Journal of Rehabilitation Research and Development
Rehabilitation R & D Progress Reports 1983

Sensory Aids

A. Blindness and Visual Impairment

B. Orientation and Mobility

C. Reading Systems for the Blind

D. Low Vision

E. Systems for the Hearing Impaired

F. Speech Technology

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Sensory Aids R&D

In this section, under the broad heading of Sensory Aids R&D, reports in the following general areas will be found: **Blindness and Visual Impairment** (including **Orientation and Mobility, Reading Systems for the Blind,** and **Low Vision**); **Systems for the Hearing Impaired; Speech Technology; Speech Impairment/Aphasia.**

BLINDNESS AND VISUAL IMPAIRMENT

VA RR&D CENTER HINES

EFFECTIVENESS OF A BLIND REHABILITATION PROGRAM

R. W. Lambert, M.D.; S.W. Becker, Ph. D.; B. Wright, Ph. D.; S. Courington, M.A.; and **L. H. Ludlow, M.A.**
VA Rehabilitation R&D Center
Edward Hines, Jr., Hospital
Hines, Illinois 60141

In a study designed to assess the effectiveness of the Blind Rehabilitation Center, it was necessary to develop instruments which would measure "quality of life."

The model required that a patient's life state be measured prior to entry into the rehabilitation program; shortly after completing the rehabilitation program, and again 6 to 9 months later. One hundred and ninety patients have completed initial interviews; 110 patients have completed second interviews; and 63 patients have completed third interviews. The data collection process is continuing and further efforts are of three sorts: (i) continued analysis of the measuring instruments validity; (ii) preparation of the programs and data for future analysis and (iii) integration of the data into a larger data base management system.

All of our measuring and survey instruments have been constructed. Most have been thoroughly tested, analyzed, and reported in the literature. The attitude-toward-blindness scale has been evaluated and compared to existing measures. The usefulness of the measure in a rehabilitation program is discussed in another paper. The method of scaling used in developing the measure is now being compared with factor analytic techniques.

Data have been collected in order to measure change-in-life state over time. Such measurement requires unidimensional scaling, which in turn makes necessary the development of new and innovative programs for analyses by use of a computer.

Two information systems have been constructed for the blind rehabilitation evaluation project. A large amount of data is collected from each patient in multiple interviews. There is a demographic file, a medical history and physical examination, an ophthalmologic examination, 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 which can be adapted to many types of project management. The patient information resides in a data base management system which 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 ■

VAMC ATLANTA

MUSICAL LANGUAGE COMPUTER APPLICATIONS

Gary W. Kelly and **Theresa M. Ackerman**
Veterans Administration Medical Center, Atlanta
Rehabilitation R&D Program
1670 Clairmont Rd., Decatur, Georgia 30003

This system provides the blind user a lower-cost means of accessing information from digital sources.

Progress — This system originated as a graduate feasibility study. It has now been implemented into the "SONA Tune-Maker" (SONA is an orientation & navigation system with environmental control applications, reported elsewhere in this issue). Data-gathering from users in the field continues, and persons interested in using the language are encouraged to contact us. A survey determining the needs of users is presently being conducted in order to assist the development of software meeting user needs in computer applications where muscial language can be an alternative to voice output.

Implementation of the first SONA devices with musical-language output has begun. This system will be tested as reported under SONA.

Future plans — Plans are to continue data acquisition from volunteer users and implement the SONA Tune-Maker into "real-world" use. Plans are presently to assist manufacturers in implementing this system into new equipment, including talking terminals. This work is expected to continue at the Atlanta Veterans Administration Medical Center ■

VAMC ATLANTA

SONIC ORIENTATION AND NAVIGATIONAL AID

Gary W. Kelly, Theresa M. Ackerman, and **Richard Bass**
Veterans Administration Medical Center
Rehabilitation R&D Program
1670 Clairmont Rd., Decatur, Georgia 30033

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

Progress — The first SONA/ECS system has had a limited evaluation by three quadriplegics who have utilized the system in their homes or on the job for periods of 3 months to 1 year. Preliminary results indicate that the system is very successful at providing reliable decentralized control at a relatively low cost.

One unit has been constructed and tested that provides automatic remote control over van doors and van wheelchair lifts. This system allows the quadriplegic to open the van doors from as much as 80 feet away from the van using a transmitter carried on the wheelchair.

The system has been commercialized by Amber Enterprises, Inc., Atlanta, Georgia. A 60-channel system is being constructed by the company for installation in a home in Florida. Amber has developed the system to control dimmer functions for dimming lighting, motor speed control for ventilation, and volume control for music systems. The company will make units available for testing and evaluation on a purchase order basis.

The SONA (Sonic Orientation and Navigational Aid) for the visually impaired traveler has been produced in sufficient numbers to allow the first field testing to be scheduled at the Atlanta Veterans Administration Medical Center. Thirty-five units have been produced. Initial field-testing awaits installation of the units in the hospital where they will be used to give visually impaired clients easier access to important facilities within the hospital. The units are equipped with the new "tune-maker" musical language board developed since the previous progress report. The tune-maker has been redesigned to be less labor-intensive in production and to have a slightly lower unit cost. This unit is expected to be available from Amber Enterprises, Inc. early in 1984.

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 center in two main areas: broadening the present applications of the ECS features, and evaluating the utility of SONA to the visually impaired traveler.

Technical development will also emphasize production engineering of the products, including the application of human-factors data gathered during testing ■

ORIENTATION AND MOBILITY

VA RR&D CENTER HINES

THE EFFECTS OF PREVIEW DISTANCE ON THE MOBILITY OF THE BLIND PEDESTRIAN

R. L. Hollyfield, Ph. D., and **K. Haag, Ph. D.**
VA Rehabilitation R&D Center
Edward Hines, Jr., Hospital
Hines, Illinois 60141

The optimal distance at which blind pedestrians should receive information regarding their upcoming environment is an important variable for the design of mobility aids. Previous research in this area has not provided a definitive distance or range of distances for the necessary foreknowledge or preview of the environment.

