

Journal of Rehabilitation Research and Development

Rehabilitation R & D Progress Reports 1985

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XIII. Sensory Aids

A. Blindness and Low Vision

1. General

The Use of the Electroretinogram to Predict Retinal Cell Activity

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Sponsor: VA Rehabilitation Research
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Purpose—The electroretinogram (ERG) is a graphic recording of electrical potential which is measurable on the cornea and is linked, in a not so well known manner, to retinal cell activity. The retinal cells thought to cause the ERG (predominantly Mullers and receptors) act as localized current dipoles. Although the orientation and position of these current dipoles are not known *a priori*, field theory dictates that an exact knowledge of these sources would be sufficient to predict the ERG signature—given knowledge of the medium's conductivity.

The hypothesis is that the process can be worked backwards; given the potential information across the cornea one can infer from its inverse what the retinal cells taken as a localized composite are doing. Such knowledge would of course realize a quantitative retinal diagnostic.

Progress—The methodology to date has been to establish a base of data correlating retinal current dipole sources to measurable corneal potentials. Data are collected by injecting a needle dipole current source through the retinal wall of a cow eye and measuring the potential with point electrodes. The current is injected at a frequency ranging from 100 Hz to 1000 Hz. The received signal is examined with a sensitive frequency analyzer which eliminates any spurious signal sources. (The eye is a rather good antenna). Placement of both the source and the receiving electrodes is varied to ascertain the effect of: 1) tangential versus normal sources; 2) cross-corneal potentials in the horizontal and vertical planes; and 3) magnitude of signals expected with respect to both ambient noise and input signals.

Preliminary Results—Literature studies reveal the common notion that the vitreous is thought to be isopotential. Of course this cannot be (from a field theory perspective) nor is it what our test results to date reveal (although we have not made the tests *in situ*). The cross-corneal potential is, however, quite small for symmetrical source excitation (equal light stimulae over the retinal region). Off-center excitation indicates a marked increase in measurable cross-corneal potential.

Future Plans—A concentrated effort is being given to realizing a numerical algorithm to predict the corneal potential as a function of space and source

excitation. The conductivities of the R membrane, lens, vitreous/aqueous, and extraocular region are used to construct a resistive grid which is solved according to Kirchoff's voltage laws (equivalent to a finite-difference for grid solving Laplace's equation). After validating the code, we will have a convenient means of predicting corneal potential for asymmetrical retinal wall source excitations.

Intraocular Lens Implantation During and After Cataract Extraction ---

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Sponsor: VA Rehabilitation Research
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Purpose—The objective of this project is to evaluate intraocular lens implantation as a means of visual rehabilitation for cataract patients. This includes implantation of intraocular lenses both during the time of surgery and as a secondary procedure. Parameters to be evaluated will include:

- 1) Method of cataract extraction;
- 2) Type of intraocular lens;
- 3) Position of intraocular lens;
- 4) Complications from intraocular lens implantation surgery; and
- 5) Medications to be used prior to and after the intraocular lens implantation surgery.

The research plan is to use an intraocular lens as the means of visual rehabilitation in selected patients who consent to the surgery and technique. The parameters described will be identified and the patient will be followed one day, one week, three weeks, and eight weeks after the surgery. After that time they will be seen once a year.

Methodology for the project includes selecting patients either with cataracts or who have had cataract surgery in the past and have elected to have intraocular lens implant, using age and other criteria presently accepted by the FDA. Patients are taken to the operating room after proper measurements have been taken preoperatively. Under local or general anesthesia an intraocular lens implantation, after cataract extraction, is performed. Patients are sutured according to the skill and discretion of the resident and attending surgeons.

Preliminary Results—To date, findings of the project have been as follows:

1) Intraocular lens implantation in the selected patient population has been a viable, safe alternative for visual rehabilitation after cataract surgery. In fact, in most cases intraocular lens implantation is the preferred method of visual rehabilitation after cataract surgery.

2) The exact surgical technique chosen appears to depend more upon the competence and familiarity of the surgeon rather than agreement upon any one particular exact technique. In general, it appears that a posterior chamber intraocular lens implant with an extracapsular procedure is the preferred technique for use with the patient who is having a cataract extraction and lens implant in one procedure. The postoperative complications in the long run appear to be diminished with this technique.

In patients undergoing secondary intraocular lens implantation, an anterior chamber lens appears to be the preferred technique.

Implementing Micro-Technology and Computer-Assisted Learning

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Sponsor: Research Centre for
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Purpose—A series of mimeographed newsletters have been produced at the Research Centre, describing progress on producing and evaluating software for the use of blind adults and children. Copies of the newsletters and further details of the various projects can be obtained from the first-named investigator at the Research Centre.

Assessing the Manual Dexterity of the Blind

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Purpose—The Purdue Pegboard Test of Manual Dexterity has been administered to nearly 1,000 newly-blinded people in the course of their rehabilitation, and the investigators expect to publish an account of their findings within the next few months. Further details can be obtained from the first author.

Blind in Birmingham—A Pilot Survey of Knowledge of Available Services

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Sponsor: Research Centre for
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Purpose—This paper gives the results of a survey designed to obtain from blind people information about their personal and vocational status, their self-perceived needs, and their knowledge of the services available to them within England's second-largest city, Birmingham. The names of 50 people were drawn at random from the city's register of blind persons, and they were interviewed, face-to-face, by the writers.

The resulting report was published in the *New Beacon*, March 1984, Vol. 68, No. 803.

Survey of Local Authority Social Rehabilitation Services for Visually Handicapped Adults

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Purpose—Phase One is a survey of a sample of local authorities in England and Wales, in order to examine the following:

- 1) Current levels and methods of provision of social rehabilitation services for visually handicapped adults;
- 2) The aims and attitudes which inform the policy of local authorities in the provision of social rehabilitation for the visually handicapped; and
- 3) How local authorities perceive the present and future role of the RNIB in the provision of social rehabilitation on a national scale.

The survey was conducted by postal questionnaire and personal interview among a proportionately stratified sample of 19 local authorities in England and Wales.

Phase Two is a survey of a sample of visually handicapped adults. This survey aimed to assess the clients' expectations as well as their evaluation of current rehabilitation procedures, in order to determine what kind of rehabilitation services visually handicapped themselves require. The survey was administered by personal interview among a sample of 153 recently registered blind adults, stratified by age.

Preliminary Results—A publication has been issued with the following title: Local Authority Social Rehabilitation Services to Visually Handicapped People, RNIB, April 1985.

Project Poly-Son: A Computer Sound Peripheral Device for Visually Handicapped Children and Adolescents

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Sponsor: National Institute for Health and Medical Research, and National Agency for Research Valorization.

Purpose—A device has been developed, that will be usable by blind and partially sighted children and adolescents, to allow them an active practice of Computer Science. It consists of a sound peripheral which permits the creation and the operating of sound objects—music, words, sound-effects—through programs written in a microcomputer in high-level languages. For very young children (4 to 7 years old) simplified commands use a perforated-card reader.

This device offers a series of immediate applications in several domains; 1) initiation to technology and Computer Science; 2) logical and mathematical games; 3) sound information games; and 4) training for programming.

Easily usable by sighted subjects, this device makes it possible to organize common activities between sighted and blind individuals and is likely to facilitate the integration of the latter in schools, universities, and professional institutions.

Early commercialization for the sound peripheral is predicted by Dr. G.C. Lairy, Research Director of the Group for Research in Theory and Practice in Psychopathology of Infants, which is a division of the National Institute for Health and Medical Research (INSERM).

Rabbit EERG Response to White-Noise-Modulated Stimuli

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Purpose—If severe hemorrhaging occurs in the human eye, the media can become so opaque that light from normal illumination is unable to penetrate the curtain of blood. It is important in this situation to determine whether the retina has normal photopic and scotopic responses. A yes/no answer is usually adequate, but the scotopic measurement is rarely accurate and the photopic protocol is usually impossible.

We propose a totally new approach to characterizing the ERG for the above paradigm, i.e., a gaussian white-noise modulation of current will be presented as the stimulus, and the Electrical ERG (EERG) response will be measured. In most practical applications of the white-noise protocol, the small (gaussian) amplitude distribution of the stimulus is a very undesirable feature. On the other hand, the white-noise characterization scheme is highly resistant to uncorrelated noise; also,

nonlinear characteristics (e.g. refractory periods) often can be resolved. Hence, it seems to be an ideal protocol for the EERG.

In an attempt to identify the functional significance of the white-noise EERG, a two-input experiment will be attempted: while the electrical stimulus is presented, a light stimulus will be superimposed. Both stimuli will be white-noise modulated and a "cross-kernel" will be calculated which will reveal how an impulse of light interferes with an impulse of current. For example, if the bipolar cells are responding to a light impulse, then they will respond differently to a superimposed current stimulus. Conversely, the current initiated response can interfere with the light response. Hence, it will be possible to identify the corresponding components of each ERG response based on the latencies indicated by the cross-kernel.

Progress — During the first two months of this project, we have written computer programs to acquire and analyze the anticipated data. We also have begun assembling electronics which will generate the electrical stimulus and amplify the EERG response.

Princeton Cutaneous Research Project

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Sponsor: National Institutes of Health

Progress — The reporting period has been made in the following projects:

P-26 Intermodal Perturbations of Temporal Order Judgments;

P-32 Computer Generation of Vibrotactile Patterns;

P-47 Vibrotactile Pattern Recognition, Discrimination, and Masking; and

P-49 Vibrotactile Supplementation of Lipreading Information.

The following is an account of progress made on Project P-32 as part of the Princeton Cutaneous Research Project's Report No. 45, June 1985.

During the last report period, two major modifications to the existing laboratory hardware have been made. First, there was completed a Senior Independent Project that enables us to control the Optacon, a reading machine for the blind, with a Commodore-64 computer. The second change involved the purchase of an IBM-XT computer to replace the aging DEC PDP-8/f computer in its role as controller of the large vibrotactile matrix. At the same time, an interface system is being developed to provide for control of the Optacon array by the IBM-XT. Details of these changes are given below:

The first project was completed at Princeton. The complete thesis will be available on request to interested readers. In brief, the interface connects the User Port of the CBM-64 to the Input/Output connector of the Optacon. No modification of the Optacon is required other than disabling the onboard clocks and inhibiting the camera input by grounding the appropriate pins on the I/O connector. Patterns to be generated by the Optacon are downloaded from disk storage into the computer's memory as blocks of 24 8-bit digital words. The right-most 6 bits of each word are used to define the on-off status of each pin in one of the Optacon's 24 rows of vibrators. Each word is placed onto the parallel output port serially as the system clock, built into the interface, counts off 24 time

intervals within each frame period. Level-shifting circuitry within the interface converts the 5-volt computer-generated pulses into the requisite -7.5 volt and -18.25 volt pulses for the Optacon. These voltage levels are provided by the Optacon, so the interface requires no separate power supply. Frame loading is conducted under 6510 microprocessor machine-language instruction, while user input and output is handled by the master program, currently written in the BASIC language. Improvements in the software are being made to allow the system to have the versatility of the original matrix system.

The second project involves developments of an IBM-XT-based system for control of both the original vibrotactile matrix system and the Optacon. At this time, data are being downloaded from the DEC PDP-8/f into the IBM-XT for analysis, using a direct connection ("null modem") and a simple Terminal Program. The Optacon interface (under construction) will be based primarily on the system developed in the laboratories of the University of California, Santa Barbara, while the Vibrotactile Matrix interface will involve a simple parallel output bus. We also have incorporated ideas from the IBM-Optacon interface system developed at the University of Wisconsin. With these changes, we expect to be able to conduct experiments with a more reliable system, as well as to be able to examine inter-site interactions in the perception of vibrotactile patterns. Furthermore, the exceptional software base that exists for the IBM-XT will allow for improved data analysis.

Aids for the Deaf-Blind

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Sponsor: National Institute of
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Purpose — A major new area of research for our Center in the field of aids for the deaf-blind is the investigation of robotics applications for this target population. We have undertaken a project to design a simplified state-of-the-art robotic finger-spelling system. Through the courtesy of Dr. Sam MacFarland of the Southwest Research Institute REC, we obtained on loan an early prototype of such a robotic finger-spelling system, and through collaborative arrangements with Stanford University and the Veteran's Administration, we studied the feasibility of new approaches to this problem. We contracted with Stanford University students, supervised by Dr. David Boonzaier (a visiting staff member at Smith-Kettlewell and Stanford) to construct an experimental prototype robotic finger-spelling system which could be used for our investigations.

The prototype has been completed. It is designed in such a way that each finger joint can be "frozen," allowing us to study the minimum required number of degrees of freedom for a future device.

We have also engaged the services of Dr. Harry Bornstein (formerly of Gallaudet College) to conduct a theoretical analysis of the finger-spelling system used by the deaf-blind, in order to suggest possible simplifications (especially those which involve reductions in the number of required fingers or joints). Initial results indicate that a greatly simplified version can be produced, and modern robotics technology should enable further reductions in cost. Should this project

be successful, the capability for both face-to-face and remote communication for large numbers of deaf-blind individuals (especially those unfamiliar with braille) will be greatly enhanced.

Progress — Several exciting new developments have occurred in this area during the past year. The Telebraille (a telephone communications system for the deaf-blind) is now being manufactured by TSI. We are particularly interested in this development because the early prototypes of the Telebraille were developed under a collaborative arrangement between the Smith-Kettlewell REC and TSI.

During this reporting period, we also have developed an inexpensive new vibratory paging system for the deaf and deaf-blind. It is currently being tested by the Kansas Parents Association for Hearing Impaired Children.

Microprocessor-Based Job Instrumentation

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Purpose — This center has completed two microprocessor-based job instrumentation projects. The first of these was a Talking Telephone Switchboard Monitor, which has been successfully tested in service by a blind operator using a 30-line switchboard. During the coming year, this design will be adapted to make it more suitable for replication by others. The second project is a microprocessor-based voice read-out system for monitoring the status of refrigeration pressure gauges. This design is about to be field-tested by a blind refrigeration engineer.

Progress — The results of these projects will be applied toward the design of a “universal” microprocessor-based job instrumentation system, capable of accepting inputs from a wide variety of instruments and transducers commonly used in vocational situations. Several output options also will be available, including speech and auditory-braille coding. Our experience with the two initial projects described here has enabled us to conceive a “universal” approach which can be readily adapted to different job situations by merely inserting an appropriate Eprom. We believe this new approach will enable both an increase in employment of the blind in varied fields, and a decrease in the cost of the specialized instrumentation which has hitherto been needed.

Form Board

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Progress — During the past year, we have developed a new version of our electronic Form Board. This device provides both auditory and tactile feedback for blind and multihandicapped children as they match shapes and figures on the top of the Form Board. The new version of this device utilizes magnetic read switches, rather than mechanical switches, to initiate the auditory and tactile feedback, obviating the problem of accidental closure of the switches through finger contact. The design has also been repackaged in a cosmetic plastic case suitable for production. This project is now complete, and a manufacturer is being sought with the assistance of the Electronic Industries Foundation REC.

New Volatile Braille Display

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Purpose— We have conceived a new approach to the development and production of single-line volatile braille displays for use by the blind in accessing computer information. Our new approach, using inexpensive parts of high reliability, should enable us to overcome the problems of cost and reliability associated with earlier displays. We have fabricated a single-cell prototype to test the feasibility of the system, and work is currently proceeding on the first 20-cell version for evaluation.

