded by many demonstrations of what is possible, by improved technical services, and by court decisions regarding "least restrictive alternative." This concept requires that students be educated in the mainstream unless there are compelling reasons justifying special placements. Probably less has been done at college and graduate levels than at other levels, but forces for change are mounting there as well.

I hope that the energies of AAAS might be joined, by very careful design--through the Project on the Handicapped in Science--to the larger movement to make more inclusive arrangements for schooling of all kinds for the handicapped person.

NOTES

¹J. E. W. Wallin, "Grade Teachers are not Qualified," The Nation's School, 10:1 (1935):38.

Providing Quality Science Education for the Handicapped Student

Martha Ross Redden, Director
Project on the Handicapped in Science

The Project on the Handicapped in Science was directed initially toward the problems of the adult handicapped person who faces barriers and discrimination in employment. Soon we realized that basic to most barriers was the early training that handicapped children received in elementary and secondary schools. Actual experiences related to us by disabled scientists made us aware that continual drive and determination were necessary to get an education in science. It seems that for people who were disabled at birth or at an early age the acquisition of a quality science education comes only through a miraculous series of events.

Dr. Phyllis Stearner,¹ who has cerebral palsy, says that after thirty years as a scientist in radiobiology she considers with amazement the series of improbable events that led to her obtaining a Ph.D. from the University of Chicago and to her career as a biologist. She says that as a young child she learned about the bumblebee, an animal that, according to accepted aerodynamic principles, should not be able to fly. However, the bumblebee knows nothing about such principles and may be seen winging its way among flowers on a warm summer day. She watched the bumblebee with great interest and thought of many questions, but often there was no one to provide the answers. As a child, she did not know what research and science were all about, but in her determined way she eventually succeeded, somewhat like the bumblebee--not designed to fly, but nevertheless flying.

Many scientists, like Dr. Stearner, handicapped since birth, as well as many who became disabled later in life, have urged the AAAS to consider the needs of young handicapped children as one of its priorities.

In elementary grades children are first introduced to the scientific method of problem-solving and learn the vocabulary that allows understanding of scientific concepts. Without this background it is almost impossible to achieve success at the secondary level and beyond. A survey of past and current curriculum guides for teaching science to the handicapped child reveal that, where it is taught at all, science is presented as a way to solve specific life problems of health and safety. Science concepts, laws, and processes as well as attitudes of curiosity and problem-solving are usually ignored. At present there is no national science program designed for nonretarded children with specific disabilities. The Lawrence Hall of Science in California is seeking funds to cooperate with the American Printing House for the Blind in producing quality science curriculum for blind students. If this project is funded, it will ensure the availability of science curriculum materials to all teachers of blind children and will set a model for other groups such as the deaf and mobility impaired.

In the schools across America today there are over seven million youth, one in ten, with some form of handicap. The handicap may be physical, emotional, mental, or social, or more often a combination of two or more of these. Often their handicaps have been allowed to hinder the learning of these "special" youth. Placement in special classes or special schools usually has meant that if these youth are taught science, the instructors are special educators who often have little or no training in science.

Until recently, most educators felt that the "special child" could receive better training when separated from "normal" peers. This attitude led to the creation of special education programs built around the idea of disability rather than ability. The child was labeled as disabled, thus emphasizing his or her dissimilarity, when in fact the similarities to other children were always greater than educators realized.

This attitude of spotlighting the child's differences has met with severe criticism from many groups, forcing educators to reconsider their placement of the special child.² The move toward mainstreaming has gained momentum. Whole school systems are doing away with special education practices of the past and, when possible, placing handicapped children in the mainstream of the educational system.

What does this mean to teachers of science? To teachers of science this means that they may have special children with various types of handicaps in their regular classes, and that they will have to include the handicapped child in regular class activities and set a wide range of competence goals for the class which will include the special child. Teachers will have to assess the ability of the child and realistically consider how the child's handicap does or does not affect his or her ability to study science. The teacher may have to locate or adapt science materials for the particular disability of the child. Because of the extra work involved in doing this, the teacher may be tempted to exclude the special child from the "hands-on" part of science. But a broad range of science experience, both theoretical and practical, is necessary to guide the handicapped child toward an understanding and an appreciation of science or even to the possibility of choosing science as a career. It is

the teacher in day-to-day contacts with students who can offer the tools and skills to overcome handicaps. It must be the teacher who provides the kind of science education that allows the handicapped child to live a fuller life and even to choose science as a career.

Mainstreaming is inevitable on a nationwide scale. Court rulings³ and research findings which have established the "principle of normalization"⁴ all point to the fact that students have a right to function in an optimum environment that is least restrictive to their personal development.

To provide a quality science education for the handicapped child while also addressing the needs of their nonhandicapped peers, the teacher will need access to a wide variety of materials and human resources. Organizations such as the AAAS and the National Science Teacher's Association can and should lead in identifying those resources and making them widely available. Mainstreaming will offer richer educational opportunities to handicapped students than they have had before, but it will not guarantee them improved science education. Teachers of science in the mainstream school settings must accept the challenge of involving the handicapped child as a contributing member of their regular classes.

There are teachers who accept this challenge. Kathy Cooper, a teacher formerly from California and now in Massachusetts has spoken of her excitement in teaching science to blind children. She related her fears at the start and her growing awareness that the excitement in learning science was the same or even greater for her blind students as for those who could see. In fact, she says that the children's contagious excitement makes science easier to teach than some other subjects. Ms. Cooper found that materials and guides that make many years of training unnecessary are available to assist in teaching science, and that making the learning of science an exciting experience is not something that only people with special talent can do. She believes any competent teacher can teach science well. Any shortcoming in the teacher is compensated for by the enthusiasm of the students. They will inspire teachers to do things they never dreamed they could.

I am sure that the people who listened to Ms. Cooper are now convinced that good teachers can be good science teachers. Hearing the successful experience of others inspires each of us to try harder. However, there is a great need to get this message to teachers across the country, and the teachers of all children need adequate materials to teach science.

For these reasons, the AAAS is focusing its attention on the science education resources, both human and material, to assure their optimum use by elementary and secondary school science teachers for the benefit of handicapped students. Teachers are among the first persons to offer the tools and skills needed to overcome handicaps.

The AAAS Project on the Handicapped in Science made a preliminary survey in the fall of 1975 to find out how much science education handicapped students are getting. From the survey, it can be concluded that most handicapped students, whether in special schools or public schools, get little science, and what they do get is not adequate to allow them to pursue science as a career.

In conducting this survey, the AAAS staff contacted science and special educational officials in state and local education agencies and in institutions of higher education to discover the kind of science education available to handicapped students. The survey also included administrators of schools for the blind and/or deaf, organizations and agencies for and of the handicapped, deans of schools of education who have grants for mainstream education projects from the Bureau of Education for the Handicapped (BEH). Also included in the preliminary survey were Educational Resources Information Center (ERIC) and Smithsonian Science Information Exchange (SSIE) searches for science programs, curricula, materials, and/or research for the physically handicapped; the National Learning Resource Center Network; and other standard bibliographic resources. Again, little information has been found that would indicate that quality science education is available to the non-retarded disabled child.