We hypothesize that a decline in performance indicates an insufficient amount of preview for the blind pedestrian. Insufficient preview does not allow sufficient time to respond appropriately to upcoming environmental features, and it also disrupts the pedestrian's processing of other, more global, mobility and orientation information such as route knowledge. Thus, this project assesses a range of these preview distances to determine at what distances both the overall mobility, and a set of specific parameters of gait-related mobility, deteriorate.

This study should yield significant insight into optimal preview distances. Then, future mobility aids can be designed to be more informative and compatible with the user, and less disruptive of the basic psychological processes that underline mobility ■

VA RR&D CENTER HINES

MEASURING THE MOBILITY OF BLIND TRAVELERS

R. L. Hollyfield, Ph. D.; S. M. Courington, M.A.; J. L. Trimble, Ph. D; and **L. Farmer, M.S.**
Hines Rehabilitation R&D Center
Edward Hines, Jr., Hospital
Hines, Illinois 60141

To perform a valid evaluation of a training program in blind mobility, the means for measuring the effect of that program on the blind traveler must be available. Previously, two quite different approaches have been taken in assessing the blind person's mobility performance: (i) measuring, either qualitatively or quantitatively, the travel skills of the blind person or (ii) ascertaining the amount and type of travel in which the blind person is reported to have engaged. Earlier attempts at measuring both of these have been less than optimal. Moreover, the two types of measures have never been compared in relation to each other. It is now possible to determine the effect of travel-skills training on the actual travel behavior of the trained blind traveler. Recent improvements in both of these types of measures make it feasible to do such a comparison.

This study measures the travel skills and the travel behavior of two groups of veterans from the VA Central Blind Rehabilitation Center: (i) a low vision group and (ii) a blind group. Each group's travel skills, as measured by the inter-ankle distance (ultrasonic) measuring system (IAMS) (Fig. 1), and travel behavior as measured by the Travel Inventory, will be determined at four times; twice before training, once at the end of the training period, and once 6 months after training. The relationship between travel skills and behavior will be determined for each of these five measurement points. Comparisons between the IAMS and the Nottingham group categories of mobility skills will be made. It is hypothesized that the level of travel behavior at the third and fourth measurement points will not be fully explicable in terms of the level of acquired travel skill. Factors unrelated to travel skills, such as spatial abilities and psychological stress, will result in lower travel activity than would have been anticipated from the level of travel skill ■

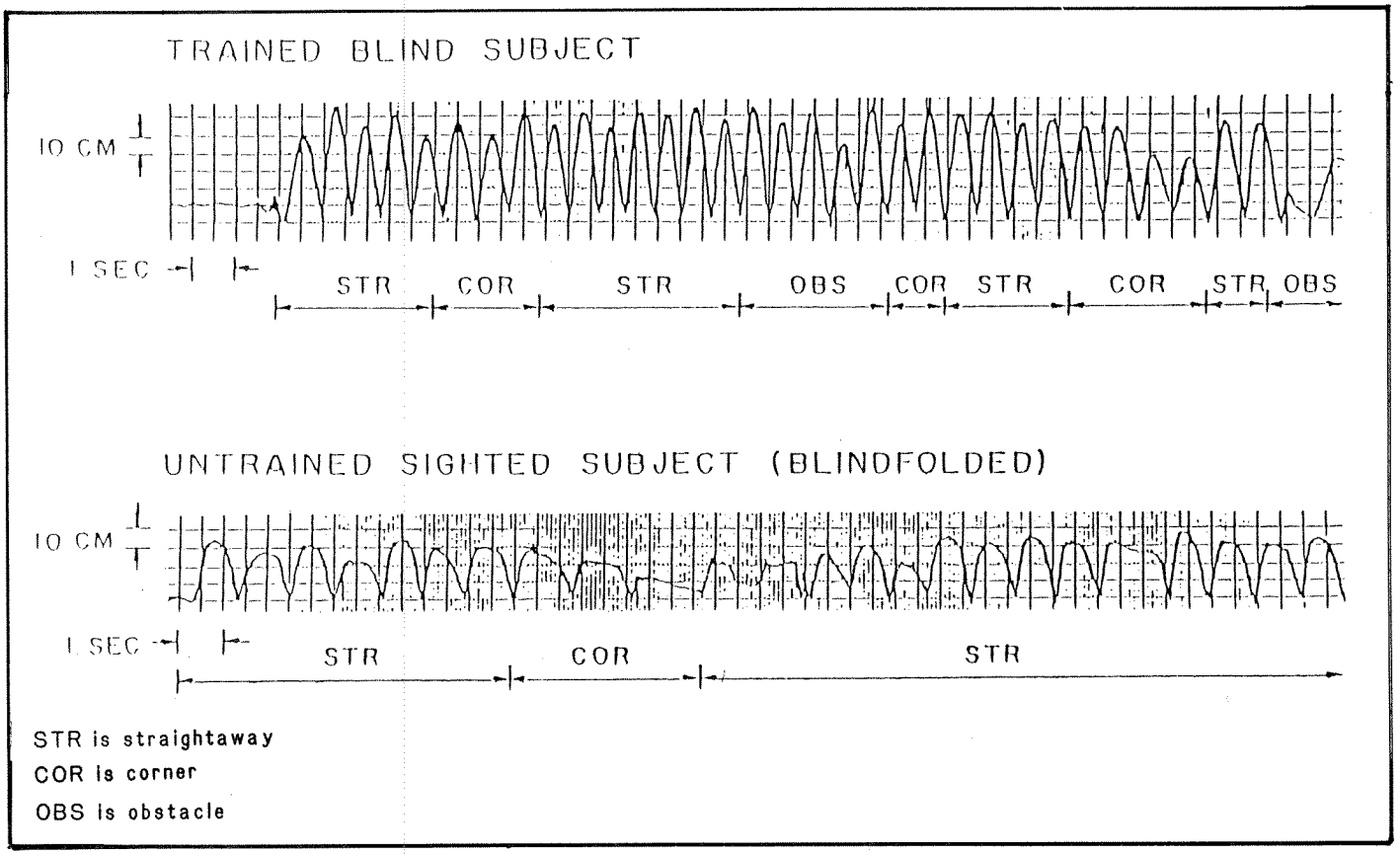

FIGURE 1
Plot of distance between subjects' ankles differs significantly when data generated by a trained blind individual is compared with data from a blindfolded sighted person. Both walked the same course, using canes to guide themselves.