New Ways to Access Microprocessor- and Computer-Based Aids

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Progress— During the past year, we have conceived and implemented new approaches to computer-based learning systems for blind children. The connection of physical objects and systems (such as manipulata, clocks, puzzles, word games, etc.) to the computer, bypassing the conventional keyboard, both improves the motivation of the student and increases the flexibility and learning value of the computer-based sensory aid. We have tested this concept by constructing a system for teaching blind children to tell the time, using a large clock (with movable hands) connected as a peripheral to an Apple computer. Other peripheral modules serving a wide variety of functions can be added.

Several well-known commercial manufacturers involved in the computer industry have expressed interest in the future potential of these computer-based learning modules.

Geriatric Research

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Purpose— Under private funding, we have conducted research to determine the contribution of the vestibular system to the problems of balance and mobility faced by the aging population, both sighted and blind.

Progress— Vestibulo-ocular reflexes (VOR) in the blind were found to have characteristic abnormalities caused by the loss of vision (see previous Annual Report). We have implemented a mathematical model of the VOR on a microcomputer. That model, which is based on the actual neuroanatomy of the system, accurately simulates normative vestibulo-ocular responses. We are currently simulating the responses of the blind to determine the anatomical structure adversely affected by the loss of vision.

Vestibulo-ocular reflexes of older individuals will be measured to assess the effects of aging on the VOR. The procedures and techniques used to assess the VOR in the blind will be used to assess the VOR in the aged. Our findings will indicate whether visual-vestibular interactions contribute to the balance difficulties experienced by the aged.

Oculo-Encephalographic Communication System

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Progress— The new method of communication by eye gaze, developed by Erich Sutter, Ph.D., has reached a new phase in its progress towards the attainment of a truly portable system. The system has now been implemented using a Motorola 68000 processor, and is now transportable in the sense that a connection to a mainframe computer is no longer necessary. Simultaneously, substantial improvements in the signal processing have been made in order to make the system's operation faster and more efficient.

The fabrication of two even more transportable prototypes will enable us to pursue our collaboration with the Trace Center REC and the Artificial Language Laboratory of Michigan State University. Those laboratories will develop and refine the communication interfaces for the system. Zygo Industries of Portland, Oregon has contracted to act as manufacturer for the completed system.

Pediatric Program

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Purpose— The innovative Pediatric Rehabilitation Engineering Program, which was established with seed funding from the Smith-Kettlewell Eye Research Foundation, focuses on the development of new vision testing and screening technology for infants. In many visual handicapping conditions, the critical phase occurs very early in life (the first few weeks and months), and detection and intervention at this stage is crucial for satisfactory rehabilitation. Major achievements of our pediatric research program to date have been the development of a rapid visual-evoked potential screening system for assessment of infant visual function, along with development of a simple photorefractive technique using inexpensive equipment.

Progress— During the last several months, we have successfully extended the sweep Visual-Evoked Potential (VEP) technique, which we developed for acuity measurement, to the determination of contrast thresholds. In collaboration with Dale Allen of the University of California, Berkeley, School of Optometry, we conducted a comparison study of the sweep VEP and conventional psychophysical measurement of the contrast sensitivity function. The two measures were very highly correlated, suggesting that the sweep VEP may be used as an objective measure of contrast sensitivity. We also have measured infant contrast sensitivities using the same method, and have found contrast sensitivities that are markedly higher than those reported using behavioral methods and older VEP techniques.

Progress has also been made in developing a computer ray-tracing model of the photographic refraction system this center has been developing over the last two and a half years. The model enables us to predict the dioptric error of each eye, based on measurements of retinal reflexes such as those obtained in retinoscopy. The significance of this recent effort is that we are now able to determine the refractive error using an analytical method that includes this important parameter, and we expect that a significant improvement in the accuracy of our photorefractions will result from using the new analytical model.

Evaluation of Computer Hardware and Software for Visually Impaired Persons

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Purpose—The TASO System, developed by Dr. Joachim Frank of West Germany has been evaluated at this center. The system utilizes an Osborne computer with a specially adapted keyboard (containing vertical and horizontal sliding potentiometers with auditory feedback) for screen access. Initial results have been most favorable, and have enabled the center's blind engineers to become fully integrated with the word-processing system utilized by the rest of Smith-Kettlewell. Feedback from our staff has assisted Dr. Frank in updating his design, and we are currently providing assistance in selecting appropriate commercial document-reading equipment to further extend his machine's capabilities.

We also have evaluated programs for the Cranmer Modified Perkins Braille, and given appropriate feedback to Maryland Computer Services. In particular, we evaluated a geographical graphics package, which we found required modifications. Evaluation results have been shared with the company.

Portable Electronic Braille Note-Taker

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Purpose—We have developed a new concept in braille note-taking for blind students and adults. Our goal is to provide an electronic alternative to the traditional pocket braille slate, which is both slow and noisy in use. Our proposed system will provide a quiet, rapid, and pocket-size replacement for this traditional note-taking medium. Initial development work on this project is under way, and full details will be available at the end of the 1985-86 reporting period.

Sensory Substitution

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Purpose—Following the loss of vision, rehabilitation engineering approaches have been shown to be effective in providing substitute sensory information. An example of this is the ability of the congenitally blind person to perceive visual information picked up by a TV camera and provided in a tactile form onto his back. Further exploration of this concept of sensory substitution is being done with expansion to other disabilities. Specific areas that are being explored are:

- 1) the provision of pressure shear and proprioceptive information for an insensate diabetic foot in order to reduce the incidence of ulcer formation leading to amputation, and to improve the ataxic gait;
- 2) the provision of "touch" and vibratory information that a blind diabetic patient receives through the use of a long cane;
- 3) the provision of contact sensation to minimize pressure sore formation in spinal cord injured persons;
- 4) the provision of contact "touch" and other superficial sensation to insensate hands.

Demonstration of a Low-Vision Aid Clinic as an Employment Enhancement Technique _____

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Sponsor: National Institute of
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Purpose—The purpose of this study is to determine whether providing a partially blind person with a low-vision aid (LVA) will enhance his or her employment, as measured by productivity and self-satisfaction in employment in sheltered settings.

Progress—In Phase I of this study, 50 partially blind persons from the Mississippi Industries for the Blind (MIB) were randomly selected to participate in this study. These subjects were serially screened for LVA prescription by 1) complete medical and extraocular examinations and 2) Goldman field examination. Following LVA prescription as required for maximum efficiency in the subjects' work environment, specific training was provided to encourage utilization of the LVA on the job.

Of the 50 participants in this study, 32 were prescribed LVAs. Analyses of payroll data and other interview data were collected at 30 days, 6 months, and 12 months after receipt of the prescription. An analysis of the data through the 6-month period shows that the LVA group has responded favorably to the aids. The LVA group questioned said that they could work better with the aids and had little or no trouble using them.

Future Plans—An interim progress report will be published. Subjects for Phase II of this study will be selected from sites other than MIB during the upcoming year.

Industrial Services Program Model for Sheltered Workshops for Legally Blind Workers _____

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Purpose—To determine whether the Industrial Services Program Model (ISP) enhances the employability of blind persons. The research project addresses two questions:

- 1) Does the ISP pre-employment training increase the productivity of blind workers who are newly employed in a protected industry?
- 2) Does an adapted ISP increase the productivity of blind workers who are newly employed in a competitive industry?

A multiple time series design has been utilized to investigate the effectiveness of an ISP on the performance of twelve blind persons who received ISP pre-employment training. The control group consisted of the last 12 employees hired by MIB prior to the initiation of in-plant ISP training.

A non-sheltered setting in which blind persons could participate in ISP training in Mississippi was sought, but not found.

Preliminary Results—Preliminary analysis of the data collected at MIB may be interpreted as indicating no significant differences between the experimental population which received ISP training and a control group which did not. Data collection on this project has been completed.

Assessment of Current Career Development Intervention Services and the Needs of Blind and Severely Visually Impaired Individuals

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Purpose — The purpose of this project is 1) to assess current career development services for blind and severely visually impaired persons and 2) to assess the career development service needs of these persons. The project addresses two questions:

- 1) How effectively do current career development intervention strategies facilitate the employment and career development of blind and severely visually impaired persons?
- 2) What are the career development needs of blind persons?

The research design determined the extent to which current career development services meet the career development needs identified by blind students, their teachers, their parents, rehabilitation agency personnel, and blind adults.

Preliminary Results — Analysis of the data collected during this project has been divided between the impressions of blind persons of their career development needs and the perceptions of educators and rehabilitation professionals of the extent to which career development needs of blind persons are being met.

Illumination Level and Color Contrast Studies

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Sponsor: National Institute of
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Purpose — The purpose of this project is to determine whether manipulating the illumination level, and altering the color contrasts, significantly increases the productivity and comfort of severely visually impaired production workers. Specifically, this project addresses three questions:

- 1) To what extent does increasing or decreasing illumination affect the performance of severely visually impaired production workers on a task performed visually?
- 2) To what extent does varying color contrast affect the performance of severely visually impaired production workers on a task performed visually?
- 3) To what extent does optimizing the illumination of the work site and the color contrast of materials used in performing tasks in the work site increase the productivity and comfort of severely visually impaired production workers?

Progress — Fourteen subjects, nine of whom utilize high-power low-vision aids prescribed in RRTC/B-LV project R-1 (Demonstration of a Low Vision Aid Clinic as an Employment Enhancement Technique), were tested with respect to various illumination levels and color contrast conditions to determine the specific levels of these variables which maximized their productivity and comfort. The job site of each subject was then modified in accordance with that subject's optimum illumination and color conditions.

The design was an A-B-A-C-A-D-A single subject withdrawal design, with A representing non-treatment phases and B, C, and D representing light-only, color-

only, and color-plus-light modification phases, respectively. Before and after each modification (or treatment) phase, the modifications were withdrawn, resulting in non-treatment phases alternating with treatment phases. The dependent measures were productivity rates and comfort ratings.

Functional Outcome for Blind or Severely Visually Impaired Clients of State Rehabilitation Agencies

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Sponsor: National Institute of
Handicapped Research

Purpose — The purpose of this study is to identify the factors which may predict the results of rehabilitation services provided to blind and severely visually impaired clients of selected state rehabilitation agencies. More specifically: To what extent can the functional outcome of blind individuals closed successfully or unsuccessfully rehabilitated by state rehabilitation agencies be predicted by 1) services received, 2) client characteristics, 3) county economic conditions, and 4) proximity to rehabilitation services?

Progress — A stepwise multiple discriminate analysis was utilized to assess functional outcomes and related characteristics of 619 blind and partially blind persons whose cases were closed as either successfully or unsuccessfully rehabilitated by state rehabilitation agencies in Florida, Kansas, Mississippi, and Ohio. Subjects were selected at intervals in proportionate numbers according to rehabilitation case closures from the four state agency populations in FY 1978, 1979, and 1980. Subject totals were: Florida, 146; Kansas, 42; Mississippi, 124; and Ohio, 307; for a 3-year grand total of 619. With the exception of Kansas, for which data for 1978 were unavailable, data are evenly distributed over 3 years.

A stepwise multiple discriminate analysis was used to develop a multiple discriminate function to predict the work status outcome criterion variable. This process allows the computation of the best possible combination of predictive variables associated with the functional outcome group. Other analyses will be conducted as are deemed appropriate.

Publication of a report of the findings of this study is planned for 1986.

Visual Field Limitation in the Patient with Dementia of the Alzheimers Type

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Sponsor: VAMC S. Cloud,
(station-appropriated
funds.)

Purpose — This paper investigates the existence of a visual field limitation and its effect on the advanced Alzheimers patient. The data presented was obtained by testing 12 patients with Alzheimers disease and 12 control patients. The control patients were demented from causes secondary to reasons other than Alzheimers disease.

The results indicated that patients demented due to Alzheimers have visual field losses significantly greater than other demented patients. This significant visual loss is of importance in assisting in differential diagnosis and in planning patient environments.

Development of Electromechanical Vocational Assessment Technology for Finger Dexterity and Hand/Foot Coordination

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Sponsor: National Institute of
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Purpose — The purpose of this study is to determine the reliability and validity of six pre-employment evaluation and training electromechanical work task units (EVAT). Specifically: Are each of the six electromechanical work task units reliable and valid pre-employment assessment technologies for blind or severely visually impaired employees?

A test-retest over time design was utilized on 30 subjects drawn from the following rehabilitation facilities and sheltered workshops: Mississippi Industries for the Blind, Jackson, Mississippi; Addie McBryde Rehabilitation Center, Jackson, Mississippi; Royal Maid Association for the Blind, Hazlehurst, Mississippi; Regional Rehabilitation Center, Tupelo, Mississippi; Royal Maid Association for the Blind, Tupelo, Mississippi; and Louisiana Association for the Blind, Shreveport, Louisiana.

Background data were collected on all subjects tested. These data included: date of birth, medical and psychological information, work history, and level of education. Additional information included relevant vocational evaluation and assessment scores: Valpar, WRAT, IQ, and the Pennsylvania Bi-Manual Dexterity Work Sample. For individuals who were employed at the time of testing, a job analysis and ratings by their supervisor were obtained.

Reliability levels indicating test accuracy over time were established by the computation of a coefficient of stability obtained through test-retest procedures. Product-moment correlation is the primary method utilized. A standard error of measurement also is being determined.

Practice efforts on the test-retest reliability have been minimized through data collection procedures. The length of interval between testing periods and the lack of intervening training activities reduces the impact of practice on the reliability measure.

Preliminary Results — A report of the findings of this study will be available during 1986.

Adaptation of the Vocational Educational Readiness Test

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Sponsor: National Institute of
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Purpose — The purpose of this project is to determine whether each of the Vocational Educational Readiness Tests (VERT) adapted for blind and severely visually impaired persons is an appropriate (reliable and valid) assessment tool for determining the readiness of these persons to enter training programs for auto mechanics, electrical wiring, quantity foods, and industrial sewing.

Progress — Each of the VERT modules was screened to determine the elements requiring vision. The training samples were then constructed at the field work site. Project personnel have been provided training and consultation in use of the training samples and recording of project data. Based on the training sample data

being collected at the field test site, revisions to the training samples or training sample procedures are being made.

A test-retest over time design is being utilized. The tests are being administered to present trainees and employees at two different locations: Royal Maid Association for the Blind (Tupelo, MS) and Regional Rehabilitation Center (Tupelo, MS). Participants have been randomly selected from a group of volunteers from each location. There have been 15 individuals tested and retested on each work task. Sighted standards and norms have been developed for blind persons. Baseline data have been collected for all training samples.

Reliability levels will be established by computation of coefficients of stability obtained through test-retest procedures. Retests will be conducted within a 90-day period. No additional training on the work sample will be conducted. Practice effects will potentially impact any performance-based assessment technique. The length of the interval between testing periods and no-training activities reduces the impact of practice on the coefficient of stability.

Validity will be determined in two ways. Concurrent validity will be established by correlating training task scores with the subjects' scores on other vocational evaluation systems for which similar tasks are available. Content validity will be established by comparing the job analysis of the job on which the training sample was designed with the resulting training sample.

Other data will be gathered on the client data form. This information will include visual disability and information on secondary disabilities.

Test and retest data on three of the four assessment modules have been collected. Analysis has primarily focused on the auto mechanics module. A "powder puff" class of sighted persons also was assessed with the adapted VERT auto mechanics module. All tasks save one were shown to be both reliable and valid.

Further modifications were made in the procedure to administer the auto mechanics module, and a standardized instruction manual has been written. The auto mechanics module is currently being field tested at the Arkansas Enterprises for the Blind. Additional field sites will include the Alabama Institute for the Deaf and Blind and the Criss Cole Rehabilitation Center.

Future Plans — This research design will be employed to establish the reliability and validity of the industrial sewing, auto mechanics, and quantity food modules.