The Library of Congress, Division of Resources for the Physically Disabled, offered a list of organizations for the handicapped but reported nothing specifically about science or science education.

The preliminary survey revealed widespread interest in improving science education for the handicapped and evoked expressions of concern that so little was being done. The survey also uncovered some creative examples of what can be done for handicapped students, but its overwhelming conclusion is that most handicapped students get so little science education that science careers are effectively closed to them.

The responsibility for assuring an adequate science education for the nonretarded, handicapped student is a matter that largely has been neglected by both science educators and special educators. There are several possible reasons for the neglect: until recently, most handicapped students have received their education in self-contained classes taught by special educators who have little or no training in science. If a handicapped student enters a regular elementary or secondary science class, the teacher is usually not trained to adapt the regular program to meet his/her needs. And, finally, even if the special educator or science educator is trained and is willing to teach science to the handicapped student, quality materials to do so are not readily available.

Although the picture is bleak, the survey did uncover some shining exceptions. It identified a few individuals who have developed materials and techniques to include one or more handicapped students in their science programs. Ruth White, while at the Pathfinder School in Bethel Park, Pennsylvania, adapted part of Science - A Process Approach⁵ for use by handicapped students. There are also some local school systems, Dallas, for example, scattered across the country that seem to have developed quality programs in science that include the handicapped. Even a few states such as California, New York, Texas, and Florida have guidelines that indicate a strong move in the right direction by offering supplementary support to regular science teachers.

Residential schools for the blind and deaf that were surveyed reported that efforts are being made to improve science education for the "college-bound" student. We learned of few innovative programs, although science at the elementary level generally was reported to need much improvement. Overall, we can speculate that, at the present time, handicapped high school students in residential facilities receive a better science education than those in the "mainstream" of education or in special classes in public schools. On the other hand, the general opinion of the science educators at the residential schools is that their secondary programs are far from adequate, and their elementary programs are all but nonexistent.

The responses from the state supervisors of science to the AAAS preliminary survey were encouraging. Many offered assistance and asked to be informed of ways in which they could help to improve science education in their states. Responses from the university deans receiving BEH grants for mainstream projects indicate that, after a year of planning and initial program development, they, too, have found a need for better dissemination of information in specialized areas such as science. Several of the deans endorsed the investment of the AAAS resources in the mainstream science effort, and have asked to be informed of further developments.

To summarize, the preliminary survey of educators representing both science and special education at the state, local, and university levels showed that little is being done in terms of organized and coordinated efforts for the development of a total program of science education that would allow the handicapped student to choose science as a career. Furthermore, there appears to be no clear guidelines as to where the responsibility for providing science education to the handicapped should be placed. Few states have provided for such curriculum development; most reported that responsibility for science education for the handicapped was vested at the local school-district level. This localization, however, does not lend itself to feedback and dissemination. The demography of the handicapped population is such that effectiveness of science education program development is dependent upon widespread communication and exchange of ideas. Hence, the need is evident for consolidating information from the many different resource pools which exist.

We found that little responsibility is being taken at the state level for providing quality science education for the nonretarded, physically handicapped student, and there is confusion on the part of science educators as to their individual responsibility in adjusting programs to accommodate the handicapped. This situation will be intensified as an increasing number of mildly handicapped students enters the regular science classes because of the move toward mainstreaming. At the same time there are some little-known efforts being made by curriculum developers and classroom teachers.

There is, then, an established need for the collection of information on resources, and, among science educators at the university, state, and local levels, there is a widespread interest in the possibility of improved science education for the handicapped. During the coming months we plan to collect, review, evaluate, describe, and catalog these efforts and to make them widely available to all educators who are in a position to make changes in science education for the handicapped.

Our overall objective in the area of science education is to improve its quality for handicapped elementary and secondary school students. We believe that increasing the availability of appropriate science resource materials and identifying experienced personnel who can provide advice and assurance will give teachers the means to assist handicapped students to share fully in science education.

There are four specific objectives necessary to accomplish full access to science education:

1. To prepare and publish four documents: A Survey of Literature on Science Education for the Handicapped, an annotated bibliography on teaching science to the handicapped; Science Education Materials for the Handicapped: A Critical Review, an evaluation of the science resource material component of Learning Resource Centers in terms of its cost-effectiveness, scientific worth, adaptability for individualized programming, etc.; An Inventory of Experiences: Approaches that Work, a catalog of successful classroom experiences; and A Directory of Human Resources, a roster of experienced individuals who are willing to help other teachers. These publications will be an invaluable aid to teachers of science in any situation where handicapped students are found--residential and day schools, special classes, mainstream settings, etc.
2. To disseminate these publications so widely that they will be known and available to every teacher who needs them.
3. To identify, through the process of preparing the publications, the gaps in materials and training resources and to make recommendations to policymakers on the research and development still needed.
4. To disseminate widely those recommendations to state and federal policymakers, and to professional organizations of and for the handicapped who have an interest in promoting further research and development.

When these objectives have been fulfilled, the publications and recommendations can have an impact nationwide on the quality of science education received by all handicapped students.

The project is designed to bring together the existing, extensive resources for improving science education for the handicapped. In coupling compilation with evaluation, the results will assist in directing teachers to the most effective resources available for accomplishing the goal of full access to education for all handicapped students.

I have reviewed AAAS's plans for improving science education for handicapped youth. We would like to know about teachers who are teaching science in an exciting way to this sector of the community and about curriculum materials that are particularly useful. Suggestions and comments on the program are always welcome.

Beyond the AAAS projects, there are many things we all can do to improve science education for handicapped youth. First, I hope that what you have heard today will better equip you to ask questions about programs in your own schools. Your tax dollars pay for those schools. It is your right and responsibility to see that some of those dollars are spent to assure that all youth receive a quality science education. Ask the supervisor in science in your home district to describe the science program for the handicapped. Ask for a comparison of that program with the one for able-bodied youth. Ask how many disabled youth there are at the secondary level and how many of these are in science courses. If the numbers are small, ask why. Ask to visit classes where science is being taught to handicapped youth. Offer your assistance to study the situation and to propose a program to improve it!

The second area that needs assistance is that of personal support and encouragement of handicapped youth and their families. I encourage disabled scientists as well as their able-bodied colleagues to make themselves available to able, handicapped youth who aspire to a career in science. Handicapped scientists and other professionals can serve as role models with whom youth can identify. Many handicapped youth have never met or talked with a successful professional. These young people, often isolated from the mainstream of life, do not have the opportunity to discuss career aspirations with a wide range of people. Often they are advised to enter fields already crowded or in which they have little interest or aptitude. Handicapped students, their parents, counselors, and teachers

need to speak with successful scientists, both disabled and able-bodied, in order to receive the necessary factual information concerning a wide variety of jobs in science, the training necessary to enter various fields, and the barriers they are likely to encounter in pursuing an education and a career in science. The strategies for coping with problems inherent in achieving a successful career in science should be shared with this group.