READING SYSTEMS FOR THE BLIND

VA RR&D CENTER HINES

INKBRAILLE AND TACTUAL READING BY THE BLIND

B. Zuber, Ph. D.; D. Hislop, B.S.; S. Elster, B.S.; and **J. Trimble, Ph. D.**
in collaboration with
L. Mowinsky, B.S.; and **H. Lauer, M.S., of the Blind Center, Hines VA**
and
M. Butow, B.A., of the Hadley School for the Blind, Winnetka, Ill.

VA Rehabilitation R&D Center
Edward Hines, Jr., Hospital
Hines, Illinois 60141

The first objective of this research has been the development of rational measures for the evaluation of tactile reading performance, and the definition of an effective means for comparing alternative tactual "reading systems." A second objective has been to apply current knowledge and technology to the conceptualization and design of more efficient tactual reading systems for the blind. A third objective has been to gain a more fundamental understanding of the operating characteristics of the systems which mediate reading behavior in general and tactual reading in particular.

In our experiments we found that tactual readers appear to invoke a constant-rate text scanning strategy over a wide range of text difficulty levels. This finding has some interesting implications regarding the central neural mechanisms for processing this kind of information, and is the same finding reported for sighted reading studies. Also, we confirmed the great disparity in rates that exist between embossed braille and Optacon letter-print reading, and have initiated further studies to explore the rate-limiting effects of the several functional distinctions between these two tactual reading processes.

Inkbraille, which is a reduced-sized ink-image version of the familiar braille code, was conceived as an experimental tool, and as a potential basis for a new tactual reading system for the blind. Our initial studies of Inkbraille reading have demonstrated that embossed braille readers can readily transfer their skills to the reading of Inkbraille with the Optacon. Our results to date indicate that Inkbraille readers read Inkbraille cells at about the same rate as they read letters. This observation suggests that the poor performance of Optacon readers is related to aspects of the instrumentation and/or the Optacon reading process.

In an attempt to more closely approximate embossed braille reading, with its relatively fast reading rates, we are currently designing a device (the Inkbrailler) that will electronically generate a tactile braille cell when Inkbraille is scanned. It is hoped that this device will enable the blind to read at rates approaching those of embossed braille.

Assuming that Inkbraille and the Inkbrailler facilitate acceptable rates of tactual reading, several important advantages of Inkbraille over embossed braille should be readily apparent. Inkbraille is inexpensive, durable, and simple to produce. Moreover, Inkbraille text is compact; thus, Inkbraille books of a size similar to letter-print books would become feasible ■

VA RR&D CENTER HINES

"MAGIC WAND" — THE BRAILLE TEACHER

J. Trimble, Ph. D.
VA Rehabilitation R&D Center
Edward Hines, Jr., Hospital
Hines, Illinois 60141

Despite the development of computerized voice-output reading aids for blind people, braille remains an important medium for conveying information. Many educators and rehabilitation professionals believe that without a written language like braille, functional illiteracy would increase among blind people.

However, braille is difficult to learn. Students of braille must learn a new language that is written with new symbols. The presence of a skilled teacher is almost always necessary. Self-teaching is virtually impossible. There is a great need for better ways to teach braille.

Recently, a new educational product was introduced by Texas Instruments that appears to have great potential in braille teaching. The product is called the "Magic Wand Speaking Reader". The product incorporates a hand-held optical scanner and voice synthesis. Accompanying books contain pictures, printed words, and bar code. By passing the scanner over the bar code, beginning readers can hear the printed word.

At this Center we have made a simple change to the Magic Wand books that allows blind people to use them. Transparent braille characters have been overlayed on the printed words. Raised lines have been placed around the bar code to allow easy localization. By passing the scanner over the bar code,

users can link word sounds with braille characters. This allows students to learn independently at their own pace.

This Center is now working with consumers, rehabilitation professionals, and manufacturers to develop a complete set of braille learning materials suitable for beginning readers of all ages ■

VAMC PALO ALTO

DEVELOPMENT OF A CAMERA FOR APPLICATION IN SENSORY AIDS FOR THE VISUALLY IMPAIRED

Sally L. Wood, Ph. D.; Richard D. Steele, Ph. D.; Paul A. Marks, M.S.; Rafael A. Miranda, M.S.; Dean Hennies, M.S.; Robert Smith, M.S.; and **Melva Chang, B.S.**
Veterans Administration Medical Center
3801 Miranda Ave., Palo Alto, California 94304

The purpose of this work is to develop, for visually-impaired persons, an improved hand-held camera for use as the input device for a reading machine which accepts materials such as newspapers, magazines, and typewritten documents. The camera will communicate with a microprocessor which will convert the text to computer-readable form. Together, the camera and accompanying microprocessor serve as an input module to communicate with home computers or commercially available speech output devices, allowing the user to hear the output as spoken English.

Direct conversion output will include the options of stereotoner-type musical patterns, tactile output on an Optacon, and enlarged characters on a liquid-crystal, plasma, or light-emitting-diode screen display. The camera optics will have high-enough resolution and a large-enough field of view to allow the reading of print, from the quite small sizes found in telephone directories up to newspaper headlines approximately ½ inch tall.

Camera: the necessary parts for the construction of a prototype camera (the lenses, retina, shaft encoder) have been acquired, and fabrication of the initial camera and scanner has been completed.