Training Opportunities Profile for Visually Impaired Persons

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Sponsor: National Institute of
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Purpose — The intent of this project is to develop a series of assessment materials that can be used in vocational evaluation centers to assess the capabilities of blind persons to enter training in one of the five following job clusters: 1) computer programming, 2) counseling/social work, 3) management, 4) sales, and 5) allied health. The research question may be stated as: What are the characteristics which indicate the aptitude of blind and severely visually impaired persons to enter training in one of five job clusters?

Progress — Technical and professional job clusters were identified as meeting the conditions of 1) a high number of employed or in-training blind persons and 2) labor market forecasts indicating employment possibilities which will continue to exist for the foreseeable future. Information concerning the job task and manpower requirements was obtained from literature reviews and interviews with sighted and blind workers as well as with trainers of blind and sighted persons in each of the job cluster areas.

This information was utilized in constructing assessment materials for each job cluster. The assessment materials will be criterion referenced for use in career decision-making by blind persons.

The first phase of this project was a review of assessment instruments used to test the abilities of blind and severely visually impaired persons. The result of this effort was the publication in 1984 of *Work Samples and Visually Impaired Persons: A State-of-the-Art Review and Resource Manual*.

The second phase of this project is currently in progress. A comprehensive literature review has been completed for each of the five job clusters. Job analyses have been conducted through literature reviews and interviews. Critical occupational tasks, traits, and dimensions have been identified. Drafts of the manuals for each of the job clusters have been completed.

Future Plans — Manuals to assess the likelihood of blind persons entering jobs in each of the five job clusters will be published during 1986.

Pre-Vocational Work Ability and Success-Acquisition Training of Deaf-Blind and Other Multiply Visually Disabled Individuals

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Sponsor: National Institute of
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Purpose — This project follows preliminary findings of the RRTC/BLV research project, Development of Electromechanical Vocational Assessment Technology (EVAT) for Finger Dexterity and Hand/Foot Coordination. Three of the EVAT units found to be reliable and valid assessment technologies of finger dexterity and hand/foot coordination will be adapted to determine whether they may be utilized as pre-vocational work ability and success-acquisition training technologies. The Research Questions: Which, if any, of the adapted EVAT work task units selected for inclusion in this project, when used as pre-vocational training technologies, provide deaf (or otherwise multiply disabled) blind persons with transferable pre-vocational work skills and success-acquisition skills?

A single subject research design will be employed to assess the utility of three EVAT task units with 15 deaf or otherwise multiply disabled blind children between 14 and 22 years of age in Jackson, Mississippi.

This project will be conducted in three phases. During the first phase, the EVAT task units will be modified for use by the subject population, and a pilot study with the adapted equipment will be undertaken. Training manuals also will be developed. A brief case history of each of the subjects will be collected during this phase as well.

The second phase will consist of assessment of each subject's pre-vocational skills.

During the third phase of this project, each subject will be trained in the use of the EVAT task units. On subsequent trials, the data for the following table will be collected.

Progress — Each of the EVAT units to be used in this project were modified for use with deaf-, or otherwise multiply disabled-, blind persons. Instruction manuals for using each training task unit for pre-vocational training classes were drafted.

All three units together with revised standardized instructions were pilot tested with 13 deaf-, or otherwise multiply disabled-, blind students at the Mississippi School for the Blind.

Future Plans — The reliability and validity of the adapted work task units will be investigated. A report of the findings of this study will be published.

Assessment of Eye-Hand Coordination and Manual Dexterity Under Different Illumination Levels and Contrast Conditions

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Sponsor: National Institute of
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Purpose — This project is an extension of the strategies and techniques developed in RRTC/BLV project R-5, Illumination Level/Color Contrast Studies, to increase knowledge about the effects of modifying the visual environment on various types of visual performance which are basic to many work abilities. The research questions are:

- 1) To what extent do environmental modifications such as changes in illumination level, contrast, size, and presentation speed affect performance of low-vision subjects on tasks involving perceptual and psychomotor skills?
- 2) How do these environmental characteristics interact to affect performance, and are the effects and interactions consistent across tasks requiring different combinations of skills?
- 3) How much variation exists among low-vision persons with respect to such effects, and can relationships to subject characteristics be identified?

The tasks on which dependent measures are to be obtained tap basic perceptual and psychomotor skill abilities which underlie much visual functioning. These tasks will be novel to the subject and thus require a continuous use of vision. The testing for optimal stimulus characteristics will be done on multiple tasks, each requiring a different combination of perceptual and psychomotor skills, allowing for greater generalizability to on-the-job skills and an investigation of the consistency of stimulus effects across a variety of tasks.

The number and type of independent variables or stimulus characteristics have been increased over those used in the previous project, resulting in the following improvements:

- 1) Contrast will be studied in terms of its components, luminance contrast, and chromatic contrast.
- 2) For each task employed, the two primary independent variables to be manipulated are illumination and luminance contrast. In addition, each will include one or more of the following task characteristics as independent variables: illumination, size, speed of presentation, and chromatic contrast.

Data collection on each subject will be completed in a single day, rather than the months required in R-5. This allows for better control of motivational variables and the elimination of history effects.

The subjects to be included in this study will be 40 persons who are legally blind in the State of Mississippi. They will be obtained through the cooperation of Mississippi Vocational Rehabilitation for the Blind. Selecting subjects in this manner should better insure their representativeness.

Instrumentation, tasks, and independent variables to be used in the project have been designed to answer the research questions.

Progress—Construction of stimulus sets, modifications of apparatus, and refinement of testing procedures were completed. The entire procedure was pilot-tested on 50 subjects with simulated visual acuity losses. This was done not only to test the methodology and procedure, but also to provide data for a “standard measure” to which the performance of actual low-vision subjects might be compared. These data have been analyzed to determine the relative strengths of variable effects, presence of interactions between variables, etc.

Testing of rehabilitation clients has begun. In addition to data collection for research purposes, each client’s performance on each task under the various conditions is examined in relation to his or her career goals. An evaluation report is submitted to the client’s rehabilitation counselor, providing feedback on the client’s performance, information concerning the relative importance of environmental variables to his/her performance, and recommendations for career advancement.

Future Plans—Analysis of the data collected will be completed. A report of the findings of this study will be published.

Selected Career Development Factors and Outcome of Vocational Rehabilitation Services Provided Middle-Aged and Older Blind Persons

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Sponsor: National Institute of
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Purpose—This study is an intensive investigation of one of the sub-populations identified in RRTC/BLV project R-4, Functional Outcome for Blind/Severely Visually Impaired Clients of State Rehabilitation Agencies. The research questions are:

1) In agencies providing services to them, do middle-aged and older blind clients of rehabilitation agencies differ from younger clients, as well as from one another, with respect to (i) disabilities (primary, secondary, tertiary), (ii) proximity to their rehabilitation counselor or to a rehabilitation facility, (iii) services received, (iv) funds expended, (v) vocational skill levels, and (vi) functional outcome? If yes, to what extent with respect to each?

2) Do the functional outcomes of blind middle-aged and older persons closed either successfully rehabilitated or unsuccessfully rehabilitated by state rehabilitation agencies differ from each other with respect to (i) services provided, (ii) client characteristics, and (iii) county economic conditions? If so, what factors predict successful as opposed to unsuccessful closures?

A multivariate discriminate analysis will be utilized to assess the functional outcomes and related characteristics of middle-aged and older persons from the data base of 619 blind persons whose cases were closed either as successfully (status 26) or unsuccessfully (status 28) rehabilitated by state rehabilitation agencies in FY 1978, 1979, and 1980 in Florida, Kansas, Mississippi, and Ohio. Middle-aged subjects will be defined as those persons who were 40 to 54 years old at referral. Older subjects will be defined as those persons who were 55 years of age or older at referral. Younger subjects will be defined as those persons who were 39 years of age or younger at referral.

Progress—Subjects were selected at intervals according to rehabilitation totals from the four state agency populations in FY 1978, 1979, and 1980. The data base has been built from individual case files abstracted for project R-4. The same statistical analytic procedure will be employed in this project as has been utilized in R-4.

A review of the literature and an analysis of selected demographic characteristics of the three-sub-populations have been completed.

Future Plans—Analysis of data on this project will be completed in 1986 year. A technical report of findings will be available from the Rehabilitation Research and Training Center on Blindness and Low Vision.

Sensory Aid Technology: A Career Development Intervention Strategy for Blind and Severely Visually Impaired Persons

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Purpose—The purpose of this study is to determine the effects of sensory aids on the employability and career development of blind and severely visually impaired persons.

The instrument to be developed was constructed by the RRTC/BLV staff with consultation from a sensory aid technology specialist, and a data formatting specialist. The data formatting specialist was used to assure efficiency in data entry and analysis. The survey instrument was pilot-tested in Mississippi. The sensory aid technology specialist and data entry specialist were asked to review the responses. Changes were made as warranted. The responses to the survey were analyzed using SPSS-X 83 release. Probable programs to be used include crosstabs, report, etc.

Predicting the Visual Abilities of Partially Sighted Persons

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Sponsor: VA Rehabilitation Research
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Purpose—More than three-fourths of America's legally blind population may have useful, residual vision. Many of these people could benefit from visual aids, but either they have not had them prescribed or they are not using the aids they have been given. Accordingly, they must rely upon sighted people to help them perform many of the activities of daily living.

One explanation for this problem has been that the traditional tests of visual function used to prescribe low-vision aids do not tell us about an individual's ability to perform everyday tasks. This information is essential for prescribing aids that allow an individual to make the most of his or her remaining vision.

The goal of our study is to apply new measures of visual function to give us an understanding of the visual environment of partially sighted persons. The measure we are concentrating on is called the "contrast sensitivity function" or CSF, which gives us an indication of how well people see details of different sizes.

We are measuring the contrast sensitivity function of partially sighted persons and using these functions to process images by computer. Theoretically, the computer-processed images will show us how the environment appears to partially sighted persons. If this is true, then we will perform additional studies to see which aspect of the contrast sensitivity function is most closely correlated with the person's ability to perform certain tasks. In the first stages of the study, we will examine simple tasks such as recognizing letters, shapes, and faces. Later, we will study more complex tasks such as those encountered in daily living.

If our study is successful, we will not only gain a better understanding of the implications of severe visual impairment, but we will also provide techniques that can be used to reduce the handicaps associated with it.

The Effectiveness of a Blind Rehabilitation Program

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Purpose—To assess the effectiveness of the Blind Rehabilitation Center, it was necessary to develop instruments to measure quality of life or life state—i.e., attitudes toward self and blindness, independence in activities and travel, and psychological state. We validated scales to measure these variables with data collected in a series of pilot tests. (The way in which these scales were to be used in the evaluation study and the way in which they fit into a general model of the rehabilitation process were described in a previous report.)

Progress—Our evaluation model required that we measure a patient's life state before he or she entered the rehabilitation program, shortly after completing the program, and again 6 to 9 months later. Since the report mentioned above, 245 patients have completed initial interviews, 190 patients have completed second interviews, and 143 patients have completed third interviews. We are continuing the data collection focusing in three areas: continued analysis of the measuring instruments' validity; preparation of the program and data for future analysis; and integration of the data into a larger data base management system.

We have constructed all of our measuring and survey instruments; most have been thoroughly tested, analyzed, and reported in the literature (see previous report). In the past year, we compared the method of scaling used in developing the measures with factor analytic techniques. We found that Rasch Scaling techniques gave stable unidimensional scales, while factor analysis gave scales of indeterminate strength, fluctuated from group to group, and, so, were too unreliable for research purposes. We revised the Attitude Towards Blindness

Scale, to make it applicable to wheelchair-bound individuals. We then completed the analysis of the validity of the activity and travel measure. While we collected data primarily to validate the activity and travel measure, our additional analyses made it possible to develop a needs assessment of the rehabilitated blind veteran.

We also have constructed two information systems for the blind rehabilitation evaluation project. Through these systems a large amount of data is collected from each patient in multiple interviews, including a demographic file, a medical history and physical exam, an ophthalmologic exam, and five separate survey instruments, each of which is administered three times. The information system to manage the flow of work and data is an easily mastered, user-friendly system that can be adapted to many types of project management. The patient information resides in a data base management system that is an industry standard DBMS with full security protection and privacy locks. It has the capacity to be used by many different programs and can easily be adapted to other research projects.

Musical Language and Large-Print Considerations in Human-Factors Engineering _____

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Purpose — The purpose of this project is to determine the optimal cost-effective methods of interfacing the visually impaired person to computer display, digital information recovery, and entry systems.

Progress — A preliminary study has been conducted which consisted of analytical interviews with a visually impaired computer user. The recommendations which resulted from these interviews were published in a paper: Human Factors Considerations In The Development Of A Large Print Display For The Visually Impaired Computer User, published in the Proceedings of the Second Annual Conference on Rehabilitation Engineering, June 1984, Ottawa, Canada. In addition, some of the recommendations of the interview have been implemented on an Apple computer and are being tested by several visually impaired computer users. It was also suggested that the musical language be combined with the large-print displays as a means of providing bimodal display recognition. This is now being implemented and will soon be tested by several visually impaired users. The musical language referred to here was the result of a graduate feasibility study, the results of which have been discussed in previous reports.

Future Plans — The investigator intends to continue the implementation of the recommendations of the abovementioned study and further testing of these implementations by computer users under a variety of work and home situations. Finally, the results of these implementations and tests will be used as a guideline in the development of a Video Emulator Monitor and Display (VMED) for the visually impaired computer and word-processor user. The VMED is intended to be a universal device which will act as an interface between any computer and the visually impaired person.

2. Mobility Aids

The VA Guide Dog Harness

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Sponsor: VA Rehabilitation Research
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Purpose— This is a student design project. The purpose is to design and test new guide-dog equipment made with a more appropriate choice of materials technology. The goal is to develop a harness and leash that give better wear, require less care, have superior esthetics, and cost less to produce.

Progress— Prototypes have been completed for fieldtesting and evaluation. Leather has been replaced by nylon strapping because it is lightweight, more comfortable, requires little care, and is believed to have a longer lifetime. All buckles have been replaced with Scotch-Mate, a product similar to Velcro, because it is infinitely adjustable and believed to be more comfortable for the dog. The initial harness handles were made from both acrylic and polycarbonate rod. The simplicity, practicality, and esthetics of the new harness and harness handle were rated highly by persons using guide dogs. The new handle excelled as a communication link between the dog and the disabled person. However, there have been continued problems with the handle/harness interface.

Future Plans— The cooperative testing of the VA Guide Dog Harness with several guide dog schools is currently in progress. All of the field evaluations have not been completed, but we have received many positive results, as well as some possible design improvements. When the field testing is complete we will evaluate the results and incorporate the ideas into a possible production prototype. A potential manufacturer has been located and production will follow successful testing.

SONA/SONA-ECS

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Purpose— The SONA/SONA-ECS is a digital radio transmitter-receiver system that has applications for visually impaired persons as an orientation aid and for manually impaired persons as a Decentralized Environmental Control System (ECS).

Progress— Both the Sona and the SONA-ECS have proved to be highly reliable and to function well technically. SONA-ECS has had approximately 4000 hours of field testing to date, in both a work environment and a veteran's home. It is also being used to operate a door and wheelchair lift control and interior lights in a van.

The transmitter and SONA-ECS have been redesigned to simplify the hardware involved by replacing the discrete digital ICs and DIP switches with a single-chip

microprocessor and a few support devices. SONA is also being redesigned in the same manner. In addition to simplifying the hardware, the new designs will also enhance the system's capabilities, because many modifications and improvements can be implemented through software. A broader range of output devices, including input to a computer, can be easily interfaced to the system. The digital coding of the radio signal can also be expanded so that a transmitter for different uses or disabilities will send a different generic use-code in addition to the device code.