Thirdly, we must urge our professional associations to actively advocate better science education for handicapped youth. The concerns of the handicapped should immediately be added to those considered by their education committees, and they can publicize the needs and accomplishments of handicapped youth in journals and newsletters. Scholarships and awards committees should actively seek out deserving handicapped youth as recipients. Professional associations of science educators, such as the National Science Teachers Association, should be urged to take an active role in assessing and changing the quality of science education offered to the handicapped.

In closing I would urge you to insist that at all levels of the educational system disabled scientists be involved in planning and decision-making to assure that a quality science education is provided for handicapped youth. Further, let us insist that each of these youth be given every opportunity to choose the career most suited to his/her particular interests and abilities, and that he/she has an active role in the decisions made about career choices. Let me remind you that the group our project serves, handicapped scientists, joined by the larger membership of the AAAS can be a powerful force to ensure that handicapped people receive a quality science education and are guaranteed access to a wide variety of science careers.

NOTES

¹Vito Proscia; Phyllis Stearner; E. C. Keller, Jr.; Donald L. Ballantyne. "A Challenge to Teachers from Handicapped Scientists," Science and Children 13 (March 1976):15-16.

²Martha Ross Redden and Shirley Mahaley Malcom, "A Move Toward the Mainstream," Science and Children 13 (March 1976):14.

³Public Law 99-380, Part VI B. Education of the Handicapped states that "to the maximum extent appropriate handicapped children should be educated with children who are not handicapped and that special classes, separate schooling or other means of removal of handicapped children from the regular educational environment occurs only when the nature or severity of the handicap is such that education in regular class with the use of supplementary aids and services cannot be achieved satisfactorily."

⁴The "principle of normalization" states that the handicapped person functions at his/her optimum level in an environment and lifestyle that are as close to normal as possible.

What Can Professional Societies do to
Foster Opportunity for the Handicapped Person in Science?

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What can professional societies do to foster opportunity for the handicapped person in science? There are, first of all, the obvious corporate actions. Each professional society can adopt a policy of facilitating participation in meetings and other activities by members and students who are handicapped. Professional societies can begin by using the manual AAAS will publish on making meetings accessible. Each society also can consider what steps to take so that qualified handicapped scientists can take part in its governance. This means not only making board and committee meetings accessible but using affirmative action approaches in recruiting board and committee members. For some purposes only minimal accommodation will be required, for example, recruiting a deaf scientist for editorial review of journal articles. A higher degree of accommodation is required to enable colleagues with smoke-sensitive pulmonary problems to participate at meetings.

Since handicapped scientists, and in particular prospective scientists, may not have an easy access to the society's journals or be accustomed to consulting them for opportunities, the society which is increasing its outreach should also use channels of communication directed especially to various categories of handicapped people. For example, more and more societies are arranging for tapings of major sessions; the availability of these tapes is usually publicized primarily through the society's publications. But each society should go further and ensure that the availability of these tapes is known to the major organizations of the blind persons whose major professional activity does not center in a scientific field to share in a cultural experience. The AAAS Office of Opportunities in Science can advise professional societies on ways to reach blind, deaf, paraplegic, and other disabled persons through their own organizations. The state library service for the blind and physically handicapped can be contacted directly.

A very important contribution can be made if each professional society reviews realistically the functional requirements for productive participation in the respective professions and subprofessions it represents. The U. S. Civil Service Commission has set an example by waiving standard but not essential job requirements when a handicapped applicant is certified by a vocational rehabilitation agency as able to do the job. A recent article in *Science* pointed out that it is not necessary for a psychiatrist to be proficient in the use of a microscope, yet heretofore such proficiency was required of all medical students. A paraplegic can cox a winning crew: a premed student did just that at the Henley Regatta.

Each society should establish a committee composed of (1) successful scientists, both handicapped and non-handicapped; (2) handicapped persons not in the sciences, but familiar with capacities of the handicapped, and the associated technologies; and especially (3) college faculty members in the various specialties, to review the functional performance requirements for achievement in various fields represented in the professional society and to give guidance to employers, undergraduate and graduate admissions committees, high school guidance counselors and the handicapped themselves.

Buildings constructed for public use and funded in whole or in part with federal funds, now must be free of architectural barriers to mobility of the physically handicapped. However, even when federal funds are not involved, such standards should be followed in university buildings and industrial laboratories, as well as libraries and museums. Scientists in academia can insist on this. The professional societies representing disciplines which use specialized space can make a further contribution by initiating studies to develop criteria for these special facilities which will make them more readily usable by handicapped faculty, students, employees, and visitors. A future theoretical physicist will be expected to take laboratory courses as an undergraduate. Making a laboratory accessible to someone in a wheel chair takes only a little advance planning.

Progress depends on individual initiative; it is not merely corporate activity, but that of the society's individual members that will make a difference. To begin with, it is essential to recruit to this cause the most influential persons in each profession. There are two target groups, individuals with prestige as reflected in various ways (election to office, requests for invited papers, favorably reviewed books, participation in national policy advisory bodies to government, and citations in the literature) and faculty members. The latter are important regardless of national prominence for two reasons: (1) they are gatekeepers for the professions; and (2) they provide role models for the professionals of the future. Affirmative action by these persons, based on a genuine recognition of the scientific qualifications of individual scientists (including students) who are handicapped, can set the tone and tempo of progress.

Finally, what can the handicapped members of these professions do to assure more equitable opportunities? The AAAS has already invited them to share their understanding of what the rest of us can do to eliminate unnecessary barriers, whether physical, social, attitudinal, legal,

or other. They can do as John Gavin did, point out, reasonably but firmly, how the societies can cease and desist from inadvertent discrimination, and accomodate their handicapped members with relatively little discomfort to other members. In addition, they can volunteer to assume tasks for their professional societies which they know they can discharge successfully, thus gaining visibility while demonstrating that no essential compromise need be made with quality.

Even though putting himself or herself forward may initially make the handicapped person a little self-conscious, there are times when such action should be seen as a social responsibility. Harold Russell, who lost both his hands in World War II, has served for some years as chairman of the President's Committee on Employment of the Handicapped. This brings him into contact with many national leaders as well as with ordinary citizens. His complete aplomb and his competence in what he is doing create affirmative public images for all the physically handicapped. It is wrong to exploit a handicap to gain concessions but it also is wrong to be so anxious to be seen "for one's self", that one resents being recognized as a person with a handicap. Admitting the handicap in conversation and in behavior when relevant, is an important contribution successful people can make to the next generation. Finally, in his/her desire to overcome obstacles the handicapped person should not forget that most so-called "normal" people modify their respective career aspirations in the light of recognized weaknesses as well as strengths, all of which are relative.

Handicapped scientists belong to a privileged intellectual elite whether they admit it or not. To have succeeded in joining this elite is a source of legitimate pride; however, it does not justify arrogance toward other handicapped persons who are not so successful. In many cases intellectually superior or highly articulate blind, deaf, or physically disabled persons are just as likely as their nonhandicapped peers to "put down" those less able in their category. For example, the alumni of a school for the deaf resisted the admission of multiply handicapped, deaf children to that school for fear it would damage their own self and public image.