Interface Modules: Three interfaces to output displays are ultimately envisaged. For direct conversion feedback to guide handtracking, an interface to the TSI Optacon tactile stimulator and an interface to a stereotoner-type tone output display will be available. For output to other computers or to a text-to-speech device, an RS-232 serial interface will communicate a stream of ASCII-encoded characters.

An interface board used to communicate between the industry standard multibus computer bus structure and the TSI Optacon tactile stimulator has been designed, tested, and debugged.

This same 8085-based subsystem can communicate image information in the standard stereotoner format, or in a modified format designed for tracking guidance rather than direct reading by the user. This addition to the interface is currently being designed, and various alternatives are being evaluated. The option of tonal output for tracking guidance rather than tactile output offers a large potential cost reduction for the reading system.

Work on the three tasks described here will continue independently for 2 to 3 more months, after which we will begin system integration. It is anticipated that evaluation trials will commence approximately 8 months after that. We are hopeful that the development of this camera, which can provide input to a variety of assistive devices serving both visually-impaired individuals and the normally sighted, will find a rather broad appeal. ■

NSF

IMPROVED OBJECTIVE SPEECH-QUALITY MEASURES FOR LOW-BIT-RATE SPEECH COMPRESSION

Thomas Pinkney Barnwell, III, Ph. D.
School of Electrical Engineering
Georgia Institute of Technology

This study proposes to develop a number of new objective measures for speech quality, and to use these measures to design improved low-bit-rate speech coding systems. The design of the objective measures will be accomplished using a large previously developed data base of 18 hours of distorted speech, and an associated data base of subjective quality results derived from the Diagnostic Acceptability Measure (DAM) subjective quality measure.

The research is divided into four basic areas. The first area is the design of improved objective speech quality measures, based on segmental preclassification of the speech signal. The second area is the development of an improved set of objective measures specifically designed to predict the parametric subjective quality results available from the DAM test. The third area is the study of an iterative technique for designing linear predictive coder (LPC) parameter quantizers subject to a complex objective quality measure. The final area consists of the design of a number of new low-bit-rate speech coders, based on the results of the other three areas.

The experimental work for this research will be performed using a minicomputer-based digital signal-

processing laboratory, a highly interactive facility specifically designed for speech and digital signal-processing research. Careful subjective speech quality tests will be performed on promising speech coders, using an automated speech quality testing facility ■

NSF

DESIGN OF VARIABLE-RATE, SUBBAND CODED SPEECH ENCODING USING VECTOR QUANTIZATION

Huseyin Abut
San Diego State University
Dept. of Electrical and Computer Engineering
San Diego, California 92182

This research project is concerned with low-rate speech communication systems using vector quantization. Good fixed-rate and variable-rate vector codes will be designed, using full search or tree-searched schemes on waveform encoding and on linear predictive speech-coding problems. The design of variable-rate subband coded vector quantization of speech samples will be investigated. Special emphasis will be given to the development of algorithms, and to the design of systems, with computational simplicity, fast convergence, robustness against channel errors, and cost effectiveness, to make them amenable to implementation ■

LOW VISION

VA RR&D CENTER HINES

SIMULATION OF RESIDUAL VISUAL FUNCTION

J. Trimble, Ph. D.; R. W. Lambert, M.D.; and **S. J. Starr, Ph. D.**
VA Rehabilitation R&D Center
Edward Hines, Jr., Hospital
Hines, Illinois 60141

A large portion of the nation's 2.5 million legally blind people have some residual vision. Many remedial devices and techniques have been developed to allow these people to function well despite their disability. Despite those efforts, experts in low vision generally agree that present training methods and aids are inadequate. This failure may be partly attributed to the tests used for assessing visual function.

The tests now commonly used in low vision clinics include: visual acuity, visual fields, depth perception, and range or accuracy of eye movements. Ironically, although these tests tell us something about the quality of a person's vision, they may not tell us about his ability to perform complex visual tasks. There is a definite need for tests that provide this knowledge. These tests could be used to guide remedial training, specify designs for optical aids, or study the sensory or cognitive processes of visually-impaired people ■

VAMC ATLANTA

ELECTRONIC TYPEWRITER FOR THE VISUALLY IMPAIRED

Gary W. Kelly, Theresa M. Ackerman, and **Jeffrey L. Smith**
Veterans Administration Medical Center, Atlanta
Rehabilitation R&D Program
1670 Clairmont Rd., Decatur, Georgia 30003

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

Progress — Construction of three prototype test units is proceeding. One of them will have large-print CCTV output as well as a vacuum fluorescent display. The system has been designed as an electronic add-on to the Sony Typecorder and is plug-compatible with the Sony LCD display. The system under construction already has RS-232 serial interface to allow communications with common computer equipment. The display utilizes an 8741 microprocessor.

The first unit is functioning and has been sent to an interested potential manufacturer. Additional units are being constructed and work is beginning on the CCTV interface.

Recently the new Epson HX-20 microcomputer has become available and it is being considered as a replacement for the Typecorder, which has only one-way communication and is essentially a dedicated word processor. The Epson is being evaluated to determine if it has sufficient capabilities to warrant modification for this application.

Future plans — Construction will continue for the next 3 months and lead into field evaluation of the units after that time. Initial contacts have been made with potential interested manufacturers and the research team is working closely with these to evolve a production-ready prototype ■

VAMC ATLANTA

GUIDE-DOG HARNESS DESIGN

Gary W. Kelly and **Dawn Williams**
Veterans Administration Medical Center, Atlanta
Rehabilitation R&D Program
1760 Clairmont Rd., Decatur, Georgia 30003

This is a student design project. The purpose is to design and test new guide-dog equipment with a more appropriate choice of materials technology. The goal is to develop a harness and leash that have better wear, less care required, superior esthetics, and lower production cost.

Progress — The first prototype is almost complete and testing will begin within 30 days. Nylon has been chosen as the main material to be used and acrylic rods will be used for the handle. All buckles will be replaced with Scotch Mate, and other metallic hardware will be minimized.