The SONA (Sonic Orientation and Navigational Aid) for the visually impaired traveler is now undergoing initial fieldtesting at the Atlanta Veterans Administration Medical Center. Response to the system has been very favorable. This initial testing involving 35 units is beginning to determine some design criteria for improvements in both the technical and human-factors areas. The use of microprocessor technology in the system will greatly facilitate the implementation of these improvements. One such improvement involves the proposed use of synthetic speech units for applications where the musical language output is inappropriate.

Future Plans—The Atlanta Veterans Administration Medical Center intends to continue development and evaluation of this system in both of its aspects. This research will focus on two areas: enhancing the performance and capabilities of both systems through the application of microprocessor technology, and evaluation of the SONA as an aid to the visually impaired traveler.

The final result of this research is intended to be the development of products which are low in cost and easily manufactured.

Design and Evaluation of Sensory Substitution Systems

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Purpose—For many years, the design of artificial systems for blind people enabling them to interact with visual aspects of their environment has been attempted to compensate impairments of blindness. Among the possible solutions for such artificial systems, one may use an intact sensory channel like somesthesia or audition, avoiding, on such a way, problems of long-term compatibility with implanted biomaterials. In this case, visual information has to be detected, decoded, and transmitted in the form of vibrations or sounds to the substitutive organ. Moreover, this tactile or auditory stimulation has to be correctly interpreted by the subjects, involving problems of learning and of plasticity of nervous structures. This is the theory of sensory substitution proposed by P. Bach-Y-Rita in 1972.

We are involved in a program devoted to the study of sensory substitution. Our research prospects are to evaluate this theory, by physiological means, on men and animals. To achieve that, we are following two main ways.

Progress—First, we are searching behavioral cues giving evidence of space perception enhancement obtained by using an ultrasonic binaural sensory aid roughly similar to the Sonicguide designed by L. Kay.

In these experiments we have attempted to measure, in relation to visual experience, improvements in space-perception tasks induced by this sensory aid. Space perception was studied in the grasping space and in the space of locomotion; direction and distance estimations in spatial localization tasks were recorded by means of verbal and motor responses.

Future Plans — We plan to detect possible sensory substitutions by metabolic as well as electrophysiological means.

Secondly, we focus on designing more-sophisticated visual prostheses. Our aim is to optimally design a prosthesis substituting audition to vision. This system would 1) improve spatial localization; 2) also improve performance related to other visual modalities, e.g. pattern recognition; and 3) in spite of resulting design sophistications, limit the necessary learning to a minimum of length and difficulty. These design efforts are now in progress.

Illumination and Mobility

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Purpose — Among persons with low vision, the most commonly reported functional problems relate to glare and photophobia. When a person has an impaired visual system, any reduction of visual acuity can have a profound effect on both the perceived and actual ability to travel safely. This project was designed to explore the effect(s) which sunlenses have on the mobility performance of pedestrians with low vision.

Progress — Subjects were randomly placed in either a control or treatment group. Each group was required to walk a 10-block route in a residential and small-business environment. The control group did not wear sunlenses while the treatment group did. Data were collected on heart rate (measured by a heart monitor connected to a tape recorder), illumination levels, visual acuity with and without sunlenses, mobility performance, and environmental characteristics such as crowd density, temperature, and traffic density. At the completion of the project, 104 subjects had been tested.

The data are currently being analyzed. Specifically, T-tests are being utilized to determine if sunlenses provide for a difference in mobility performance as measured by heart rate, visual acuity, and obstacle detection.

Expansion of a Computerized Information System for Use in the Study of Low Vision Mobility

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Purpose — This project concerns the expansion of a computerized information system to assist researchers and practitioners in developing and evaluating theories and aids to improve mobility for low vision persons.

Progress — This project has focused on the expansion and restructuring of the Low Vision database developed and described in a previous project (NIHR, 1983)

in order to facilitate its use by researchers and patient care professionals. As indicated in a previous report (R&D, 1984), the major revisions in the data base structure, the related changes in input forms, and the development of an English-language report generator took up most of the first year. Relational modules specifically designed for projects three and four were also created. Input of patient and subject information was continued.

The input of patient and subject information has been continued into the last year of the grant. The O&M modules have been finalized and put into use by projects three and four. In addition, programs designed to analyze the data have been developed and refined. These programs have been used for generation of demographic information, for interfacing with statistical and exploratory analysis software packages, and for tabulation of clinical data associated with use of specific aids. The latter is being used in the evaluation of low vision aids through study of the patterns of their issuance. In addition, evaluatory protocols for use by Eye Care Professionals in the individual assessment of various types of mobility related, low vision aids have been developed.

The Effects of Low Vision Aids and Training Methods on Mobility Performance and Stress

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Purpose — To determine the effects of low vision aids, and traditional versus non-traditional training methods, on the independent mobility performance and stress levels of individuals with low vision.

Individuals with reduced vision experience more stress (as measured by increased heart rate) in mobility than their fullysighted counterparts. Traditional mobility training techniques have not addressed the mobility needs nor the higher stress levels of individuals with low vision. The use of low vision aids combined with orientation and mobility training and relaxation techniques will lower heart rate and reduce mobility-critical events as well as self-perceived stress levels of subjects during mobility situations. In addition, overall self-image will be improved.

Progress — Forty subjects were selected who met the following criteria: 16 years of age or older; metropolitan Philadelphia residents; with mobility problems; with enough residual vision to benefit from a telescopic device; and with adequate health to walk a 10-block route.

All subjects received the following: 1) comprehensive low vision evaluation consisting of social intake and history, acuities, fields, ocular health, blood pressure, color testing, sun lens evaluations, and optical aid evaluation; 2) 1 hour of training with a telescope; 3) a 10-block mobility screening during which heart rate was recorded and mobility "critical events" (problems) were noted; and 4) administration of a battery of seven questionnaires measuring attitudes about low vision mobility, stress in general, stress related to mobility, psycho-social status, and attitudes about blindness.

All subjects recorded their experiences in a journal. All subjects were randomly assigned to one of four treatment groups, with maximum of 10 per group.

Group A received the telescope, a maximum of 30 hours mobility training incorporating use of the telescope, and 10 hours of relaxation training over a 7-week period.

Group B received the telescope and 30 hours of mobility training incorporating use of the telescope over a 7-week period.

Group C received the telescope and 10 hours of relaxation training over a 7-week period.

Group D received the telescope for a 7-week period.

At the end of the 7-week period all subjects returned for post-testing and to submit their journals. Post-tests consisted of the following: Optometric (acuity, fields, color testing, and blood pressure); Psycho-Social (battery of questionnaires); and Mobility (a similar but different 10-block route while heart rate and mobility critical events were recorded).

Preliminary Results—Preliminary findings yield trends showing varying degrees of improvement in mobility in Treatment Groups A, B, and C: no change and even regression is shown in Group D. Results will be analyzed and reported.

The Spatial Orientation of Low Vision Persons

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Sponsor: National Institute of
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Purpose—This project is about the spatial learning and orientation of low vision persons. Spatial learning and orientation were assessed in terms of the accuracy of observers' judgments of the spatial relations learned among the important landmarks of 4 × 4 block business and residential districts where they had traveled extensively. The participants were asked to judge the following from memory: the straightline and walking distances among landmarks, the heading to landmarks from three different points of observation, and the two most efficient routes connecting three pairs of landmarks. The 91 subjects included 79 with low vision, six with no vision, and six with normal vision. The low vision participants varied in their etiologies, type of remaining vision, and age of onset.

There were three specific aims of this study. One aim was to develop procedures to assess the spatial learning and orientation of low vision persons and to examine the reliability and validity of the measures. The odd-even item correlations computed to assess reliability were good, ranging from 0.70 to 0.90. To assess validity, a multitrait-multimeasure approach was used. The pattern of correlations across different methods of measuring the same thing and across similar methods of assessing different things indicated good validity.

The second aim was to assess variations in spatial learning and orientation as a function of the participant's type of low vision and age at onset of visual loss. Preliminary analyses indicate that type and onset of visual loss play little role in participants' judgments of routes they have learned. However, they indicate that people with early onset of visual field loss, but not early onset of acuity loss, error greatly at judging straightline distances and directions, abilities thought important in devising new routes and helping learn a new space. And, finally, the third aim was to investigate the effect of age, amount of orientation and mobility teaching, and demographic factors on the spatial judgments.

The Mobility of Persons with Low Vision

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Sponsor: National Institute of
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Purpose—The aim of this project is to assess variations in mobility in novel situations as a function of variations in the person and in the situation. The major person variables are acuity, contrast sensitivity, visual field size, and amount of formal mobility training. The major situational variables are level of ambient illumination, nature of the space, and specific environmental feature to be navigated. The 42 adults who participated included 30 with low vision, six with light perception or less vision, and six with normal vision.

Progress—Although data collection is complete, the results are not yet available. The remainder of this abstract outlines the project's methods and specific aims.

During the tests, participants walked routes in 3 unfamiliar places: an office building (0.2 mile), an outdoor business district (0.7 mile), and an outdoor residential district (0.7 mile). Their primary task during the walk was to travel efficiently and safely. To evaluate primary task performance, their travels were continuously videotaped. The tapes were later scored to count the number of collisions, stumbles, pauses, changes in rate, changes in gait, and other incidents. In addition, participants performed a secondary-choice reaction time task while walking; errors and latencies on the secondary task were recorded as well. Participants walked each route two times, once under normally bright levels of illumination and once under dim illumination caused by wearing 1-percent wraparound filters. Participants' vision was assessed in terms of Snellen acuity, contrast sensitivity to sinewave gratings ranging from 0.25 to 28 cpd, modified bowl perimetry, and confrontation perimetry.

One specific aim of this project is to identify specific features of environments that are problematic for persons who have specific types of low vision. The second specific aim is to relate variations in level of ambient illumination to specific travel difficulties. The third specific aim is to investigate the relation of variations in visual field size, acuity, and contrast sensitivity to variations in the level and kind of difficulty encountered when traveling in each of the specific situations.

Measuring the Mobility of Blind Travelers

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Sponsor: VA Rehabilitation Research
and Development Service

Purpose—To conduct a valid evaluation of a blind mobility training program, you must be able to sufficiently measure the effect of the program on the blind traveler. In the past, two different approaches have been used to measure the blind traveler's mobility: 1) a measurement of the travel skills of the traveler; and 2) a determination of the amount and type of travel for the traveler.

Previous efforts in both types of measurements have been less than optimal. In addition, researchers have never compared the measures to each other. Thus, the relationship between travel skills and travel behavior is unknown.

Progress—Recent improvements in the two measures now make it feasible to study that relationship. One of these improvements is the use of a portable, ultra-

sonically based gait-measuring system, developed at the Hines VA Rehabilitation R&D Center. This system measures the traveler's step length, time, and cadence while walking. The other improvement involves the use of a more psychometrically valid questionnaire for assessing the travel behavior of the blind person.

Our study measures the travel skills and travel behavior of two groups of veterans: low vision travelers and blind travelers. We are measuring the travel skills with the interankle distance measuring system and the travel behavior with the Travel Inventory. We are measuring the skills and behavior on four occasions; twice prior to training and twice after.

Once we have gathered the measurement data, we will assess the relationship between these two sets of measures and across the four measurement points. It is hypothesized that the level of travel behavior at the fourth measurement will not be fully explicable in terms of the acquired travel skills. There are other factors in addition to travel skill that affect actual travel behavior.

Evaluation of Travel Skills of Visually Impaired Veterans ---

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Sponsor: National Institute of
Handicapped Research

Purpose—At the present time, there is no universally accepted evaluation procedure for the performance of orientation and mobility by blind and partially sighted subjects. This has serious implications in terms of progress and device evaluation, as well as for documentation of patient progress.

To address some of these concerns, NIHR is currently supporting the development of an orientation and mobility evaluation protocol at the Pennsylvania College of Optometry (PCO) Research and Development Center.

Progress—The investigators in this project, through cooperative efforts between the VA's Eastern Blind Rehabilitation Center and the College, have been actively involved with the development of this protocol, which has been fully implemented and is now in use at PCO.

While the population sample at PCO is large and potentially representative of the visually impaired population of the United States, there are basic differences related to gender, visual history, and secondary conditions between this population and that served by the Veterans Administration. This project seeks to adapt the O&M evaluatory protocol to accommodate these perceived differences in the population as seen at these two locations and to integrate and extend the number of subject scores contained in a cumulative database.

Future Plans—In the course of implementing this project, the O&M staff will be in-service trained on the exact protocols and data-collection techniques. This will directly involve the entire O&M staff with an ongoing research and quality-assurance project. By doing this we will not only quantify the measurement of O&M problems experienced by veterans, but also the measurement of O&M services delivered to this population and their remedial effects. In addition, we will increase the level of instructors' awareness of, and abilities in, implementation of research methods.

As we have documented, previous endeavors by research groups have theorized about the evaluation of O&M but have done relatively little to implement their ideas with a large subject pool. This research will implement at the EBRC an evaluation protocol which was developed by professionals from a variety of disciplines and experiences. Most important is the commitment to obtain data on a large sample so that, as deficiencies in the protocol become apparent, extensions of the protocol can be developed and implemented.

Development of a Graphic Braille Display

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Sponsor: VA Rehabilitation Research
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Purpose—Computer access for the blind and partially sighted has become of increasing concern within the rehabilitation community because of the economic and educational promise of this technology. A major, unresolved concern is access to graphic information. This information includes charts and graphs, schematic diagrams, accounting tables, and other information necessary in the day-to-day use of computers. This proposal has the goals of developing a two-dimensional, tactual display useable by the visually impaired, and the development of software necessary to interface the display with many common computers. These computers include the Apple Ile, IBM PC, and the Data General One.

The American Foundation for the Blind estimates that there are some 2 million blind and partially sighted persons in the United States. Estimates based upon incidence and prevalence rates supplied by the National Center for Health Statistics and census data from the Veterans Administration indicate that there are some 267,000 severely visually impaired veterans. Most of these veterans are age 60 and above, however approximately 60,000 are age 55 or younger. These veterans have potential working careers of 10 or more years.

Computer access is a clear necessity for many vocational and educational opportunities today, and it is clear that over the next decade many more opportunities will require computer access. Current estimates are mixed; however, it appears that perhaps as many as 50 percent of all jobs now require some interaction with a computer. By the year 1990 it is estimated that 80 percent to 90 percent of all jobs will involve interaction with a computer. A major component of the expanded use of computers will be the use of graphics to display information. Graphic displays may be used to highlight particularly important messages, to concisely display complex information (e.g., pie charts), to represent complex commands (e.g., icons), to improve the aesthetics of visual displays, and for a variety of other uses. The use of graphic displays poses a potential problem for visually impaired computer users.

The most common means used by the visually impaired to access computers are synthetic voice, single-line refreshable braille displays, hard-copy braille printers, low vision aids, and large print computers. Synthetic voice output from computers is an inexpensive means of attaining access; however, it does not allow access to graphic information. Single line refreshable braille displays do not provide access to graphic information. Hard-copy braille printers provide access to two-dimensional graphic information, but their slow printing speed does not

allow their use in interactive situations. Large print computers currently allow access only to alpha-numeric information. Low vision aids can be used by some partially sighted individuals to access conventional graphic displays and in these cases represent an effective, low cost solution. However, it currently appears that low vision aids are effective for only a small percentage of the visually impaired population.