Are physically handicapped persons any less prejudiced than the rest of the population against the former mental hospital patient? The person who has become handicapped in mid or late life, after education is complete and a place in the work force has been established, not infrequently expresses some disdain for the person with the same disability who has been disabled since early childhood. There are hierarchies of the handicapped in the popular attitudes of the public and among the handicapped themselves. Handicapped scientists have the same obligations as the rest of us to bring those attitudes into tune with realities rather than prejudice. For it is often now outdated and discarded pronouncements of scientists of earlier years that are the basis for present discrimination.

Finally, it behooves scientists, both the handicapped and the hale, to remind each other that in science we seek to reward merit without compromise. It was Dr. Phyllis Stearner of Argonne National Laboratory who insisted, from her wheel chair, that all of us must demand excellence from each other. It is consideration and respect, not concessions, that our handicapped peers require and deserve.

A Natural Partnership

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Education is in very difficult straits, not only in this country but in the whole world, largely because of problems scientists have created with the inventions of computers, sophisticated communications media, fire, wheels, and other modern innovations. In truth, people are really much better off today than they ever have been. They live longer and better and even freer than most philosophers ever thought possible, but they do not feel better off because they have not worked out their relationship to modern technology; and the schools have not found a way to help them.

As I see the educational system, it is confronted with the following problems:

- Technological advances, particularly in the industrialized countries that are removing almost all of the unskilled jobs.
- An information explosion that is forcing people to learn very specific things in order to obtain semiskilled or paraprofessional jobs.
- A higher degree of materialism makes large numbers of people dissatisfied with the income they can earn with a general, liberal arts education, and more inclined to risk becoming "over-specialized" for immediate monetary rewards.

The educational system has responded, not only in the United States but everywhere in the world, reactively rather than actively. To make time to teach children the facts they need to get jobs, or into college or graduate school, schools at all levels no longer teach them how to pursue independent study. Industry has specific jobs, higher education trains people for those jobs, and secondary education trains people to be trained by higher education. In short, education has created people to fit technology's needs, and every time technology advances, those people are thrown out of work and out of balance with reality.

Let me relate this process to special education. In that reactive educational process which looks at subjects to be learned rather than students to be taught, people are sorted out statistically, and mass produced. If students have handicaps, if they are paraplegics, for example and cannot make it into the labs, or deaf and unable to hear through a stethoscope, they do not fit the system, and the system has become so specialized that it cannot adapt to them. When the Bureau of Education for the Handicapped was established in 1967, it found that most regular education systems encouraged students to specialize before they had mastered the basic skills, and that there were thousands of separate and unequal special education programs designed to train handicapped children to fill the occupations rejected by others.

I would like to stress that no one is to blame for what happened to education or to special education. It was the result not of bad educational policy, but of no educational policy at all. Moreover, no one person has ever had the power in this country to make a uniform, singular educational policy. However, with the enactment of the Education for All Handicapped Children Act of 1975, the United States Commissioner of Education is responsible for developing an educational policy that will ensure that handicapped children have an opportunity to reach their maximum potential. The Commissioner has charged the Bureau of Education for the Handicapped with developing and implementing that policy. Specifically, the new law requires:

- An individualized educational program plan for every handicapped child.
- Guaranteed nondiscriminatory testing and placement procedures.
- Adequate child identification.

The Bureau defines "appropriate" education as more than a mirror response to immediate technological needs. We are putting discretionary money into programs designed to develop the cognitive and affective abilities of handicapped children. The Division of Personnel Preparation supports programs in higher education to train regular educators to respond to the individual needs of handicapped children in their classrooms.

Our research efforts include the development of prosthetic devices, sensory aids, and techniques designed to overcome physical obstacles that have made it difficult in the past for handicapped people to receive an education. We also are working to eliminate architectural barriers, and to change negative attitudes toward handicapped people that have resulted from

misinformation or no information about their needs, skills, and essential humanity.

We come now to what we can do together as organizations. I think that AAAS represents a significant end to which we are the means: "The conduct of human affairs," in the words of Alfred North Whitehead, "is entirely dominated by our recognition of foresight determining purpose, and purpose issuing in conduct . . . we speak of the policy of a statesman or . . . corporation but cut out the notion of final causation, and word 'policy' loses its meaning."¹

The Bureau's policy is intended to overcome the physical, social, and psychological barriers that have kept handicapped children from receiving an appropriate education, and we are committed to this policy even if it means that education has to improve for all children. But we cannot change the conduct of industry, the way industry defines its jobs. That will require professionals who work for and consult with industry, professionals who can speak to the advantages of having people of varied experience in similar jobs, and who can encourage difference instead of uniformity.

The objectives of the Project on the Handicapped in Science address that need, but the steps you have taken need to be adopted by other professional organizations and by employers. I see a natural partnership between us: you go back to your corporations and universities and stress the demand for professionals who are truly educated, and we will provide the resources and assistance to give handicapped children an opportunity to become those professionals.

¹Alfred North Whitehead, The Function of Reason (Boston: Beacon Press, 1958).

Rehabilitation Research on Disability:
New Horizons

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It is fitting that in the year of the Nation's bicentennial, the AAAS should recognize, for the first time, the contribution that handicapped citizens have made to American science. Individual men and women with handicaps have been accepted in the past for their specific achievements, but the general opportunities for the handicapped in the scientific professions have not been explored.

Research on disability can be properly classified as a scientific activity. James Bryant Conant in Science and Common Sense defined science as "an interconnected series of concepts and conceptual schemes that have developed as a result of experimentation and observation and are fruitful of further experimentation and observations. The validity of a new idea and the significance of a new experimental finding are to be measured by the consequences--consequences in terms of other ideas and other experiments. Thus conceived, science is not a quest for certainty; it is rather a quest which is successful only to the degree that it is continuous."¹

How does research on disability fit with Conant's definition of science? The scientific statements which we make about disability are not static laws and theories. Our knowledge concerning the natural history of disease and disability is never certain, never complete. There is no systematic body of information which codifies knowledge about disability. If research is measured "in terms of stimulating other ideas and other experiments," then research on disability has been productive. Research on disability, however, has not always used experimental methods in determining the consequences.

Can nonexperimental research on disability be considered scientific? Karl Popper, in The Logic of Scientific Discovery, discussed the question of nonexperimental methods of scientific research. For example, the historical method may be used to find out what research has been completed in the past. How have other scientists coped with a particular problem? How did they formulate the questions? How did they try to solve them?

Popper points out that purely abstract ideas have been of the greatest importance to scientific theory. From the atomic theory of Greek science to the speculation about forces by Newton and the ideas about energy and field of forces by Einstein, there has always been room for intuition, broad speculation, and imagination. In the early part of the twentieth century, especially in Vienna after World War I, there developed a position in the philosophy of science which stated that philosophy was nothing more than the analysis of mathematical and logical statements. This position asserts that any statement which is not capable of being verified is meaningless. The ultimate position in this direction has been stated by Wittgenstein, for whom "every meaningful proposition must be logically reducible to elementary propositions."²

In my opinion this is a narrow view of science. Popper discusses the futility of restricting all science to a series of logical, analyzable, and reducible statements. If we were to follow this logical reasoning, then the search for universal natural laws would be considered abstract and speculative and outside the realm of science. Science must represent the world of experience. All scientific test is one of experience. It must be possible to show by experience that a scientific statement is false.