Future plans — Plans are to develop several prototypes and cooperate with interested guide-dog schools in testing the units. Several schools have expressed interest in testing the new equipment and have generously provided excellent recommendations and marketing data. A potential manufcturer has been located and production is expected to follow successful testing ■

SYSTEMS FOR THE HEARING IMPAIRED

VAMC MARTINEZ

SENSORINEURAL HEARING LOSS: FREQUENCY DISCRIMINATION, INTENSITY-RESPONSE FUNCTION, & BINAURAL DIPLACUSIS

E. William Yund, Ph. D.; Helen J. Simon, Ph. D., and **Robert Efron, M.D.**
Veterans Administration Medical Center
150 Muir Road, Martinez, California 94553

The purpose of this research program is to characterize the suprathreshold auditory function of an individual with sensorineural hearing loss (SNHL) by means of a theoretical model of pitch processing (Yund and Efron, 1977), and then to use that characterization to design a signal-processing system to compensate for that hearing loss. If the results indicate that the model is useful in designing compensation systems (hearing aids) for SNHL subjects, the next phase of the research will be the adaptation of these methods to the clinical setting.

Frequency Discrimination — The study of frequency discrimination in SNHL patients has a dual role in this research program.

In the first respect, it is essential to establish that SNHL does not consistently degrade the ability of the auditory system to process frequency (pitch) information. If a large degradation of the information carried in the frequency domain were an integral part of SNHL, this would indicate not only that the Yund-Efron model could not be applied to SNHL, but that any idea for improving the design of hearing aids faced the virtually impossible task of recovering information which is not just distorted in some regular way, but instead is entirely lost.

Secondly, it is important to determine whether the frequency information in any particular band in either ear of a patient is degraded. If only one ear shows degraded frequency information in a particular band, information in that band can be delivered only to the other ear. Alternatively, if neither ear can process frequency information in a particular band, it may be better to eliminate sound energy in that band from both ears rather than include information that cannot be processed accurately. (This would be an empirical question to be answered individually for each subject.)

Frequency discrimination was measured in the left and right ears of 15 SNHL subjects at as many as possible of the frequencies: 500, 750, 1000, 1500, 2000, 3000, and 4000 Hz. While the poorest frequency-discrimination performance generally occurred where subjects had a significant threshold elevation, the relationship between discrimination performance and intensity threshold was not a very close one. Comparing the performance between the two ears of the same subject indicates that the superior discrimination is not always in the ear with the lower intensity threshold at that frequency, and furthermore, that large differences in frequency discrimination (up to an order of magnitude) may be found in the absence of any difference in intensity threshold.

Data indicate that frequency-discrimination and intensity-threshold deficits are essentially independent, and furthermore, that the frequency discrimination deficits found in SNHL subjects often occur in only one ear or in different frequency bands in the two ears.

Intensity-Response Function — The current reporting period has been devoted to increasing the subject population and, more importantly, to solving two problems which have occurred in attempts to measure I-R functions in some subjects. Specifically, (i) a greatly reduced dynamic range accompanied by recruitment, or (ii) binaural diplacusis at the test frequency. In the case of a greatly reduced dynamic range accompanied by recruitment, the slope of the I-R function is changing very rapidly with intensity. Under these conditions, small variations in stimulus intensity caused by variations in positioning of the standard headphones become significant. Using insertion earphones instead of the standard headphones eliminates intensity variations and thus reduces the measurement variability to the level normally encountered in such measurements. Binaural diplacusis at the test frequency may or may not be accompanied by a frequency discrimination deficit in one or both ears. If a major frequency discrimination deficit is present at a test frequency, the I-R function measurements are done at a nearby frequency where no such deficit is found. If, on the other hand, binaural diplacusis occurs with no discrimination deficit, frequency corrections for the diplacusis are incorporated into the I-R measurement procedure.

Binaural Diplacusis — Some of our SNHL subjects, however, show a binaural diplacusis of more than 10 percent. Such a large difference in the perception of the same frequency information depending upon the ear to which it is delivered might cause considerable confusion in the more natural situation where the two ears usually receive a very similar array of frequency information. At the present time, the significance of binaural diplacusis in producing a functional deficit in the SNHL patient in unknown. We will study the role of binaural diplacusis in SNHL by introducing compensation for the diplacusis (in addition to the compensation for the I-R function) into stimuli delivered to our SNHL subjects, and determining the extent to which that diplacusis compensation improves the SNHL subject's binaural hearing ■

VAMC NASHVILLE

THE MODULATION TRANSFER FUNCTION AS A PREDICTOR OF SPEECH INTELLIGIBILITY

Larry E. Humes, Ph. D.; Gene W. Bratt, Ph. D.; Christopher Ahlstrom; and **Stephen Boney**

Veterans Administration Medical Center
1310 24th Ave. South, Nashville, Tennessee 37212

Vanderbilt University School of Medicine
Division of Hearing and Speech Sciences
Nashville, Tennessee 37232

The overall objective of this project is to evaluate the effectiveness of the modulation transfer function (MTF), and the speech transmission index (STI) derived from the MTF, as a predictor of speech-recognition performance in hearing-impaired listeners.

There are three phases to this project. In the first phase, the acoustical MTF is measured, the STI calculated, and speech-recognition performance assessed, for a variety of listening conditions including: (i) filtered speech; (ii) additive noise; (iii) reverberation; (iv) filtering-plus-noise; and (v) reverberation-plus-noise. Speech materials include the Nonsense Syllable Test or NST, the Speech Perception in Noise or SPIN test, and Northwestern University Auditory Test No. 6 or the NU-6 test.