Blind and partially sighted individuals have a clear need to access computers and computer-based information. Such access is critical in attaining education and in securing and maintaining employment. The inability to access graphic information represents a severe limitation to computer access. The current project seeks to ameliorate this situation by developing a relatively low cost graphic display system and the necessary software to interface it with commercially available computer equipment.

Progress — Over the past years the American Foundation for the Blind, under the direction of Mr. Doug Maure, has been developing a low cost, graphic and braille display. The mechanical design of the display is well advanced; however, several key questions remain. These concern the human factors design of the device and the development of software to support the display. Solutions to these concerns will be followed by the dissemination of all design information to a suitable manufacturer.

Resources available are the Western Blind Rehabilitation Center, the American Foundation for the Blind, and the Veterans Administration Medical Center in Palo Alto, which also houses a Rehabilitation Research and Development Center which provides a locus for biomedical engineers, physicians, psychologists, and others interested in developing technology to assist the disabled. Academic affiliations of the above include Stanford University, University of California, Berkeley, San Francisco State University, Western Michigan University, and California State University, Los Angeles.

The subject population for the project will be drawn from three sources: 1) staff of the Western Blind Rehabilitation Center include totally blind and partially sighted experienced computer users. These individuals constitute an "expert" subject population which will be used for initial testing and debugging of hardware and software; 2) the veteran population attending the Western Blind Rehabilitation Center includes numerous individuals motivated to learn computers, but who are relative novices. These individuals will be used as subjects in studies designed to test the ease of use of the display and associated software; 3) the local community contains many blind individuals who currently use computers in day-to-day work situations. These individuals will be used to assess the function of the braille display and software in actual work environments.

There are three primary areas to the current project: hardware development of the display, software development, and human factors evaluation of the display and software.

Delivery of the first prototype display module (from the American Foundation for the Blind in New York) occurred in March 1985 and was followed by a 2-month period of familiarization for the Palo Alto investigators and preliminary software development. The prototype display had uniformly high quality braille; however, the refresh rate was slow, requiring 4 to 5 minutes to completely refresh

the display. The second prototype is expected to be considerably faster with an expected refresh rate of 40 to 60 seconds per page. In June 1985 concurrent development of graphic software and human factors evaluations will begin. Initial software development will be geared to providing necessary software for the human factors studies. These studies will provide information on legibility of the display, reading rates, fatigue factors (if any), and will result in design recommendations for future prototypes.

Future Plans — The above studies are expected to continue through the first year of the project. Concurrent with them will be the attempt to develop additional capacities for the braille display. These capacities may include the addition of a dedicated keyboard, voice synthesizer, and printer I/O ports. Purchase of the components necessary to support these capacities has begun and development work will continue into the second year of the project. At present, since such features will increase the cost of the display, they are conceived of as “options,” That is, when the display is manufactured it may behave in an analogous manner to a “dumb terminal.” However, the consumer would have the option of increasing its capabilities.

During the second year of the project final recommendations to the design of the display will be made if appropriate; however, the primary emphasis will be on the development of application software. This will be facilitated by testing the software within the context of the Western Blind Rehabilitation Center which provides both experienced and novice computer users, and by testing in actual job settings.

Upon completion of the project it is expected that the display with application software will be sufficiently advanced so that it can readily be turned over to a manufacturer. By developing the hardware and software through non-profit and government grants, much of the development cost that would normally have to be passed along to the consumer can be defrayed. This will minimize the ultimate cost of the display and make it a more economical and more widely used aid than would otherwise be possible.

The Effects of Preview Distance on Blind Mobility

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Sponsor: VA Rehabilitation Research
and Development Service
(R&D Center Core Funding)

Purpose — The objective of this research project was to establish boundaries for the effective preview distance for blind pedestrians. Using an ultrasonic ranging device, we did this by systematically varying the preview distance for a group of experienced, blindfolded travelers walking over a predetermined course six times.

Progress — The first time the group walked over the route, we used no preview device and we placed no movable obstacles on the route. This trial familiarized the traveler with the route and gave baseline data on walking speed, step length, cadence, etc. In the remaining trials, we placed movable obstacles randomly along the route, and each subject had the preview device along.

For the test, we used a modified version of a Polaroid ultrasonic ranging device, setting it to a predetermined preview distance for each subject in each trial. This distance varied from 1 foot to 10 feet. Half of the subjects had increments of even distances (2,4,6,8, and 10 feet) and half had odd distances (1,3,5,7, and 9 feet); also, half of the subjects had ascending preview distances over their five trials and half had descending distances.

We measured the mobility behavior of the subjects with a gait-measuring system developed at the Hines Rehabilitation R&D Center; the system provided data on interankle distance over time. From these data, we were able to determine measures such as step time, length, and cadence for the entire route and parts of the route (e.g., at obstacles).

Currently, we are analyzing the data. Of interest will be the effect of the differing preview distances on the gait characteristics of the travelers, particularly the distance or distances at which degradation in performance occurs.

Development of a Solid-State Reading Aid for the Visually Impaired Person

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Purpose — Blind and partially sighted individuals need an affordable, portable, and versatile reading aid that gives them access to printed materials such as newspapers, magazines, and typescript pages. Blind access to printed materials is currently limited under the three available approaches: 1) using specially-prepared materials (Braille books, “talking books” on cassette tapes); 2) employing electronic reading aids, such as the expensive Optacon (which allows the user tactually to feel the shape of letters), the occasional Stereotoner (which produces chords of tones from the shapes of letters), or the copier-sized Kurzweil Reading Machine (which reads the text in synthesized voice output); and 3) engaging the services of sighted readers. Each of the current approaches has drawbacks: Braille materials are bulky and expensive, and cover only a small fraction of inkprint materials; cassette recordings are typically available only for mass market items, such as popular novels, but not for newspapers, magazines, technical publications, personal letters, etc; Kurzweil Reading Machines are expensive and cannot be moved by a single person; and older persons with failing eyesight are typically unsuccessful in learning to use the Optacon. Sighted readers perform well, but they are expensive and not always available at users’ convenience. In all, there is a need for a portable, easy-to-use, and affordable reading machine that can communicate to the user using the mode of his choice (e.g., voice output, Optacon display, enlarged letters).

The objective of this project is to produce a working prototype of a compact and affordable reading device, specially designed to meet the needs of visually impaired individuals. This device will comprise the following major components: 1) a hand-held camera which the user can track over inkprint to capture an optical image of the printed characters; 2) a microprocessor to carry out image processing and optical character recognition, and to drive the output displays; and 3) a special

interface board, to provide plug-compatibility for this device with commercial products already widely used by the visually impaired community (e.g., the Optacon, the Stereotoner, enlarged print displays). In addition, the device is designed to be plug-compatible with commercially available speech synthesizers and with home computers.

Progress — Our approach is to employ contemporary technology innovatively to meet our objectives. Our hand-held camera, for example, utilizes an Optic RAM (Random Access Memory) for image capture. This solid-state imaging device, only recently on the market, is inexpensive, compact, durable, operationally fast, of high resolution, and able to alter its imaging window under software control. The image is brought to the Optic RAM by two types of fiber optics—a demagnifying component, and a Selfoc (self-focusing) fiber optic “lens.” The fiber optics contribute to keeping overall dimensions down. Illumination is provided by light emitting diodes (LEDs), which are compact, rugged, of low power requirements, long-lasting, and cool to the touch. Printed circuit boards and hybrid chip technology allow reduction in the support circuitry layouts for the Optic RAM and LEDs, making a hand-held unit feasible. A special Optic RAM controller board services the Optic RAM, acquires data, packs them efficiently into bytes, and deposits them directly into memory, all without burdening the device’s microprocessor. An advanced, 16-bit MC68000 microprocessor interprets the data, executing algorithms written in C (a high-level programming language) and in assembly language for speed and efficiency. A special interface board, built upon an Intel 8085 microprocessor, provides plug compatibility with the Optacon, the Stereotoner, and a TSI Enlarged Display Light Box.

We are very close to having a first working laboratory prototype of reading aid operational. The electronics for the hand-held camera on PC board have been constructed, along with the mountings for the optics and the imaging units, and workings of these components in capturing an image have been verified. The Optic RAM controller board has recently been completed and is available for integration into the laboratory prototype. With the incorporation of the LEDs for illumination, we will have the front end of the device operational. Algorithms have been written and tested for automatic thresholding of the device; for character location, isolation, and normalization; and for a template-matching scheme of optical character recognition. The output interface board was completed and displayed at RESNA in June 1984, and awaits incorporation into the final device.

A Large-Print Word Processor for the Visually Impaired Person

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Sponsor: VA Rehabilitation Research
and Development Service

Purpose — The large-print word processor is a generic equivalent of cassette-braille machines designed for large-print users. The system features a large-print display and typewriter keyboard with microcassette storage of information.

Progress — Construction of prototype test units has been completed. There are currently two units in working order. This system is based upon the Typecorder, a

battery-powered portable Sony word processor. The Typecorder has been modified to accept an intelligent interface and a large-print display suitable for use by visually impaired persons.

The new system was designed as an electronic add-on and is plug-compatible with the Sony LCD display. The Typecorder interfaces with a new display, the Deco 245A. It is a vacuum tube fluorescent display with a standard ASCII character display set. To connect the Typecorder with the Deco display, an interface circuit was built. This interface had to transform the Typecorder's cursor instructions into instructions recognized by the Deco display. Those two functions are handled by the Intel 8741 peripheral controller. A third function of the interface is to provide electrical isolation between the CMOS circuitry of the Typecorder and the TTL circuitry of the Deco. That electrical buffering is handled by Motorola MC14503 buffers.

The completed prototypes now offer an alternative display with 40 characters of 0.2 inch height. The display is of high resolution and considerable brightness. Preliminary tests indicate it to be of great value to the population that needs it, at a reasonable cost when compared to the alternatives. The problems remaining include the provision of reading material on the Sony microcassette format, and the legal questions involved in any such attempt.

Future Plans—Work will continue to locate a suitable manufacturer for this product.

The Evaluation of Low Vision Aids and Prediction of Visual Performance Through Low Vision Aids

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Sponsor: National Institute of
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Purpose—The goals of this study are to evaluate the optical properties of low vision telescopes and telemicroscopes, and to determine which objective measures of optical performance are the best predictors of visual performance through the aids. The optical evaluation of the low vision aids will include measuring their modulation transfer functions (MTF), resolving power, angular magnification, field of view, eye relief, exit pupil diameter, and, finally, light transmittance.

Visual performance in normal sighted and visually impaired subjects will be assessed by measuring their contrast sensitivity functions (CSF). The CSF is the visual analog of the modulation transfer function. It is a subjective measure of visual sensitivity across an entire range of spatial frequencies. Contrast sensitivity functions may reveal visual disturbances that are not evident from acuity testing, perimetry, or other clinical examinations. The CSF quantifies a visual deficit that may correlate with the patient's own subjective complaints or explains visual complaints that some patients find difficult to express. It is thus likely to have predictive value in assessing visual performance through low vision aids. The effect of the modulation transfer function on the contrast sensitivity function promises to provide an important criterion for specifying and prescribing the most beneficial low vision aid.

This study will provide, for the first time, detailed specifications and optical

quality measures for low vision aids that will reveal how well each manufacturer controls quality, and how aids of different manufacturers compare.

We will optically evaluate low vision telescopes and telemicroscopes to determine their modulation transfer functions, resolving power, and such paraxial properties as field of view, angular magnification, eye relief, exit pupil diameter, and light transmittance. A computerized database containing these measurements will be established. The database will be accessed to compute figures of merit for comparing the low vision device and to select devices for visual tests. We will also develop optical performance standards for low vision aids.

Low vision subjects generally will include, but not be limited to, individuals of all ages referred by the low vision clinics of the NYAB and the College of Optometry.

Progress— At the time of submitting this report, the design and fabrication of modulation transfer function apparatus is nearly complete, as are modification to measure contrast sensitivity functions through optical devices.

A "Moon" Writer

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Sponsor: Research Centre
for the Education
of the Visually
Handicapped

A report published in the *New Beacon* for July, 1984 (Vol. 68, No. 807, pages 173–176) is an account of the evaluation of a portable device which enables blind people to write Moon, a raised-line reading system designed in the 19th century by Dr. Moon. Moon is widely used by the elderly in Great Britain if their tactual ability makes braille difficult to learn.

Until the invention by Mr. Gerd Sommerhof of the Moon Writer, the use of Moon for everyday purposes (such as the labelling of household goods or the writing of shopping lists) was impossible, since Moon could only be produced by large machines required for the wetting and subsequent drying of the heavy-duty paper on which it is embossed. The evaluation described in the report involved teaching sighted people and blind people who did not know Moon, and skilled readers of the system. It was concluded that the "device is the most promising mechanical advance in the 40-year history of the Moon system (and has) the potential to transfer Moon into a reading and writing system."

Speech Transmission Laboratory: Quarterly Progress and Status Report

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Sponsor: Royal Institute of
Technology

The Quarterly Progress and Status Report (QPSR) of the Speech Transmission Laboratory for January through March, 1985, carried the following individual reports in the subject areas noted.

"Speech Production: Dynamic Line Analogs for Speech Synthesis," by Johan Liljencrants.

"Speech Analysis: Analysis of Spoken Digits—Project Liisa," by J.U.J. Stålhammer, and "Glottal Wave Forms for Normal Female Speakers," by Inger Karlsson.

“Speech Recognition: Automatic Time Alignment of Speech With a Phonetic Transcription,” by Mats Blomberg and Kjell Elenius; and “A Parallel Speech Analyzing System,” by Rolf Carlson, Björn Granström, and Sheri Hunnicutt; and “Phonetic and Orthographic Properties of the Basic Vocabulary of Five European Languages,” by Rolf Carlson, Kjell Elenius, Björn Granström, and Sheri Hunnicutt.

“Speech and Hearing Defects and Aids: The Use of a Synthesis-by-Rule System in a Study of Deaf Speech,” by Anne-Marie Öster.

Reading Aids for Blind Readers

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Sponsor: Hines VA Research and
Development Center, (Core
Funding)

Purpose—Reading with the Optacon: We examined the manual scanning patterns and reading rates of a population of blind optacon readers. The results provide baseline measures for this type of reading. Similarities to sighted reading were a surprising result, providing a basis for speculation regarding the dramatic difference between sighted and blind reading rates.

Inkbraille: We are exploring the possibility of using printed braille as a medium be read by means of a simple inexpensive electronic reading aid. Braille reading rates are the highest achieved by the blind. The economics to be realized by printing, rather than embossing, braille patterns are considerable. We have begun pilot experiments to determine if blind subjects can read Inkbraille at rates higher than those observed, e.g., with the Optacon. Preliminary design work is underway on a device to translate Inkbraille to a suitable tactile pattern.

“Magic Wand,” The Braille Teacher

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Sponsor: Hines VA Research and
Development Center (Core
Funding)

Purpose—Learning braille is a difficult task. It is like learning a foreign language, but harder because you must learn to read with your fingers. We have made learning braille easier by adapting a consumer product by Texas Instruments called the “Magic Wand Speak and Learn.”™ The Magic Wand was designed to help children learn to read by associating printed and spoken words. It uses special books that contain text and bar code. When the “Magic Wand”™ is passed over the bar code, the text is converted to synthetic speech.

Progress—We adapted the Magic Wand™ books for braille teaching by simply placing braille over the text and adding tactile symbols to make it easy to find the bar code. With our books, students can easily study braille by themselves without help from either a braille teacher or sighted person. This not only gives them more independence, but also gives braille teachers more time to help students.

We are now working with Texas Instruments to develop books specifically for teaching braille to children and adults. These will be distributed to public and private rehabilitation organizations for evaluations.