Disability rehabilitation research is properly classified as a scientific activity. Statements about disability can be tested by observation and by conducting tests on handicapped individuals. Rehabilitation research frequently is conducted in everyday experiences. It is easy to test by experience the assertions about disability for falsifiability.

Research on disability is carried out primarily in the field rather than using the techniques of laboratory science. For example, if we wish to test the statement, "handicapped persons make better workers than nonhandicapped persons," we first must reduce this statement to its fundamental elements (assuming we can arrive at an operational definition of work, handicapped and nonhandicapped). Next, we must conceive of test situations in which handicapped and nonhandicapped workers can be compared. At first, this may seem to be an easy task, but we may have ignored the many extraneous variables that may impede this comparison. Handicapped and nonhandicapped would have to be matched according to similar types of duties in similar work environments. Even if these conditions are met, there is no control for conditions of age, sex, previous work experience, or motivation. Unlike experimental research, disability studies cannot control for many conditions which exist naturally outside the laboratory. Research on disability is an applied science in that its aim is either the application of a general theory to a specific practical problem, or the application of the general tools of scientific method to solving a specific problem.

Research on disability is not carried out in isolation from the handicapped themselves. Consumers of rehabilitation services are vital participants in helping to define the issues of research. Consumers of services are helpful consultants to those who interpret research findings because they bring to the task an insider's perspective.

Within these broad boundaries, rehabilitation research engages in many different types of activities. As examples, I will discuss some severe physical disabilities with which I am personally familiar and which I and my research group have studied.

Research on spinal-cord injury affords an example of interdisciplinary scientific research. Epidemiologists have investigated the incidence and prevalence of spinal-cord injury. The incidence ranges from 12.4 per million/year to 50 per million/year or 5,000-10,000 new cases in the United States annually.³ The prevalence of spinal cord injury is estimated at 150,000 by the National Paraplegia Foundation. Adjustment to the multiple disabilities resulting from spinal cord injury requires the investigative skills of many research specialists. Genito-urological aspects of spinal cord injury are investigated by urologists. Studies by Bobo, Pearman, Guttman, and others⁴ indicate that urinary infection can be controlled with 91 percent of patients being discharged with low residual urines.

The physical dysfunctions resulting from spinal cord injury have been investigated by specialists in physical medicine and rehabilitation. Functional assessment scales have been developed to measure the capacity of the injured person to take care of his bodily needs, to dress, to eat, to transfer himself into a wheelchair, to transfer himself into a car, and to work. The meaning of the loss of sexual function and the management of psychosexual adjustment of spinal cord injured persons has been studied by physiologists, biologists, and experimental psychologists. The ability to have an erection or an ejaculation depends upon the extent to which the spinal cord has been left intact, and the completeness or incompleteness of the lesion. Bors (1963)⁵ reported that 80 percent of male paraplegics and quadriplegics were able to have erections, and Jackson (1971)⁶ reported 85 percent had erections. The ability to ejaculate varies between 10 and 15 percent with almost total loss with complete upper-motor lesions, and with a minimal retention in complete lower-neuron lesions. Both men and women need to experiment with alternate styles of lovemaking that utilize the residual assets of spinal-cord injury. For both men and women who have been acculturated to conventional modes of sexual expression, it may be helpful to undergo a program of sex education and counseling. Cole⁷ has produced several films depicting the sexual relationship between a disabled and a nondisabled partner and has conducted a sexual education program for spinal cord injured adults and their spouses or friends.⁸

Researchers have studied the process of grief and mourning of the loss of bodily functions, a process that begins with the immediate reaction to the injury and extends over a long period. Efforts to accelerate this process by rehabilitative prosthetics and orthotics often are counterproductive because time is necessary for a person to adapt to this new condition. Although employment may be the ultimate goal of rehabilitation, a transitional period following trauma is required for the redirection and integration of vocational plans with disability. Concern with vocational plans is not reported frequently in the early period, but may become pronounced within three months after injury. A comparison of plans prior to and following injury indicates that the pre-disability history is significantly predictive of the post-disability plans. Studies by vocational psychologists indicate that motivation to work, a realistic attitude, and an optimistic rehabilitation outlook are related to successful rehabilitation. As the person gains control over physiological functions and learns to use adaptive equipment, braces, and wheelchair to compensate for lost function, a more optimistic outlook about the future develops. Their interest shifts from a state of wishes about fulfilling the past to a state of acceptance of the present and planning for the future.

Despite the research efforts of many disciplines, we need new research on eliminating employment barriers for the spinal cord injured, on alternative modes of community adjustment and family support, on models of transitional employment while the person is still hospitalized, on methods of preventing medical complications, on the cost and effectiveness of model spinal cord injury centers, and on the integration of adaptive housing, transportation, and employment opportunities for the spinal cord injured.

Some disabilities have few physical limitations but have severe social stigma attached to them. Visible disabilities generally produce more negative social stimulus and produce greater social discrimination than do invisible disabilities. Nondisabled persons have more

negative attitudes toward disabilities with physical disfigurement than toward disabilities without disfigurement. The social stigma attached to physical disability may have a more important effect upon social and psychological adjustment than the severity of the disability.

To test the effects of severity of disability with the effects of visible disfigurement, I chose two groups for study.⁹ One was a group of children with facial disfigurement resulting from burns but with minimal physical limitations. The second was a group of children severely limited physically by congenital heart disease but with no disfigurement. Each child was given a personal interview. Each was asked about vocational aspirations, post-high school career plans, interests in vocations, hobbies, social activities. Each was asked to mention the reasons why people work and what would be the most important reason for him/her to work after graduation from high school. Children with congenital heart disease scored higher on all the vocational items than did children with burns. Children with heart disease scored significantly higher on vocational aspirations, interest in careers, and post-high school career plans. Children with facial disfigurement were more vague and ambivalent in their vocational aspirations, lacked plans for a career, and maintained either no interest in work or more superficial interests in work than the first group.

What are the implications of this study for barriers to the handicapped in science? Persons with visible disfigurement are more handicapped in obtaining employment than persons with invisible disability, irrespective of the severity of the disability. Employment interviewers may reject the applicant upon the basis of first impression. The counselor of the visibly disfigured person must prepare him/her to face realistically the social rejection of employers. The counselor might help him/her to acknowledge fears, to tolerate feelings of hostility and rejection, and to attempt to lessen the social isolation between him/herself and others. At the same time employers need to be educated about what they realistically can expect of a disabled person with visible disfigurement.