In the second phase of this project, conducted in parallel with the first phase, a psychophysical corollary of the acoustical MTF is explored. This measure, known as the psychophysical modulation transfer function (PMTF), would permit prediction of an individual listener's speech-recognition performance, as opposed to prediction of average performance for a group of listeners. This experiment makes use of the temporal probe method (5) to measure the PMTF. The PMTF is measured at 0.5, 1.4, and 4.0 kHz in quiet, broad-band noise and in high-pass noise. Speech-recognition scores for the SPIN and NST were then obtained under the same conditions.

The third phase of this project will be initiated in early 1984. In that phase, acoustical MTFs will be obtained from a variety of hearing aids and the STI calculated ■

VAMC TEMPLE, TEXAS

DEVELOPMENT OF STIMULUS MATERIALS FOR COMPUTER-ASSISTED INSTRUCTION IN LIPREADING

Lennart L. Kopra, Ph. D.
Olin E. Teague Veterans' Center
Audiology/Speech Pathology Service
Temple, Texas 76501
University of Texas at Austin
Speech and Hearing Center
Austin, Texas 78712

The purpose of this project is to increase the effectiveness of lipreading instruction for hearing-impaired adults. Computer-assisted instruction (CAI) is being examined as a way of providing systematic supplementary drill and practice in lipreading for postlingually hearing-impaired adults.

Instrumentation for Computer-Assisted Instruction in Lipreading — The present system being used for presenting drill and practice sentences via computer-assisted instruction in lipreading consists of the DAVID Instructional System (Vontech, Inc.), Coulbourn Instruments Programmable Attenuator and accessories, and a Grason-Stadler 1701 Clinical Audiometer.

Drill and practice sentences are programmed in Vontech Authoring Language to provide two kinds of redundancy which accompany the visual presentation of the lipreading stimulus. In the linguistic redundancy condition, the first presentation of the lipreading stimulus is presented with no clues. If the lipreader does not identify the sentence correctly, the next video presentation is preceded by markers on the subject's CRT which indicate the number of letters in each word and the number of words in the sentence. After the third presentation, the CRT displays a clue word to the side of the markers, that is, a word is shown out of context. The fourth presentation of the lipreading stimulus is followed by one clue word in context along with the previously shown markers. The fifth and final presentation provides two clue words in context. If the lipreading student has not identified the sentence completely correctly by the fifth trial, the videotape is advanced to the next sentence.

In the auditory redundancy condition, the first presentation of the lipreading sentence is displayed without clues. If the student does not lipread the sentence completely correctly, the second presentation is accompanied by an auditory signal level at 0 dB sensation level re speech-noise detection threshold. If the student continues to need additional increase in the auditory signal level for correct identification of the sentence, the third visual presentation is accompanied by a 5-dB sensation level of the auditory signal. The fourth trial has a 10 dB sensation level, and the fifth trial has a 15-dB sensation level.

The effects of two conditions of redundancy will be examined in terms of their effect on the development of lipreading skill as lipreading students are provided formal lipreading instruction and supplementary drill and practice in computer-assisted instruction in lipreading.

Problems Requiring Resolution — Two primary problems have been encountered which make the ¾-inch videocassette player inappropriate for computer-assisted instruction in lipreading. The first problem is tape slippage with resultant inaccurate accessing of video frames.

Other Activities — Other research activities in this project have included the construction of consonant-vowel-consonant (CVC) words in preparation for the development of procedures for presenting minimal viseme contrasts in lipreading instruction. A thorough examination of the historical background of lipreading has been conducted and a manuscript summarizing this research is in preparation. Twelve 1-hour lipreading lessons have been prepared for formal lipreading instruction, which is a part of this project. Finally, a comprehensive bibliography of literature references on lipreading and topics related to aural rehabilitation of postlingually hearing-impaired persons has been a continuing effort ■

NSF

TACTILE PERCEPTION OF SPEECH

James C. Craig
Indiana University Foundation
P.O. Box 1847,
Bloomington, Indiana 47402

The major objective of this project is an examination of the feasibility of using the tactile sense as an alternate modality for the perception of speech and the understanding of spoken language. We therefore address two major questions that are fundamental to this program: first, how should the distinctive elements of the acoustic speech signal be transformed to provide recognizable tactile patterns; and second, what is the most effective training procedure for perceptual learning of tactile speech displays and for evaluating various tactile representations of speech?

We will present natural and synthetic speech tokens to the skin of the finger(s) using a computer-controlled spectral display and Optacon transducers. We will also develop and evaluate training procedures for the acquisition of tactually presented speech. A novel training paradigm will be examined: it takes advantage of the close association between speech production and speech perception by allowing the learner of tactile speech to produce, hear, and feel his or her own speech patterns in real-time. This paradigm will be used, initially, in conjunction with experiments on the utility of combining tactual information with visual information during speechreading. The results of these experiments should have broad implications for the development and improvement of speech aids for the deaf and aids for both perception and production of speech ■

NSF

USE OF VOICE-TO-TEXT IN DEAF-HEARING DIALOGS

Earl Craighill
SRI International
Telecommunications Sciences Center
Computer Science and Technology Division
333 Ravenswood Avenue, Menlo Park, California 94025

This research explores methods of coupling voice-to-text (VTT) conversion technology with speech synthesis devices, to allow better communication between the deaf and the hearing.

The research specifies, demonstrates, and evaluates VTT systems that are practicable and useful in dialogues between a hearing person talking over a phone to a deaf person who is typing.

Specific research tasks are to:

1. Define the necessary system parameters of a usable VTT system, including the level of recognition performed by machine, the degree of accuracy of machine operation, and the amount of training required by deaf and hearing persons;
2. Demonstrate an operational system coupled to the phone network;
3. Determine the extent to which deaf users can provide their own syntactic and semantic analyses; and
4. Identify key research problems that require solution.

Experiments, conducted to simulate communication between deaf and hearing persons, include simple information-transfer tasks as well as fully interactive representative dialogs.