B. Deafness and Hearing Impairment

[See also pgs. 273, 283]

Studies in Acoustic Feedback in Hearing Aids

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Sponsor: VA Rehabilitation Research
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Purpose — The causes of acoustic feedback in hearing aids are not well known and the remedies for it are limited. The objectives of this project are 1) to study the mechanisms which facilitate unstable acoustic feedback and to determine the key physical and electrical parameters and interactions which affect it, 2) to study several earmolds designed to reduce acoustic feedback and thus provide greater electroacoustic gain to the user, and 3) to build and test several prototype hearing aids incorporating circuitry that successfully suppresses unstable acoustic feedback.

Progress — Mathematical models of hearing aid microphones, amplifier/receiver, and the feedback path from earmold vents to the microphone have been developed. The results of computer simulations using each of these models compared favorably with experimental data. These models have been incorporated into a computer program for simulating the open-loop transfer function of *in situ* hearing aids. A comparison of the computer simulation with experimental data indicates that the computer provides accurate simulation of open-loop-transfer function data.

Two earmold types have been evaluated for their ability to provide additional stable gain to the hearing aid user. First, earmolds were obtained from 10 ears using Reprosil, a dental impression material. A hermetic seal of the impression in the ear canal was verified by using the air pump of an electroacoustic impedance bridge. The impression was sent to a commercial laboratory for the fabrication of the final ear piece. For 9 of the 10 years, a hermetic seal was obtained when the finished ear piece was returned from the laboratory. Functional gain measurements showed that for frequencies below 1 kHz an average 5 dB additional gain was obtained with earmolds fabricated in this way, and that an average of 20 dB gain was obtained in the frequency region of 3 kHz.

The second earmold type was developed by the National Acoustic Laboratories in Australia. This vented earmold contains a tube which terminates at the tip of the earmold with its other end terminating in a cavity in the concha section of the earmold. This design creates a high-cut acoustic filter for sounds emitted from the vent outlet. Earmolds of this type have been fabricated for 10 hearing aid users. Studies of insertion gain and of the open-loop-transfer function with this and an acoustically comparable standard, vented earmold are in progress.

A microprocessor-based feedback suppression system was developed. This system uses a technique known as active feedback cancellation (AFC). In the original version, the system used a pseudo-random noise generator to insert a low-level noise into the hearing aid circuit. That portion of the PRN which returns to the microphone is monitored. A microprocessor uses the original and the feedback PRN signals to compute the open-loop-transfer function of the hearing aid. In the

AFC system, a microprocessor uses the computed values to create an "estimator" which causes input signals to react destructively with signals returning through the feedback path, thereby cancelling the effect of the feedback signal. In the latest version, the need for pseudo noise to measure the open-loop-transfer has been eliminated and, additionally, the current AFC system is more compatible with the power requirements of the body-worn hearing aids. The current effort is to miniaturize the AFC system so that it can be incorporated into a head-worn hearing aid chassis.

Development of Materials for Computer-Assisted Instruction in Lipreading

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Sponsor: VA Rehabilitation Research and Development Service

Purpose— A computer system has been designed and software has been written for an auditory-visual laser videodisc interactive system (ALVIS) for drill and practice in computer-assisted instruction in lipreading. The system includes a laser videodisc player, a microcomputer, a keyboard, a video monitor, two microfloppy disk drives, a dot-matrix printer, an external amplifier and attenuator, a programmable attenuator with associated accessories, and earphones.

The goal of this program is to examine the effects of supplementary drill and practice with an auditory-visual laser videodisc interactive system (ALVIS) on the development of lipreading skill.

Progress— Twelve lists of 25 sentences each have been standardized and arranged in order of difficulty from easiest to most difficult as lipreading stimuli. These five- to eight-word sentences, presented in order of difficulty, were recorded on 1-inch videotape and then pressed on videodisc. Presentation of the 300 sentences is under software control by ALVIS in each of two conditions. In the first condition, word clues are presented on the video monitor for a maximum of five trials. The presentations of the lipreading stimulus in this condition are given with no sound. By the fifth presentation, three clue words are given on the video monitor.

In the second condition, auditory clues accompany the visual stimulus for a maximum of five trials. The first presentation of the sentence is given without sound. If this presentation is not identified correctly, on the second trial the student receives the auditory signal via earphones at 0 dB in relation to his binaural speech detection threshold. For the third, fourth, and fifth trials, the sensation level of the auditory signal is 5 dB, 10 dB, and 15 dB, respectively.

Each student has his own microfloppy disk. Responses during the drill are recorded, as are the number of words lipread correctly, the number of seconds taken to respond, and the total number of trials required for each sentence. In addition, the subject's identification data, hearing test data, and lipreading practice data with computer-assisted instruction are recorded on the student's disk.

The auditory-visual laser videodisc interactive system (ALVIS) is being used experimentally in a program of aural rehabilitation which includes lipreading instruction for postlingually hearing-impaired adults. Six subjects receive group lipreading lessons twice per week for 6 weeks. On days following group

instruction, each of two subjects receives lipreading drill and practice in one of three conditions: 1) with ALVIS word clues, 2) with ALVIS auditory clues, and 3) with face-to-face drill and practice with the lipreading instructor. Thus far, 2 groups of 5 subjects each have completed a total of 12 group lipreading lessons and 12 individual drill and practice. By the conclusion of this phase of the project, 36 subjects will have participated in group lipreading instruction: 12 will have received drill and practice with ALVIS clue words; 12 will have received drill and practice with ALVIS auditory clues; and 12 will have received face-to-face drill and practice with the lipreading instructor.

Clinical Trial with the Cochlear Implant Prosthesis

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Sponsor: VA Rehabilitation Research
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Purpose—This project was designed to develop assessment methodology and evaluate the rehabilitative effectiveness of the 3M-House single-channel cochlear implant as a treatment for profound sensorineural deafness. The work is now in the second of a 3-year grant period.

During the first year, a team of highly qualified specialists in hearing, speech, voice, and language was assembled; and the methods and procedures for determination of cochlear implant candidacy were developed, including generation of new high-quality color videotapes of speechreading, new recordings of auditory tests of speech perception, and a new scale of beliefs concerning deafness. Software to permit psychoacoustic procedures detection (discrimination and masking experiments) was created.

The full evaluation protocol entails: audiologic examination with and without hearing aids; psychoacoustic measurement; communication and handicap assessment including speechreading measurement and trials with a vibrotactile device; voice and speech recording; medical examination; otologic evaluation; tomography of the cochlea; optometric examination; and psychologic and neuropsychologic evaluations.

Progress—Candidates were solicited by announcing the program in letters to the VA and broader professional community and with statements in the printed and broadcast media. As a result, a subject pool of prospective candidates to be evaluated was established.

In the second project year, profoundly hearing impaired subjects were screened and possible candidates were fully evaluated. To date, 21 profoundly impaired men (19) and women (2) have been tested. The trials are still in progress, with 3 patients having been implanted and 5 more surgeries pending. Outcomes for the non-selected subjects were prescribed: tactile aids (2); new hearing aids (4); aural rehabilitation with current hearing aid arrangement (1); medical treatment referral (2); geriatric unit evaluation referral (2); and controls (2).

Preliminary Results—Data derived thus far have lead to the following submitted reports, among others: 1) single-channel cochlear implant enhancement of contrastive stress; 2) contrastive stress in an adventitously deaf adult using vibrotactile stimulation; 3) recognition of voicing and nasality by deaf adults

using vibrotactile aid or cochlear implant; 4) standardization of videotaped tests of speechreading ranging in task difficulty; 5) aural rehabilitative guidelines for the adult with a cochlear implant: case reports.

Implementation of Digital Measurement of Aural Acoustic Immittance _____

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Sponsor: VA Rehabilitation Research
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Purpose — Work during the first full year of the project (May 1984 to May 1985) has provided necessary experience with the programmable digital device and allowed development of reliable programming techniques and development of software.

Progress — Software systems have been devised for labeling, storage, reduction, and graphing of tympanograms and individual (contralateral) acoustic-reflex responses acquired with a 226-Hz probe tone and expressed in both components of acoustic admittance (Y_a). The reduction routines include automated computation of amplitude and phase from the tympanogram, plus measures of amplitude, latencies, and onset-offset characteristics from the acoustic reflex response. The graphics software creates plots of individual or stacked tympanograms or acoustic reflex responses. These software systems have been used to collect data for an investigation report, and much of the software is illustrated in a recent article submitted for publication. Other efforts have included evaluation of methods of measuring the time constant of a digital acoustic immittance instrument, development of communications between computers (Tektronix 4052 and IBM-PC) for convenient data transfer, and configuration of acoustic immittance data for access by commercial statistical software.

Future Plans — Work planned for the coming year includes development of additional software for measurement of the acoustic reflex response and acquisition of data from normal ears and ears with hearing impairment.

Direct Measurement of Loudness Recruitment in Hearing Impaired Veterans _____

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Sponsor: VA Rehabilitation Research
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Purpose — The main objective of this investigation is to further develop, test, and ultimately standardize a direct psychophysical scaling procedure for the measurement of loudness recruitment in a routine clinical setting. Particularly important is the potential to distinguish between cochlear and retrocochlear pathology.

The subjects will be volunteers recruited mainly from the adult veteran population with cochlear impairment and with visual performance of 20/60 or better. The participants, all with bilateral hearing losses, will be subdivided into three groups on the basis of their pure-tone audiograms. The groups will consist of those with mild-moderate losses, those with severe losses, and those with profound losses. From 20 to 30 listeners will be included in each subgroup; in

addition, from 6 to 8 listeners with unilateral cochlear impairment in each of the 3 hearing loss groups will participate in the study. Twenty listeners with normal hearing will serve as a control population.

First the subjects receive a complete otological examination and audiological evaluation. After the initial assessment process, which also includes a visual screening test, loudness in the impaired frequency region will be measured primarily by the direct psychophysical scaling procedures of absolute magnitude estimation, absolute magnitude production, and cross-modality matching. A limited number of alternate binaural loudness balances between a tone in the normal ear and a tone at the same frequency in the opposite, impaired ear will also be performed.

Preliminary Results—No results are, as yet, available. Progress has been made in three areas: 1) organization and arrangement of existing laboratory equipment and ordering of new, specialized equipment; 2) assembling a professional staff; and 3) discussions and consultations with the Departments of Audiology and Optometry at the VA outpatient clinic dealing with the establishment of auditory and visual guidelines to be followed in the selection of subjects.

Phoneme Confusions Associated with Room Reverberation, Age, and Hearing Loss _____

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Purpose—This study will deal with phoneme errors associated with room reverberation (T), one of the most common distortions of speech in everyday life. In the first part, effect of reverberation on speech understanding by subjects from various age groups will be tested with Modified Rhyme Test. Three Ts, ranging between 0.5 and 1.5 seconds, typical for offices, auditoriums and churches, will be used. Age range of subjects will be from 20 to 70-plus years. Subjects will have normal hearing or mild hearing losses. Dependence of speech understanding on age and T will be established.

In the second part, phoneme confusions associated with reverberation will be investigated for subjects with various configurations of hearing loss. Range of T will be between 0.25 and 0.75 seconds, typical for small offices, classrooms, and living quarters—common everyday listening environments of hearing-impaired listeners. Two separate tests will be constructed: 1) sentences with nonsense syllables to test identification of 16 consonants in initial and final positions, and 2) sentences with one-syllable words to test identification of 15 vowels. The pattern of errors will be established for four groups of subjects: 1) with normal hearing, 2) with mild flat losses, 3) with sloping losses, 4) with moderate to severe flat losses; for consonants in initial and final positions and for vowels at three Ts.

Since a small number of vowel errors is anticipated, change in the quality of vowels (timbre) will also be investigated. Each vowel recorded at three Ts will be cut off from the test word and compared with its own non-reverberant pattern. Similarity judgments will be obtained using a seven-point scale. All tests will be recorded, processed through a reverberant field, and reproduced for subjects through a loudspeaker. The study will assess speech perception difficulties in reverberation by elderly hearing impaired listeners.

This information can be used in counselling, auditory rehabilitation, and as a guideline for developing clinical procedures including reverberation as a parameter. This parameter may improve hearing aid fitting and initial acceptance of aids by patients.

Communicative Disorders Clinical Research Center

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Sponsor: National Institute of
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Purpose—This Clinical Research Center is dedicated to a multidisciplinary research program in the basic and clinical aspects of Otoneurology. The program is to be accomplished through a balanced endeavor of basic, developmental, and applied medical research.

The objective of the basic research program is the study of the function of the inner-ear receptor organs and central nervous system elements which, together, are responsible for the maintenance of equilibrium and hearing.

The clinical research program's objective is concerned with the diagnosis and treatment of disorders that cause deafness, tinnitus, vertigo, and dysequilibrium.

There is a broad representation of disciplines among the individual investigators covering medical and basic sciences pertinent to the study. The work is directed toward the application of modern technology to the development of new diagnostic methods and the acquisition of the fundamental information for the solution of otoneurologic problems.

Future Plans—One of the main goals of this project is the development of objective and reliable quantitative methods for the functional evaluation of the vestibular and auditory systems in normal subjects and in people with otoneurologic disorders. These new techniques are being developed from experiences obtained in basic science experiments. The proximity of laboratories and daily interdisciplinary cooperation make feasible the application of concepts and techniques developed through basic research.

Matching Speech to Residual Auditory Function (Human)

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Purpose—This research is directed toward improved signal-processing schemes to aid people with sensorineural hearing impairments. We intend either to develop improved schemes or to obtain a fundamental understanding of why such schemes cannot be developed. The proposed work includes study of linear amplification, amplitude compression, and frequency lowering. Also, attempts will be made to determine and understand the effects of variations in speech production on speech reception by impaired listeners.

The research on linear amplification is concerned with modelling the dependence of speech-reception performance on the speech materials, the background interference, the listener, and the linear amplification system. Initial work on this project involves an attempt to apply Articulation Theory to speech reception by impaired listeners.

The research on amplitude compression, directed towards listeners with reduced dynamic range, involves further study of multiband syllabic compression, as well as study of automatic volume control and limiting. The research on frequency lowering, directed towards listeners with poor hearing at high frequencies, continues to focus on pitch-invariant, nonuniform lowering. In both areas, the proposed work involves further exploration of the effects of various system parameters on speech-reception performance, testing of a wider variety of subjects, and attempts to determine the underlying causes of the results obtained.

The research on the effects of variations in speech production is motivated by our belief that there exist variations, both intersubject and intrasubject, that lead to substantially improved speech reception, and that an understanding of these variations and their effects will provide useful background for the development of improved signal-processing schemes. The proposed work in this area involves the development of speech materials uttered by different speakers under a variety of speaking conditions, the measurement of speech reception by impaired listeners using these materials under a variety of listening conditions, and the attempt to correlate the speech-reception results with properties of the acoustic waveforms.

Auditory Communication and Its Disorders

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Purpose — Proposed studies include: 1) monotic and dichotic identification and discrimination of speech-like and other complex auditory patterns, 2) objective tinnitus and evidence for auditory frequency analysis, 3) processes in vowel perception, 4) psychoacoustic measurements of chinchilla, 5) comparison of human and chinchilla processing of auditory signals, 6) structural, physiological, and psychoacoustic changes following prolonged and intermittent exposure to noise, 7) design goals and selection procedures for hearing aids, 8) processes in lipreading, 9) development of tests of language and of speech production for deaf children, 10) ipsilateral acoustic reflexes, and 11) refinement of brain-stem evoked-response audiometry.