Further research is needed to develop learning models for the education of employers concerning disability. Employers need to distinguish between the visible aspects of disability and the functional limitations caused by disability. Employers, like scientists, are exposed to the cultural ideal of physical wholeness and physical attractiveness. Employers, like scientists, are exposed to the prejudices against hiring the disabled. Vocational rehabilitation of the severely disabled depends to a large degree upon three variables: (1) the extent of preparation of the disabled adult for entering the labor market, (2) the receptivity of employers toward persons with visible disabilities, and (3) the person's attitude and acceptance of his/her own disability.

New horizons in rehabilitation research include studies on end-stage renal disease, cancer, stroke, cystic fibrosis, and muscular dystrophy. Until recently, rehabilitation of persons with disabilities resulting from cancer was neglected. Cancer was seen as a progressive, frequently fatal disease which did not permit a person to resume normal activities.

Research on cancer rehabilitation is carried out best with the integration of several scientific disciplines. In investigation of cancer of the head and neck, research may be carried out concurrently by biochemists, laryngologists, physiologists, psychiatrists, speech pathologists, and psychologists. Little is known concerning the vocational capacity and adjustment of persons with head and neck cancer.¹⁰ In a study of fifty-four patients in Moscow, USSR, the respiratory and cardiovascular system of patients after laryngectomy was studied three to four days and 1.5-24 months after operation.¹¹ It was found that the respiratory and cardiovascular function remained within normal limits for age. Despite the preservation of normal function, only 40 percent were able to return to their former work. A similar study¹² was carried out in the United States to measure the activity of the abdominal muscles and intra-abdominal pressure while lifting weights. The findings indicated that the intra-abdominal pressure ranges in the person with laryngectomy while lifting fifty pounds were similar to the ranges in the normal control subject. These two studies indicate that the differences between persons with and without laryngectomy with respect to their respiration, circulation, and capacity to perform complex bending and lifting maneuvers are not as great as formerly supposed.

Despite the apparent capacity of persons with laryngectomy to perform complex physical work, employers may still retain a bias against hiring them after surgery. We recently conducted a study of sixty-two persons in Massachusetts with cancer of the larynx who were interviewed about their education, work, and social history prior to cancer, and about their employment history after cancer.¹³ Prior to laryngeal cancer, fifty-three persons had been engaged in productive

activity, including fifty-two in the competitive labor market, and one in homemaking; nine were unemployed. Prior to surgery few were working. Following laryngectomy, twenty-four returned to employment in the competitive labor market, one resumed her homemaker role, and thirty-seven were unemployed. The best predictors of vocational and social adjustment after laryngectomy were remotivation, a realistic attitude toward their capacities and limitations, an optimistic outlook about their recovery from surgery, and the acquisition of speech.

Rehabilitation of persons with cystic fibrosis is another new area for research. Cystic fibrosis is the most common, genetically determined disease.¹⁴ It occurs once in every 2000 live births. Cystic fibrosis is inherited recessively. When both parents carry the gene to the offspring, the child manifests the disease. Identification of the carrier prior to birth is unreliable. Therefore, genetic counseling is not always possible. The basic feature of cystic fibrosis is an abnormal exocrine secretion with involves several organ systems. These glands secrete to their outer surfaces. Mucus, saliva and sweat are produced in excessively thick amounts which interfere with the functioning of the lungs and the digestive system, and which plug the ducts of the pancreas.

The average survival of persons with cystic fibrosis is increasing to about seventeen years of age. Many patients are continuing to live through their twenties and thirties. As long as they are kept well through medicine, they also must be provided with psychological, educational, and vocational services, yet few studies have examined these predictors of rehabilitation of these patients. Moreover, a very great need exists for rehabilitation counseling in this area.

A question often asked me and other researchers in rehabilitation is: what use is made of all this research? Benjamin Franklin, the best-known, early-American scientist, avoided a formal philosophy about science, preferring to use science for the improvement of the human condition. It is often said that Franklin was typically American because he was interested in the uses of science. Yet we know that Franklin's discoveries in electricity came about through an interest in basic research in electrostatics. The lightning rod, for example, was an application of pure scientific research. Moreover, the lightning rod was only one proof, the most popular one, of his theory of electricity.

The utility of research cannot be separated from the origins of research. People do research because they are curious, because they want to know, because they want to discover something new about man, about the universe. From this knowledge many useful applications may be made. In rehabilitation useful applications of research have arisen from cognitive research in hemiplegia; biofeedback experiments in reducing blood pressure; the Optacon,¹⁶ which increases tactile reading for the blind by increasing the field of view; the TAC-COM,¹⁷ a wireless communication and paging system for the deaf/blind; the pathsounder,¹⁷ an ultrasonic mobility aid for the blind; plastic surgery¹⁸ for cosmetic disfigurement; counseling research¹⁹ on the use of paraprofessionals and lay helpers; implanted electrodes that permit electrical muscle stimulation in paraplegia; vocational research²⁰ on kidney dialysis and transplantation; and studies of the occupational conditions among the deaf. In deafness research alone, studies of the vocational aspirations and aptitudes of young deaf adults indicate that they have potential for higher level occupations than they usually hold. Vocational and technical programs at established training centers for the deaf are required to develop their maximum potential.

The Comprehensive Service Needs Study indicated that over 400,000 prevocationally deaf are the most seriously handicapped among the 1.8 million deaf population.²¹ The prevocationally deaf consists of persons who cannot hear and understand speech and who have lost or never had that ability prior to nineteen years of age.²² About two out of 1000 persons are prevocationally deaf, or 203 per 100,000 population. The implication of this finding is that there will be an increased need for secondary and post-secondary educational programs for the deaf. In 1972, prior to the current recession, most prevocationally deaf people were employed in a variety of occupations. However, they were often underemployed, i.e., below their intellectual and educational level. The prevocationally deaf need services to help them gain self-acceptance, to help them adjust socially, find suitable mates, and adjust vocationally to the labor market. An especially acute need pertains to the provision of mental health services for the deaf. The number of deaf persons in mental hospitals is virtually unknown. They are untreated because of communication problems with staff and because they are often misdiagnosed with mental disease.

The utilization of research flows smoothly when persons who provide services and persons who conduct research can meet in face-to-face confrontation. Testing a new idea in the free marketplace of discussion is the only lasting resolution of opposing points of view.

In presenting my thoughts to you, I am reminded of a letter from Benjamin Franklin in which he wrote:

These thoughts, my dear friend, are many of them crude and hasty; and if I were merely ambitious of acquiring some reputation in philosophy, I ought to keep them by me, until corrected and improved by time, and further experience. But, since even short hints and imperfect experiments in any new branch of science, being communicated, have oftentimes a good effect . . . you are at liberty to communicate this paper to whom you please; it being of more importance that knowledge should increase than that (I)--your friend--should be thought an accurate philosopher.²³

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APPENDIX A

Report of the Planning Meeting
Project on the Handicapped in Science
AAAS Annual Meeting, Boston, 1976

The planning session was organized to call together a group of the disabled persons in attendance at the AAAS Annual Meeting in order to receive their input as to the future role of the Association in addressing the concerns of handicapped scientists. Since its beginning, the AAAS Project on the Handicapped in Science has relied on the guidance of a growing number of disabled scientists who have offered advice during the development and implementation of the program.