This is the first year of a 3-year continuing award ■

NSF

PRODUCTION AND VISUAL ARTICULATORY SHAPING OF SPEECH IN DEAF CHILDREN

Samuel G. Fletcher, Speech Pathologist
University of Alabama, Birmingham
Box 187, University Station
Birmingham, Alabama 35294

The goal of this research is to bring new scientific and engineering developments to bear on understanding and improving speech production of deaf children. Four lines of investigation are underway:

First, using a new computer-based instrumentation system, a complete physiologic, acoustic, and phonetic description of speech production by 6 to 14 year old deaf and hearing children is being developed. These data are being used to identify contrasting patterns and strategies of speech production and to investigate relationships between articulatory visibility and proficiency.

Second, visual displays and monitoring devices are used to study lip, jaw, and tongue control in articulator positioning and in manipulating forms within the mouth. These data are being interpreted from a sensory deprivation viewpoint.

Third, static and dynamic visual articulatory displays are used to study recognition of English sounds through vision.

Fourth, the efficiency and effectiveness of visual articulatory displays for monitoring the speech of others, and changing one's own articulatory patterns, are being explored.

In all of this work, the ultimate goal is to develop an accurate, internalized, conceptual schema using vision to specify articulatory targets and guide movements to and from such targets in three-dimensional space. It is expected that this research will contribute substantially toward solving the imposing speech difficulties of deaf children ■

NSF

VOCAL FOLD VIBRATION AND SPEECH

Donald G. Childers, Ph. D.
University of Florida
College of Engineering
Gainesville, Florida 32611

This study is concerned with describing the role vocal-fold vibratory motion plays in the production of speech. Basic speech models use the source-filter theory, which claims that the vocal folds modulate the air expelled by the lungs and that modulated

air excites the vocal tract to produce voiced sounds. But little is known about how the motion of the vocal cords affects the quality of speech production. Our proposal is studying this aspect of laryngeal function.

The proposal methodology includes the comparison of data obtained from synchronized ultra-high-speed laryngeal films, electroglottograph (EGG) waveforms, and recorded speech signals. We measure and compare parameters of vibratory vocal fold behavior from these films, EGG, and speech signals. This data is being used to develop new real-time speech processing techniques. The most significant parameters of vocal fold motion which contribute to reproducing or synthesizing the original speech are being determined.

The results of this study will assist us in developing training aids to assist the deaf or hearing-impaired to speak more naturally. Our results would also be useful for teaching foreign languages. We are using our findings to produce more natural-sounding synthesized speech, and to describe the differences between male, female, and children's voices ■

NSF

AUTOMATIC MEASUREMENT OF LARYNGEAL VIBRATORY PATTERNS

Donald G. Childers, Ph. D.
University of Florida
Department of Electrical Engineering
Gainesville, Florida 32611

This study is directed toward establishing a relationship between parameters of vocal cord motion, as measured from ultra-high-speed laryngeal films and from acoustic parameters extracted from audio recordings of phonation, obtained simultaneously, during the laryngeal filming process. The specific goal is to quantify and relate aspects of laryngeal vibratory motion by processing ultra-high-speed laryngeal films and simultaneously recorded phonations.

The quantified parameters will be studied to establish the relationships between the many factors in laryngeal vibratory motion, and both fundamental frequency and sound intensity. The results of the study will contribute to understanding of the manner in which the motions of the vocal folds are transformed into the unique sound generated.

No human subjects will be involved in the study, since the data are already available from a normal subject population with a normal organ for voice production and normally functioning vocal cords. The unprocessed data are in the form of ultra-high-speed laryngeal films (on the order of 5,000 frames/sec) and sustained phonations simultaneously recorded during the filming process.

This research is part of an overall program of "Science and Technology to Aid the Physically Handicapped" and may contribute eventually to the design of better machine aids for teaching speech to the deaf ■

VAMC TEMPLE, TEXAS

INVESTIGATION OF ACOUSTIC REFLEX IN ELDERLY PERSONS

David J. Thompson, Ph. D., and **Larry N. Robinette, Ph. D.**
Olin E. Teague Veterans Center
1901 South 1st Street, Temple, Texas 76501

Work through June 23, 1983, included two normative investigations of the contralateral acoustic reflex, and completion of rudimentary software for communication between a host computer and a digital acoustic-immittance instrument.

Both investigations used subjects with normal hearing sensitivity. One investigation concerned adaptation of the acoustic reflex response, measured in aural acoustic immittance with an analog acoustic-admittance instrument interfaced to a computer (Nicolet 812). Reflex-activating signals were four pure tones and broadband noise. Subjects were within the 20-79 year age range. Major results were —

1. That the rate of adaptation was greater for one acoustic admittance component (susceptance) than the other (conductance);
2. That the 2000-Hz signal provided the earliest onset of adaptation; and
3. That maximum response amplitude, and slope of adaptation, were related to subject age.

The other investigation concerned the effect of activating-signal bandwidth on the input-output function of acoustic reflex. Signals were three pure tones and bands of noise centered geometrically around each tone (octaves of 0.33, 0.5, 1.0, and 2.0). Subjects were young adults. Results indicated that slope of the input-output function was not clearly related to signal bandwidth, and could be predicted by static admittance plus the reflex response of largest amplitude.

Progress has also been made on development of host computer software for control of a digital acoustic-immittance instrument. Preliminiary calibration and assessment of the digital instrument has been completed and sufficient software has been written for acquisition and storage of data in an investigation of acoustic reflex latency. Additional control software for the acoustic-immittance instrument is planned during FY84 ■

SPEECH TECHNOLOGY

NSF

PARALLEL ARCHITECTURES FOR SPEECH RECOGNITION

Harvey F. Silverman
Brown University
Division of Engineering
Providence, Rhode Island 02912

The advent of Very Large Scale Integration (VLSI) has made feasible the development of new computer architectures and algorithms, as well as the exploration of older ideas previously not pursued because they were too costly to implement.