Effects of Aging Upon Communication

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Purpose — This group of six projects will investigate otologic, epidemiologic, audiologic, neurophysiologic, morphologic, histochemical, and laryngologic aspects of age-related communication disorders, chiefly clinical presbycusis (hearing dysfunction in the elderly) and presbylaryngis (laryngeal dysfunction in old age). From this information we hope to better understand the pathophysiology of these disorders, develop a new diagnostic test, establish better-defined hypotheses for future studies, and, thus, add to our ability to prevent, modify, and eventually, treat age-related communication dysfunction.

The first two projects examine the epidemiology of clinical presbycusis and its possible relationship to cardiovascular disease by analyzing the extensive HANES I database (project one) and by studying the auditory function of the Framingham cohort (project two).

Project three will examine the validity and reliability of cochlear distortion-products as an objective test of cochlear dysfunction using noise-damaged cats and presbycusis baboons and humans.

Project four will study the electrophysiologic and morphologic changes in elderly baboons with auditory dysfunction (identified by electrocochleography and auditory brain-stem responses) compared to young and aged controls.

Project five will study the nerve conduction time, stimulus parameters, and strength of the glottic closure reflex as well as muscle tension properties and morphology in young and aged baboons in order to isolate the pathophysiologic changes responsible for aspiration in the elderly. Project six will examine changes in steroid receptors in brain and larynx as a function of age and sex in the baboon.

Clinical Research Center for Communication Disorders

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Purpose — A Clinical Research Center for Communication Disorders in Children will be established within the Department of Otorhinolaryngology at the Albert Einstein College of Medicine. The Clinical Research Center will be formed from members of the department and other individuals working with the department presently engaged in clinical investigations in the area of children's communicative disorders.

Each project examines a specific aspect of children's hearing loss and/or speech and language abnormalities. The overall purpose of the Center is to provide information to prevent, cure, or care for hearing loss and/or speech and language disorders in children.

The data collected will give information heretofore unavailable on: 1) the incidence and prevalence of hearing losses (mild to profound) in high-risk infants, including those from middle ear effusion (MEE) and the effect of hearing loss on speech and language for this high-risk group; 2) the correlation of behavioral and electrophysiological responses in infants; 3) the acoustic properties of the external ears of children from 0 to 6 years of age; 4) the effect of less-than-profound hearing loss on speech and language in 4- to 8-year-old children; and 5) the characteristics of cortical responses to speech in children with language deficits. The Clinical Research Center will provide clinical research training for students, residents, fellows, and junior faculty in Otorhinolaryngology.

High-Frequency Acoustics in the External Human Ear

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Purpose — Recent research pertaining 1) to high frequency audiometry up to 20 kHz, 2) to the measurement of in-the-ear pressures produced by hearing aids, and 3) to the research and diagnostic applications of so-called cochlear distortion products have necessitated accurate knowledge of the acoustic wave motion in the external meatus.

The acoustic wave motion within the external meatus is a function of frequency, of the size (length, cross-sectional shape) of the canal, of the physical properties

of the eardrum, of the eardrum inclination to the ear canal axis, of the location and size of the sound source, and of the size, shape, location, and acoustic impedance of the microphone to be used for the pressure measurement in the ear canal.

“Phase I” research is to collect a set of molds of the external meati and of the conchae of human cadavers in order to determine the range of sizes and shapes of the canals and conchae and the inclination of the eardrum relative to the ear canal axis. The physical dimensions and shapes of these earmolds will be measured in order to design some scaled models which have acoustically significant but yet realistic features. Initially, miniature microphones will be used to determine the acoustical significance or order of importance of each “feature,” such as curvature of the canal, eccentricity of the cross-section, eardrum inclination relative to the canal axis, off-axis placement of the source, etc. Then, specific microphone designs will be tested which will either cause a minimum of interference with the sound pressure at the microphone’s location and at the eardrum or cause a systematic predictable deviation from the true pressure so that a proper correction can be made. Such microphones might be of a segmented, annular type or of a multi-element circumferential type, for example. Theoretical models will be used as a guide for such microphone designs in terms of shapes and placement and for the prediction of sound pressures at the “eardrum.”

The long-range goals for Phase II are to develop experimental and theoretical models for sound sources, microphones, and wave-propagation models in the external ear which extend to the high frequencies.

The goal of Phase III is to produce such instrumentation commercially.

Multimicrophone Monaural Aids for the Hearing Impaired Person

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Purpose — The ultimate goal of this research is the development of sensory aids which will sample the acoustic environment at more than one point in space (multimicrophone aids) to improve the ability of hearing impaired subjects to function more effectively in complex environments containing interference and reverberation.

The more immediate goal is to explore the potential of multimicrophone systems for monaural listening in such environments.

The results of this research, combined with research on binaural interaction in impaired listeners, will provide solid background for the development of multimicrophone aids to assist impaired listeners who have significant hearing in either one or two ears.

The proposed research, which draws heavily from previous work on both natural and artificial spatially diversified sensor systems (binaural hearing and antenna/signal-processing theory), is concerned primarily with reduction of interference and coding of spatially resolved information. The techniques considered for reducing interference include both linear and nonlinear processing, and both fixed and adaptive processing. The study of spatial coding, which is motivated by the need to monitor the general acoustic environment as well as to focus upon a particular source, is concerned with the extent to which signals that

are spatially resolved physically can be processed for monaural listening so that the resolution is preserved at the perceptual level.

Results on the reduction of interference should be applicable to cochlear implant aids and sensory substitution aids as well as conventional acoustic aids.

Rehabilitation Strategies for the Hearing Impaired Person

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Purpose—Rehabilitation strategies for the hearing impaired person will be developed and evaluated. Strategies for speech and auditory training of hearing impaired children and speech-reading training of adults will be considered. The impact of tactile and visual sensory aids on learning rates will be investigated and new types of sensory aids will be developed, including a computer-simulated master hearing aid and an experimental visual speech display system.

Basis data on the effect of classroom acoustics (i.e., reverberation) on developmental speech discrimination in hearing impaired children will be measured and appropriate sensory aids developed to reduce the deleterious effects of reverberation.

Hearing Aid Characteristic Selection

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Purpose—The overall purposes of the proposed research are 1) to study how the characteristics of amplified speech signals affect the performance and satisfaction of hearing impaired persons and 2) to identify an adequate means to identify the characteristics an individual needs in order to obtain the most acceptable assistance possible. The two principal tools we will apply in these studies are subjective judgements and articulation theory.

Three different subjective methods will be used. A magnitude estimation-production method of evaluating speech intelligibility will be developed in order to produce band-importance (BI) functions for continuous discourse and sets of nonsense sentences. Magnitude estimations of quality and intelligibility will be evaluated for reliability and validity with respect to intelligibility in a format designed for clinical use. The third method is an adaptive paired comparison procedure designed to run with a high degree of efficiency under computer control.

The adaptive paired comparison will be used to 1) investigate the relative importance of the characteristics of hearing aid reproduced sound to the acceptability of a hearing aid where acceptability is defined as the best combination of intelligibility and pleasantness, and 2) evaluate the intelligibility and other judged characteristics of new hearing aids or hearing aid types using juries of normal hearing persons.

Articulation theory will be used in an investigation of the relationship between the functional characteristics of frequency-by-intensity regions of impaired auditory systems and the speech intelligibility provided by those regions. Also, the distribution of the proficiency factor (PF) will be measured in narrowly

defined linguistic groups. Finally, hearing aid performance will be evaluated using the concept of hearing aid efficiency in which frequency response and S/N ratio effects are “controlled” by the use of the articulation index. Standard and nonstandard measures of electroacoustic performance will be related to hearing aid efficiency.

Suprathreshold Auditory Behavior

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Purpose—The long-term purpose of this proposal is development of reliable procedures for evaluation of performance of a hearing aid on persons with sensorineural hearing loss. Specifically, studies are currently in progress to establish the effects of spectral shaping on speech recognition and the effects of background competition on speech recognition.

Development of a Cochlear Prosthesis

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Purpose—Electrical stimulation of the inner ear and eighth nerve of animals and humans is being done to explore the possibilities for a prosthesis for hearing in the totally deaf. Preliminary results from this project, and from others, indicate that such stimulations can provide environmentally useful sounds, even from fairly crude electrical devices.

The goal of this research is the application of sophisticated speech and electronics coding strategies towards improvement (via multichannel electrodes) of “artificial hearing” in those deaf persons who have defective sense organs but viable nerve fibers amenable to external electrical stimulation.

Hearing Aids and Rehabilitation for Hearing Loss

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Purpose—The research project is intended to apply and evaluate recent findings in individual and group aural rehabilitation methods and materials to the study of persons with profound postlingual hearing impairment, and to develop and evaluate new methods and materials for the same group.

The major study will compare the communicative skills of persons who have received a multichannel cochlear implant with the skills of the profoundly impaired who wear a hearing aid.

Other interwoven studies explore 1) an approach to lipreading instruction that is based on an observed compensatory relationship between auditory and visual recognition of consonants, 2) the application of programmed instruction to phoneme, word, and sentence recognition, 3) the question of whether sentences

are better learned through the combined auditory and visual modalities or through the auditory modality alone, 4) the success with which those with profound hearing impairment can learn to attach meaning to a continuously repeated message that is at first unintelligible to them, and 5) the application of the tracking technique to aural rehabilitation. Findings on a Hearing Performance Inventory and the MMPI scale also promise more information on this group of patients.

Development of a Digital Hearing Aid and Fitting Procedures

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Purpose — The purpose of this project is to develop a digital hearing aid and a companion fitting procedure that will improve the precision and flexibility of fit that can be achieved with hearing aids. Towards this goal, special laboratory-based systems have been assembled to evaluate the overall concept. These systems include a digital hearing aid breadboard (DHAB) and a computer-based audiometer system. The system operates in real time and is better than most analog systems including hearing aids. The system is well suited for parametric studies of digital processing algorithms intended for hearing aid applications.

Progress — Application programs have been written for the DHAB to simulate, in real time, a four-channel instantaneous compression hearing aid. The input encoding can be changed from linear PCM to compounded PCM over different dynamic ranges to determine the effect of these signal processing parameters on the results of speech recognition experiments with hearing impaired subjects. In addition, programs have been written for the computer-based audiometer that measure the patient's residual hearing, that program the digital hearing aid, and that test the patient's ability to recognize sounds of speech. This allows us to evaluate the fitting procedure of tailoring the gain and maximum power output of the aid in a frequency-dependent way to conform to the patient's range of threshold, most comfortable listening level, and uncomfortable listening level.

Preliminary results with 12 patients indicate that the new testing procedures are accurate and efficient. More comprehensive testing will continue throughout this next year.

The preamplifier circuitry for the signal and probe microphones has been redesigned and fabricated on a tiny printed circuit board with surface-mount components. This new design, which fits easily into a behind-the-ear case and which connects to the in-the-ear transducer module, will be incorporated into the DHAB system in the near future.

Future Plans — Preliminary design of the wearable version of the digital hearing aid that will be fabricated during this next year is nearly finished. This design utilizes conventional parts and includes all of the features of the four-channel compression aid, including probe microphone reporting and communication with and control by the host computer of the audiometer during testing of patients. The wearable unit will be pocket sized and have a battery life of about 10 hours.

A preliminary study of the power consumption and size requirements of VLSI (very large scale integrated) circuitry suitable for hearing aid signal processing has been completed. Our study is based on a recent VLSI design project at Washington University in St. Louis. We examined this design assuming a feature size of 1-micrometer and a power supply of 1.5 volts. This structure is sufficiently complex for implementing the four-channel hearing aid algorithm and appears to satisfy the requirements of low power and small size.

Variables Affecting Hearing Aid Performance

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Sponsor: VA Rehabilitation Research
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Purpose—Hearing aid prescription and evaluation procedures rely either on direct or indirect estimates of sound pressure in the ear canal, or on behavioral comparisons of auditory performance. The overall objective of this program is to study variables which affect the data derived from those procedures.

The independent variables to be manipulated are: ear canal volume, ear canal static pressures, the acoustic stapedial reflex, ear pathology (both conductive and sensorineural), and transducer types. The dependent variables to be studied are: probe microphone measures of ear canal spectra, pure-tone threshold measures, and word recognition ability.

Progress—The work to date has focused on the development of a computerized (HP 1000F) system to acquire, store, and analyze ear canal spectra produced by a broad-band noise and to subsequently derive ear canal and eardrum impedance from measurements made at the driving point in the ear canal using a method similar to that described by W. Rabinowitz in 1981.

Data files have been structured to permit quick access to each of the records. Each record allows the storage and access of exact information about the nature and source of the record. Routines have been added to permit extraction of magnitude and phase data from the complex spectrum provided by a Bruel and Kjaer single-channel FFT analyzer. The programs implement conversion routines so that spectral and temporal waveforms can be stored and plotted in many forms. A three-dimensional plotting routine allows the analysis of the effects of static pressures on spectra and eardrum impedance.

Currently, statistical routines (correlation and descriptive statistics) are being tested. These routines allow selection of any set of records for analysis and comparison of one or more records to another record. Finally, a set of executive routines have been developed to allow the user to alter the flow of processing in a very flexible way. These routines also allow storage of the flow of procedures in a command (batch) file.

C. Speech Impairment

[See also pgs. 134, 135, 302, 360]

Tongue-Initiated Speech Prosthesis for the Laryngectomy

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Sponsor: VA Rehabilitation,
Research and Development
Service

Purpose—The major obstacle to the design and fabrication of a successful prosthesis for this purpose has been the inability to balance the power needed to produce recognizable speech against a secure anchor for the device. The result seems to be tissue deterioration at the anchor site whenever the power level has been adequate to produce speech. In addition, it has been extremely difficult to produce speech with any available prosthesis which did not make the patient at least somewhat self-conscious.

This project is attempting to determine the minimum frequency requirement needed to strike a balance between the quality of speech and the complexity of the prosthesis. This will require the support of the speech therapy community so that the needs of the patient can be accurately identified and addressed while, at the same time, isolating the fundamental components of each patient's speech pattern. If these components can be identified and duplicated adequately, it may be possible to provide patients with at least a partial replication of their speech pattern following surgery.

Efficacy of Remote Delivery of Aphasia Treatment by Tel-Communicology

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Purpose—There are many travel barriers that inhibit subjects with aphasia from receiving treatment. The remote location of speech-language pathology treatment centers often impedes continued treatment after the acute phase. Because of travel barriers, treatment programs may be based on factors other than the rehabilitative needs of the patient. Considering the large numbers of veterans with aphasia, results of this comparative study of TEL-C and clinic delivery systems for treatment of aphasic subjects should be of significance in the areas of service delivery and cost control.

The specific purpose of the project is to compare the efficacy of two methods of delivery of an aphasia treatment program: by 1) remote delivery of TEL-Communicology, involving both clinician and computer-assisted delivery, and 2) face-to-face delivery in the clinic.

The comparison of the achievement levels of subjects in each group is based on:
1) Pre-treatment, interim, and post-treatment evaluation of patient changes in communicative ability, and

2) statistical analyses of certain health care delivery criteria that measure availability, accessibility, acceptability, and cost-effectiveness.

The long-term objective of the project is to determine if TEL-Communicology is efficacious and cost-effective, and if it makes quality health care more available and more accessible.

Subject selection is based on criteria previously reported. Subjects meeting criteria are assigned to 1) a control group that receives 5 hours of face-to-face treatment, and 2) an experimental group that receives 5 hours of treatment by telephone. The same stimulus variables are used in both groups. The results of the pre-evaluation, interim, and post-treatment evaluations determine the rate and amount of improvement in each of the two groups.