A group of thirty-five disabled persons attended, this first planning session held at an Annual Meeting of the AAAS. Among the group were representatives of several regions across the country, a number of different disability groups and a variety of scientific disciplines. In order to have the full participation of each person attending, both oral and manual interpretation was provided.

In a brainstorming session the group identified over one hundred concerns and program ideas. These were categorized into four major areas, or issues, that were discussed in smaller groups in order to determine priorities for inclusion in AAAS programs. The larger group further refined the issues and stated objectives under each of the four categories, integration/normalization, education, employment, and communication. From this discussion also came a number of suggestions for special projects.

The following is the list of issues, objectives and project suggestions which were presented to the director of the AAAS Project on the Handicapped in Science to be considered in program planning for the future directions of the project.

Integration/Normalization

In order to promote the full integration of the handicapped scientist or student of the sciences into society:

1. increase the active participation of the handicapped in all Association meetings and decision-making activities;
2. provide for physical accessibility to all Association functions to encourage the integration of the handicapped;
3. promote the total integration of the handicapped scientists throughout the scientific professions through the communication network available to the AAAS--Science, affiliate society journals and newsletters, public news media, radio and television;
4. actively encourage similar activities in all 291 AAAS affiliate societies; and
5. encourage and support research and development of ways to accomplish more complete integration of handicapped into the mainstream of the scientific community.

Education

In order to provide a quality science education for all handicapped children and to remove the barriers to the handicapped who want to enter science as a career:

1. mobilize the full range of science education resources on all educational levels and make them available to teachers of the handicapped;
2. encourage increased funding for training teachers of science and supplying materials necessary to provide a quality science education for all handicapped students, whether they be in residential schools, special classes or in the mainstream;
3. encourage the integration of persons with disabilities into all preschool, elementary, secondary, college, technical, graduate and post-graduate programs in science;
4. maximize opportunities in science education at all levels but especially at the higher education and graduate levels for persons with disabilities through financial assistance and for the elimination of attitudinal, communication, architectural, and transportation barriers.

5. determine the "state of the art" of science education for handicapped children and youth and encourage action research to investigate areas of deficiency.

Employment

In order to improve employment opportunities of handicapped scientists:

1. increase the awareness of the AAAS and its affiliate societies of the discrimination against the handicapped laws governing employers;
2. facilitate for the acquisition of their first job and give assistance in changing jobs and advancing in the profession;
3. improve employment conditions in science careers by making facilities and transportation accessible, furnishing technical and communication aids and initiating action to change attitudes toward hiring the handicapped;
4. encourage action research in employment problems in science careers.

Communication

In order to develop a communication network dealing with information about the concerns of the handicapped in science that will serve the handicapped, universities, governmental agencies and other interested individuals and groups:

1. mobilize all communication networks available to the AAAS and to develop new networks in order to inform people of the accomplishments and concerns of the handicapped in science;
2. develop a clearinghouse of information on science education and careers to be used as a resource of the communication network;
3. provide a base for receiving input from handicapped scientists, students of science, science faculty, employers and others as to their problems and concerns;
4. increase the availability of science material in braille and/or on tape for the blind and captioned films or live interpretation for the deaf;
5. determine from among those available, the most effective communication networks to provide information necessary to increase the full participation of the handicapped in science education and careers.

Suggested Projects

The following projects were suggested as examples of those that might be undertaken to meet the objectives set by the group. These were described as action research since they test the feasibility of the particular activity at the same time that demonstration, training and information gathering/dissemination tasks are completed.

1. Collect and analyze the successful coping strategies of handicapped scientists in order that this information can be shared with other handicapped individuals, educators and the science community.
2. Determine effective methods to develop and utilize handicapped scientists as role models for handicapped youth and demonstrate these methods in projects in different parts of the country.
3. Collect and distribute information on successful experiences of persons responsible for the science education of handicapped youth including development and utilization of support services--financial, transportation, accessible facilities, counseling.

4. Investigate the feasibility of using a variety of communication networks to improve the image of the handicapped scientist within the general population, encourage the integration of the handicapped into science education programs, and relay information among the handicapped in science.
5. Develop strategies to create a positive self-image and to increase the expectations of the capabilities of handicapped persons by their parents, teachers, health care professionals, associates, society as a whole, and by handicapped individuals themselves.
6. Establish a network and information base that will link the science community, organizations and agencies of and for the handicapped and handicapped scientists to remove science education and career barriers that restrict the full participation of the handicapped.
7. Develop and improve existing working relationships between rehabilitation agency personnel, science educators and employers in scientific fields.

Edward Keller, Jr.
Chairperson

Mark N. Ozer
Planning Consultant

APPENDIX B

Science Education, Research and Technology
for the Handicapped

Exhibits at
Science International 1976

COOPERATIVE REHABILITATION ENGINEERING CENTER
Houston, TX 77025

Description: Demonstration of rehabilitation engineering technology developed at the Center for patients with severe neuromuscular and skeletal defects.

GEORGIA MENTAL INSTITUTE, EMORY UNIVERSITY
Atlanta, GA 30303

Description: Demonstration of a wheelchair with a detachable motor unit that was developed at the Research Center under wheelchair users' control.

LINCOLN-KENNEDY SCHOOL--RESOURCE CLASSROOM FOR BLIND CHILDREN
Wakefield, MA 02155

Description: Display and demonstration of a resource classroom for blind children.

LABORATORY SCIENCE AND ART FOR THE BLIND, THE AMERICAN UNIVERSITY
Washington, D.C.

Description: Display of equipment and audio-visual demonstration of science materials and curriculum developed to teach laboratory science, interdisciplinary science and art to kindergarten through junior high school students who are blind.

MASSACHUSETTS ASSOCIATION OF PARAPLEGICS, INC.
Boston, MA 02118

Description: Display that describes the program of the Massachusetts Association of Paraplegics including resource guides, newsletters and an accessibility guide to Boston.

PROTESTANT GUILD FOR THE BLIND, AUDIO RESPONSE TIME SHARING SERVICE BUREAU
Watertown, MA 02172

Description: Demonstration of the program of the Guild, and demonstration and exhibition of the first audio-response time-shared computer which has a vocabulary of 12,000 words. It can be used by blind and other handicapped persons in vocational and educational endeavors including computerized Braille translation (the first to meet standards of the Library of Congress) and computer aided instruction in touch typing.

REHABILITATION SERVICES, ADMINISTRATION SPECIAL CENTERS
Boston, MA

Description: Information on RSA's Research and Training Centers and their programs, directory of the R & T Centers, summary of the programs and other publications.

ROCHESTER INSTITUTE OF TECHNOLOGY, NATIONAL TECHNICAL INSTITUTE FOR THE DEAF
Rochester, NY 14623

Description: Information and display of training programs for hearing and deaf students for careers in science and technology.

RT-7 CARDIAC WORK EVALUATION
Boston, MA

Description: Developments that assist postcardiac patients in living a normal life.