Speech recognition is a computationally intensive technology which stands to gain widespread use through VLSI. There is a need for experimentally based research into the integrated problems of computer architecture and associated algorithms. A focus of this study is the development of new approaches for economical implementation of new intelligent algorithms. The research examines the design and implementation of multiprocessors computing systems (composed of microprocessors) for these new and more intelligent discrete utterance recognition (DUR), connected speech recognition (CSR), and digital signal processing algorithms.

The best recognition algorithms, currently only in the most expensive speech recognition systems, are "brute force" and costly to implement. Past work by the principal investigator has shown how one can reduce computational costs by an order of magnitude without loss in accuracy. Research is continuing on new algorithms which will allow large-vocabulary DUR, and better CSR, to be put into economical multiprocessor systems. It is intended to implement these new ideas to the stage of prototype hardware and software, and evaluate these in a real-time computing environment through carefully designed experiments ■

NSF

PARALLELISM IN SPEECH PROCESSING

Leah J. Siegel and **Howard J. Siegel**
Purdue University
School of Electrical Engineering
West Lafayette, Indiana 47907

The objective of this research is the study of the parallelism in speech-processing tasks and how this parallelism can be exploited by large-scale multiprocessor systems. Both parallelism within a task, and parallelism among tasks, will be investigated for a variety of specific important speech processing problems. Algorithms based on the SIMD (single construction stream — multiple data stream) and on multiple-SIMD modes of parallelism will be developed and analyzed.

A set of time complexity equations for evaluating the execution of a set of tasks on a partitioned multiple-SIMD system, in terms of parameters such as the number of partitions, the size of the partitions, the time for intra- and inter-partition communications, and instruction speech will be derived. The features needed to express parallelism in a high-level language for parallel speech processing will be evaluated.

The design of highly parallel asynchronous architecture for speech understanding, based on the use of parallel subsystems to construct a virtual nondeterministic machine, will be explored. It will incorporate SIMD, multiple-SIMD, and special-purpose processors as components.

This research is expected to advance the state-of-the-art of both parallel processing and speech processing. It will aid researchers in these areas to exploit the parallelism of the large-scale multiprocessor computer systems of the 1980's ■

SPEECH IMPAIRMENT
APHASIA

VA RR&D CENTER PALO ALTO

GRAPHIC COMMUNICATION ENVIRONMENT

Fred H. Lakin, M.A.
Rehabilitation Research & Development Center
Palo Alto VA Medical Center
Palo Alto, California 94304

GraphCom is an interface which is easy to use, can grow with the user, and offers assistance in presenting and organizing information. Because a computer is helping to control the system, it will be able to provide training and prosthetic assistance to the user. GraphCom is a non-text communication medium that helps the user manipulate images and construct mnemonic drawings to convey meaning. The interface requires only that the user be able to understand physical objects in the outside world.

Status — The GraphCom project is proceeding in two stages. In the first stage, the existing software has been installed at the Palo Alto Rehabilitation

R&D Center. The second stage is to extend that software to measure and assist the performance of cognitively disabled users. This stage is approximately 20 percent complete ■

VAMC BIRMINGHAM

EFFICACY OF REMOTE DELIVERY OF APHASIA TREATMENT BY TEL-COMMUNICOLOGY

Gwenyth R. Vaughn, Ph. D.; VAMC, Birmingham, Alabama
Walter W. Amster, Ph. D.; VAMC, Miami, Florida
Kevin P. Kearns, Ph. D.; VAMC, New Orleans, Louisiana
Amy Key Rudd, Sc. D.; VAMC, Little Rock, Arkansas
Veterans Administration Medical Center*
Audiology-Speech Pathology Service (126)
Birmingham, Alabama

Purpose — The purpose of the project is to compare the efficacy of two methods of delivery of an aphasia treatment program by (i) remote TEL-Communicology, involving both clinican and computer-assisted delivery, and (ii) face-to-face delivery of the same program. The long-term objective of the project is to determine whether TEL-Communicology is efficacious, cost-effective, and makes quality health care more available and accessible.

Experimental Results — The data collected will be used to accomplish the following primary purposes: (i) to determine the rate and amount of improvement in aphasia (comparison of intake performance with performance after 6, 12, 18, and 24 weeks of treatment), and (ii) to compare the performance of the two methods of treatment delivery: Group 1 using face-to-face clinic delivery and Group II utilizing TEL-Communicology.

Accomplishments — Between February 1 and June 30 of 1983, 14 subjects qualified for the project. As of June 30, no subject had completed the 6-month treatment period. Of the 14 participants, random assignment placed 7 subjects in the face-to-face delivery group, and seven subjects in the TEL-Communicology delivery group.

The comparison of the cost performance of the face-to-face and TEL-Communicology delivery systems is in progress ■

*Of the four Veterans Administration Medical Centers cooperating as treatment centers in this project, Birmingham also serves as Project Center and is responsible for scoring videotaped subject evaluations, compilation of data, and training of all personnel. Dr. Vaugn is Chief of the Audiology-Speech Pathology Service at Birmingham VAMC.

VAMC MARTINEZ

A TACTILE AID FOR THE TREATMENT OF SENSORINEURAL HEARING LOSS AND APHASIA

Robert T. Wertz, Ph. D.; Pierre L. Divenyi, Ph. D.; Gretchen Skalbech, Ph. D.; and **Frank A. Saunders, Ph. D.**
Veterans Administration Medical Center
150 Muir Road, Martinez, California 94553

This investigation is designed to test the efficacy of Teletactor, a wearable electrotactile sensory aid, as a treatment for speech discrimination deficit in severe sensorineural hearing loss, and auditory comprehension deficit in severe aphasia. Worn as a belt across the abdomen, Teletactor converts an auditory signal into electrical impulses and presents these as electrotactile patterns on the skin. A 20-week controlled treatment trial is being conducted to compare performance by patients with severe sensorineural hearing loss, and performance by patients with severe aphasia, when wearing Teletactor with performance to when not wearing Teletactor.

During the period from January 1, 1982, through June 30, 1983, we have completed the assembly of a computer system to generate and present acoustic stimuli and record patient responses ■