During a 29-month period, 54 aphasic subjects have met criteria and entered the study. The charts of 4,120 neurologically impaired patients were reviewed. Of those, 2,980 patients were rejected because they were not aphasic. Of the patients diagnosed as aphasic, 522 were not accepted because of localization, 266 potential subjects were rejected because of etiology, and 94 did not meet the criteria of weeks post-onset. The remaining 258 were not accepted because they did not meet the criteria of age, PICA (Porch Index of Communicative Ability), visual acuity, or amount of previous treatment.

Birmingham serves as the project center of this 3-year project. The four Veterans Administration Medical Centers in New Orleans, Little Rock, Miami, and Birmingham serve as treatment centers. Birmingham VAMC is the project center.

Technical Aids for the Speech Impaired

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Purpose—The main objective for the project is the application of synthetic speech as an aid in communication and education. Several systems have been evaluated and the experiences have influenced further development. Two of the systems were built to fit on wheelchairs.

Progress—Further adaptation and field experiments are in progress. The development is oriented to reduce size and power requirements. The goal is a fully portable communication aid. Different methods to speed up communication rate are studied. New progress in the development of speech synthesis are promising in terms of naturalness and personal characteristics of the synthetic voice.

The KTH text-to-speech system has been augmented by Bliss-to-speech programs in Swedish, English, and French. Such a program translates a string of Blissymbols to a grammatically well-formed sentence. Blissymbols and typed-in text can be mixed for both spoken and typed output.

A lexicon gives the pronunciation and part-of-speech for each Blissymbol. This information is used in a deterministic, finite state, phrase-structure grammar. Within each phrase delineated by the grammar, the appropriate inflectional endings are added.

An electronic symbol board with 500 symbols has been developed so that a Bliss user can express himself by means of synthetic speech. Symbols are chosen with a magnet, and the device responds after an adjustable delay (the magnet can thus be moved over the surface of the board without unintentional symbol activation). A user can program the board himself according to his own individual symbol cards. Three sizes of cards are available: 2×2 , 4×4 , or 8×8 cm. The symbol board may also be coupled to other electronic devices (Bliss-TV, printer,

etc.), since both the connector and the symbol code follow the international standard (i.e., BLISSCII).

The symbol board can either be built as a special attachment to a text-to-speech system or with a built-in speech synthesis module.

Several Bliss-boards are currently being evaluated. A commercial version of the board is marketed by Rehabmodul AB, Vinterv. 41, S-171 35 Solna, tel. 08-7305125.

Experiments in schools have shown that, when using synthetic speech, the children become motivated, they develop their language, and get help in learning reading and writing. The speech-handicapped children seem to need such a support. A number of educational programs to train linguistic awareness has been developed in cooperation with Irene Dahl, a researcher in Umeå.

In a separate project, a new artificial larynx with intonation control is being developed.

Lexical Prediction for a Text-to-Speech System

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Purpose — It has frequently been stated that lack of speed is the major obstacle to technical aids for speech communication. With this need in mind, we have developed a lexical prediction system. An important application will be to aid motorically-handicapped users of our text-to-speech system to increase their typing speed.

Progress — We have developed a number of lexical data files (lexicons) and accompanying algorithms to predict words either from initial letters of a word or from previous words. Each entry in a lexicon of the 10,000 most frequent Swedish words has been marked for frequency and grammatical function. We are planning to develop our algorithm so that this frequency will be automatically adjusted and updated during use to allow the user to develop a personal frequency-weighted vocabulary. Since such a lexicon forms a separate module of the system, it is possible for one user to have several lexicons, one for each of various environments, or for several users to share one system.

These lexicons are accessed by an algorithm which, given an initial letter (or letters) by the user, predicts a word, making the prediction based on word frequency and a simple phrase structure grammar. Typing the first letter of a word results in accessing the most frequent word beginning with that letter from the First Choice Lexicon. Successive predictions are made from the Two-Letter Lexicon if predicted letters are overwritten by the user. If the first word of a two-word pair in the Two-Word Lexicon is typed (or accepted as predicted), the second word of the pair is automatically predicted without its initial letter being typed.

Preliminary tests are currently being carried out to assess the efficiency of the program. Using a 4500-word conversational text, data are being gathered concerning which words are predicted, partially or completely, and which lexicon they were retrieved from. Varying sizes and frequency assignment of the "current-topic" lexicon are being evaluated, taking into account how fast the lexicon is

filled, and how many times the words in it have been used. The phrase structure grammar is also being evaluated and modified.

Our next step will be to use a large amount of conversational data from various sources to test the final version of the program. Also, work has recently begun to develop a hardware version.

Development of a Procedure to Guide Prescription of Devices for Severely Speech Impaired Clients

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and Stroke; New England
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MIT

Purpose — Research towards the development of a communication aid prescription guide is in progress at Tufts-New England Medical Center and Massachusetts Institute of Technology (under sub-contract to Tufts). The purpose of this work is to develop predictors of device-use performance. To the extent that the techniques developed prove to be valid, the procedure will permit performance predictions to be made about large numbers of devices with respect to each client—without actual device trials.

Progress — The patient-assessment procedure uses data from available sources (e.g., medical chart), from objective tests selected from published materials when available or developed within this project, and from clinician and client responses to questionnaires.

Motor assessment uses questionnaires and informal clinical evaluation to arrive at hypotheses as to which body parts and types of movement are most promising and should be examined further, using one or more of three objective protocols. Type 1 assessment looks at the dependence of performance in a reciprocal target tapping test on such variables as target width, inter-target distance, and direction of movement. The effects of key force and travel are in the process of being incorporated as variables in this protocol. Type 2 measures three quantities: switch closure time, closure to release time, and minimum time for a sequence of two closures. The third type of assessment looks at closure-to-closure time with pairs of switches mounted so as to be operable by different body parts.

A set of questionnaires for patient and familiar clinician are designed to elicit information about the patient's needs which will affect the usefulness of a communication device.

For device assessment, a protocol has been developed which specifies measures and measurement techniques to apply to devices. The protocol is intended to be exhaustive, i.e., all device information called for in the prescription process must be contained in the device file.

Development of parts of the motor assessment and some device measures is still in progress. Revisions of other portions of the assessment on the basis of pilot results with about 50 subjects (including 20 motor-disabled) are in progress.

In the area of prescription procedure, the products are a small number of indices which reflect the suitability of each device being considered for the patient. For example, one of the indices is "Maximum Motor-Determined (MDM) Rate," the best rate of communication the patient could expect, given his or her motor abilities and the device's characteristics. This score is obtained by

processing motor assessment data with each device's menu, layout, and geometry, by means of programs which, e.g., for Type 1, use the model of the patient's movement time in the reciprocal target tapping task to predict key-to-key time in the operation of planar keyboard devices.

Another score is "Benefit," the measure of the degree to which each device meets the needs of the patient (The mechanism for calculating B scores is an adaptation of the Lotus Spreadsheet). Presence and importance of needs are defined by formulas which evaluate the patient's and clinician's answers to the questionnaire on needs. Formulas applied to device data produce scores reflecting whether each potential need is met. The score for each need of the patient's which a device meets, times its importance weight, increments the B score for that device.

The third type of index, intended to reflect device learning-time demand as a function of user cognitive abilities, will not be available from the results of this project alone, since it will require collection of additional data.

Preliminary Results—Comparison of the measured communication rate of eight non-vocal keyboard-device users with their Type 1 reciprocal-tapping assessment data, revealed a correlation of $r = .865$ ($p = .003$). The results support the hypothesis that user motor abilities and the device menu, layout, and geometry are largely responsible for determining communication rate in the use of planar keyboard devices, and thus that this clinically feasible (1 to 2 hour) motor assessment procedure (Type 1) has predictive validity. Tests of the predictive validity of the other motor assessments, and of Benefit scoring, and collection of learning time data are in progress.

Experimental Analysis of Acquisition and Generalization of Syntax

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Sponsor: VA Rehabilitation Research
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Purpose—The purpose of Rehabilitation Research and Development Project #330 is to evaluate the effects of a syntax training program on the speech production skills of Broca's aphasic patients. Thus far, we have demonstrated experimentally controlled acquisition and generalization to non-trained members within response classes of the following sentence types: imperative transitives and intransitives, declarative transitives and intransitives, WH- and yes/no interrogatives, comparatives and passives. Experimental control was demonstrated by employing a within-subject multiple baseline design across five sentence types. Multiple probes were incorporated into the design to pin-point the occurrence of experimentally controlled generalization. Rapid acquisition, with generalization within response classes, has been replicated across three subjects. Generalization to non-trained stimuli, to conversational speech, and to novel-setting conditions was limited in all subjects. Analysis of error responses revealed limited variation in response topography and restricted stimulus control of all trained forms.

Future Plans—Our plans are to modify our training procedures in such a way as to provide systematic variation of setting conditions, trainers, and stimuli, in an attempt to overcome restricted stimulus control and thus promote generalization responding in aphasic adults.

Computer-Aided Visual Communication for Severely Impaired Aphasic Persons

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Sponsor: VA Rehabilitation Research
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Neurology Service of the
VA Medical Center, Palo
Alto; Dept. of Neurology,
Stanford U. Medical Center,
and Stanford U. Academic
Computing and
Information Systems

Purpose—The overall objectives of this project are: 1) to develop a new type of communication aid—one which is matched to the needs of, and is operable by, chronic severely aphasic individuals; 2) to research the questions of device training and device use by severely aphasic users and their families; 3) to determine effective screening procedures, training regimens, support group activities and follow-up needs in connection with using this device; and 4) to make this device, together with training manuals and other support materials, available to speech therapists throughout the country for use by their severely aphasic patients and those around them.

Meeting these overall objectives will require achieving specific technical objectives in device design and construction. For example, our new communicative aid must be portable, and must incorporate the latest computer technology—powerful and advanced microprocessors, recently elaborated interface concepts, and the contemporary high-resolution graphic displays. Among its notable features are to be: 1) an interface incorporating a “mouse” pointing device, capable of being manipulated by one hand; 2) a visually based, iconic communication system displayed on a high-quality graphics screen; and 3) translation facilities, text displays, and voice output for communication with those unfamiliar with the system.

Our approach is to design a system—using contemporary technology—which takes advantage of the aphasic individual’s residual strengths and abilities. Aphasia usually results from damage to the left hemisphere of the brain, which is where language processing takes place. It is often accompanied by a right hemiparesis, which leaves the subject with only his left hand fully functional. The earlier, unsuccessful aphasia rehabilitation attempts failed because, as a rule, they attempted to draw on natural language capabilities, which were destroyed and could not be restored. Our current system circumvents this problem, by emphasizing the subject’s *visual processing*, which takes place in his brain’s undamaged right side. Initial attempts at teaching aphasics this symbol language, using icons drawn on index cards, demonstrated the ability of many severely aphasic individuals to master the communication system.

The use of the computer provides many advantages. For instance, it enables us to animate symbols where appropriate. It allows us to check the user’s communications for grammatical correctness, to provide prompts where desirable, and otherwise to assist the user in his construction and translation of communications. And it provides a powerful means to provide the user with a large vocabulary in a natural and intuitive way—via “explorable pictures.”

Progress—Using an Apple Macintosh XL computer with a 5-megabyte hard disk, we have programmed a first version of our computer-aided communicative system. This implementation includes some, but not all, of the features described above. It does not yet contain either the “explorable pictures” mentioned above, or the ability to follow contexts, suggest prompts to the user, or otherwise actively assist in the construction of communications.

To test our concepts, we have trained two globally aphasic subjects in the use of

the card-based communication system, and have transferred one of these to using the computer-aided version. This subject has responded enthusiastically to the new system, and has shown significant improvement in his performance. We are now actively seeking additional subjects to train on the system.

This work has significance both for severely aphasic individuals and for researchers. For many in the chronic severely aphasic population, it holds out the hope for the first time of a return of simple functional communication, which could improve significantly the quality of their daily lives.

Portable Communication Aid with Synthetic Speech

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Sponsor: Rehabilitation and
Development Center (Core
Funding)

Purpose—Non-verbal communication aids that are easy to use, inexpensive, portable, and that produce voice and printed messages. Our ORATOR portable communicator combines all these features in a simple, cost-effective design. Messages are entered into ORATOR with an easily used keyboard. Each character is displayed as it is entered. When the message has been entered, the user can speak it, edit it, or save it for later use.

Prototypes of ORATOR are now available for consumer evaluation and market pre-testing. When we are satisfied that ORATOR does its job well, we will work with businesses to manufacture and distribute it.

The Comprehensive Communication System for Speech Impaired Persons

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Purpose—The Comprehensive Communications System for Speech Impaired Persons evolved from a previous project published as the Electronic Communicator for Speech Impaired Persons. That previous unit utilized the Morse Code entered by joystick or other two-axis controller, and featured user-programmable messages, all in a portable microprocessor-based device.

The present system resulted from the field-testing of the previous unit which determined that the Morse Code system, while usable, required a definite training time for any speeds and was probably no longer necessary with the advancement of microprocessor technology. The new system, which implemented first on the Apple II family computer, uses a joystick to select letters directly. The letters are arranged in a square around the perimeter of the joystick with essential punctuation and a "shift" key for numbers and special functions. The system is easily learned, has capability for user-defined message strings, allows for printing or saving of text to diskette, and presents the letters in a large-type font for many who have visual perception involvement along with motor impairments.

The joystick is used to select each character the user wants to print on the screen. The standard joystick is bounded by a four-sided square. Starting at a predetermined corner of this square, the joystick slides in a clockwise direction along each side. As the joystick moves, its (X) and (Y) coordinates change. The program has a table written into it; as the coordinates of the joystick change, the program selects a corresponding character—a letter or number. That character is

displayed in the top-left-hand corner of the screen. It is two inches high (on a 12-inch monitor) and may be made larger or smaller as necessary.

When the user slides the joystick to a point where the required character is displayed in the top left corner of the screen, the user presses pushbutton one, (PB 1), on the joystick unit. That character then remains printed on the screen. The joystick is moved to select the next required character. This mode is called the Writing Mode of the program.

The present program is available on diskette and requires an Apple II family computer with 64K of memory and a joystick or other two-axis input device. A monitor and disk drive are also required.

Future Plans — are to reduce the system into a dedicated-microprocessor-based device utilizing the Intel 8748 microprocessor, a vacuum fluorescent display, EEPROM memory, and RS-232C serial interface as well as a special interface to the Apple II family keyboard input. This portable "Joywriter" as it is named, will permit the user to have a comprehensive communication system that is easily learned and that may be an independent portable device, and a keyboard emulator for the Apple II family computers.

Effects of Real-Time Biofeedback on Dysarthric Speech

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Sponsor: VA Rehabilitation Research
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Purpose — The purpose of this project is: 1) to investigate the effectiveness of computer controlled real-time high resolution color visual biofeedback in inducing mild to moderate changes in respiration and speech rate among dysarthric patients, and 2) to measure other speech parameters that may co-vary with change in speech rate and respiration.

Twelve cerebellar ataxic and 12 Parkinson subjects will be compared to normal control subjects during time-series experiments that induce change in respiration and speech rate. Measures of vocal fold movement, fundamental frequency, speech intensity, and speech intelligibility will be made in addition to the measures of speech rate and respiration. Simultaneous real-time extraction of all parameters except intelligibility and rate will be made by dedicated analog instruments connected to a laboratory computer. The computer will control the biofeedback display on the basis of the analog input.

Progress — Project personnel, all analog instrumentation, and most computer hardware have been acquired. Programs for data acquisition and calibration have been written. Validity studies regarding each measure are underway. Programs for data storage, analysis, and visual displays are being developed.