RT-7 RESEARCH AND TRAINING
Boston, MA 02111

Description: Demonstration of technology for the handicapped which has been developed at the Biomedical Engineering Center at Tufts University.

RUSK INSTITUTE OF REHABILITATION MEDICINE
New York, NY 10016

Description: An overview of the evaluation and development of devices for high-level quadriplegics.

UNIVERSITY OF WASHINGTON, MEDICAL REHABILITATION R & T CENTER 3
Seattle, WA 98105

Description: Display of three adaptive aides for the severely physically handicapped person, a book reader, and illustrations of biomechanical principles applied to wheelchair and orthoses design.

VOCATIONAL REHABILITATION SERVICES FOR THE DISABLED, MASSACHUSETTS REHABILITATION COMMISSION
Boston, MA 02116

Description: Display of services available to handicapped persons through a state rehabilitation commission.

APPENDIX C

Project on the Handicapped in Science

*AMERICAN
ASSOCIATION
FOR THE
ADVANCEMENT
OF SCIENCE*

There is a new focus at the American Association for the Advancement of Science (AAAS) on the concerns of handicapped scientists. The AAAS, the largest general scientific organization in the United States, recognizes its responsibility as a leader in science to enhance the status of the physically disabled and to accelerate their advancement in all the sciences and engineering. The AAAS obtained funding from the Rehabilitation Services Administration/HEW to launch an ongoing program to explore the barriers obstructing the entry and full participation of physically handicapped persons to employment opportunities in science. In its initial eight month phase, the program examined and evaluated ways in which the scientific professional associations could contribute to equal educational and occupational opportunity. Defining a role which these organizations can play, the Project now seeks to activate and implement such efforts.

*THE
PROBLEM*

Many physically disabled individuals with interest and aptitude in science have difficulty obtaining an education, employment and promotion in the area of their interest. Science educators and employers are largely unaware of the needs of the handicapped and of their own responsibilities for overcoming the difficulties faced by disabled veterans, accident victims, persons disabled by severe illnesses and those suffering from birth defects. Physically disabled scientists working with the AAAS since 1973 have identified three aspects of the problem which they think the professional associations should address:

- Professional meeting inaccessibility.
- Recognition of the problems faced by the handicapped in their field.
- Barriers to the acquisition of training and jobs in science.

OBJECTIVES

In order to overcome these three kinds of career-related problems the initial project:

- Developed and tested methods to overcome physical and communication barriers that prevent handicapped scientists from participating fully in professional meetings.
- Developed and tested methods of increasing the awareness of all U.S. scientific professional associations of the education and career-related needs of their handicapped members.
- Developed program ideas through which AAAS and other scientific societies may enhance educational and occupational opportunity and equality for the handicapped.

ACTIVITIES

To achieve the objectives, the staff of the Office of Opportunities in Science in consultation with the project Advisory Group undertook the following activities:

- Made the AAAS Annual Meeting in Boston, February 18-24, 1976, accessible to the physically handicapped and prepared a professional meetings accessibility guide for distribution to the 291 AAAS affiliate professional societies and academies and to hotels in major convention cities. This was made possible in part through contributions from the Exxon Corporation and the Du Pont Company.
- Arranged activities at the AAAS Annual Meeting to focus the attention of the science community on the handicapped: a symposium "Science, Technology and the Handicapped"; an information center and exhibits on the handicapped in science; a luncheon and press conference; and a reception for symposium participants, other scientists, local rehabilitation agency personnel and others.

- Identified 500 handicapped scientists to serve as a resource group to guide further program development, assist in dissemination of information and form a support system for handicapped students and peers.
- Surveyed the various organizations and government agencies of and for the handicapped, and the scientific professional associations for their suggestions as to the educational and occupational barriers.
- Disseminated information to the general public and scientific community on AAAS project activities and other issues of concern to the handicapped.

*FUTURE
DIRECTIONS*

The Project on the Handicapped in Science will direct itself to the following activities:

ADVOCACY: Heightened awareness of and appropriate response to the problems of the handicapped in science on the part of professional societies, their members and organizations of and for the handicapped.

CLEARINGHOUSE: Establishment of a network and information base that will link the science community, organizations and agencies of and for the handicapped and handicapped scientists in united efforts to remove educational and career barriers.

PROGRAMS: Development and/or facilitation of projects to achieve full educational and career opportunities for the handicapped in science.

PUBLICATIONS

BARRIER-FREE MEETING: A GUIDE FOR PROFESSIONAL ASSOCIATIONS

SCIENCE, TECHNOLOGY AND THE HANDICAPPED

Founded in 1848, AAAS is the world's leading general scientific society with about 120,000 individual members interested in the advancement of science, in improving the effectiveness of science in promoting human welfare, and in increasing the public understanding and appreciation of science. Through its nearly 300 affiliated societies and academies covering the entire spectrum of science and technology, AAAS has a significant relationship with about 2 million individuals directly involved in science and technology. This relationship together with the broad scope of its interests has uniquely equipped AAAS to exercise a leadership position in convening expert bodies to analyze the technological, social, and political ingredients in significant problems facing society.



American Association for the Advancement of Science

For further information about AAAS, including information on becoming a member, write:

AAAS
1515 Massachusetts Avenue, NW
Washington, D.C. 20005

AAAS Activities and Programs

- **Science**—the weekly news magazine of science, received by 150,000 individuals and institutions worldwide, contains definitive articles and reports by scientists, engineers, and others on topical developments in the sciences, as well as on matters of public interest which involve the broad scientific community.
- **Annual National Meeting**—consists of many symposia and lectures which present the recent developments in and applications of science, as well as far-reaching discussions of the relationship between science and the problems of and prospects for society.
- **Public Information**—supplies reliable reports to the news media on the latest developments in science and science-related public policy issues from materials published in *Science*, papers presented at the Annual Meeting (covered by more than 500 reporters and science writers), and results derived from the various AAAS programs.
- **Public Understanding of Science**—develops programs to improve the quality of science presentations in the media and conducts seminars on crucial issues relating to science and technology in cooperation with community organizations throughout the country.
- **Public Policy**—sponsored authoritative studies of such problems as herbicide assessment, energy use, and air conservation, and is helping to develop seminars for members of Congress and their key staff aides and for science attachés of foreign embassies, and also sponsors a program for Congressional Fellows in science and engineering.
- **International Programs**—aids in the exchange of ideas and individuals through scientific groups in Latin America, Africa, Asia, the USSR, and the United Kingdom; also coordinates various activities and prepares reports on problems of international concern, such as population, women in development, and Habitat.
- **Science Education**—prepares guidelines for and conducts programs in teacher education; develops and publishes precollege and college level science-education materials; and conducts short courses for college teachers.
- **Opportunities in Science**—helps to coordinate programs of AAAS and its affiliated societies to improve the educational and professional opportunities in science for minorities, women, and handicapped persons.
- **Publications**—*Science Books & Films*, *Science Book List*; *Science* compendia on energy, population, food, and others to come; audiotape cassette albums on energy, origins, cancer, the physical world, and others.