SENSORY AIDS

Edited by

Howard Freiberger, A.M.
Electronics Engineer

Research Center for Prosthetics
Veterans Administration
252 Seventh Avenue
New York, N.Y. 10001

Laser Cane Blind Mobility Aid

Bionic Instruments, Inc.
221 Rock Hill Road, Bala Cynwyd, Pennsylvania 19004
J. Malvern Benjamin, Jr., Nazir A. Ali, and D. Ridgeley Bolgiano

During the period from July 1, 1974, to December 13, 1974, the main thrust of the Laser Cane project was the building of canes under a production contract. Research work concentrated on investigation of several possible improvements:

1. Doubling the pulse repetition rate doubles the information acquisition rate, making curb detection more positive, as well as detection of tree branches by the UP channel. On the other hand, it also increases power consumption. The study is not yet complete, but it appears presently that this change will be worthwhile.
2. In conjunction with 1. above, battery discharge rate was explored in more detail than it had been earlier, and under varying conditions of simulated use. Under average use conditions, it now appears that the cane will run for 8 hours before it needs recharging.
3. The pitch of the UP channel alarm was raised to reduce confusion, with provisions that for those with hearing defects, it could be adjusted on prescription.
4. The distance in front of the cane tip at which UP channel detection first takes place has been most recently set at 24 in. (after several settings from 0 in. to 30 in.). Now, the consensus is again for 30 in.; so it has been reset.
5. When the cane gets caught between a door and its frame or in a street grating, if it is not removed correctly it may break. To assure that the lower, nonelectronic staff is the part that yields rather than the expensive upper section, a friable link has been designed in the connecting joint of the lower section. This yields at approximately 20 percent lower shear force than the mating connector on the upper section.
6. Efforts have been made to replace the optical ranging on the MIDDLE channel with electronic ranging since this should be somewhat more reliable. Electronic ranging can be achieved simply by reducing

the gain for the "near" channel as compared to the "far" channel. This works because the cane is sensitive to target reflectivity. Optical triangulation is, of course, still being used for basic ranging. After suitable laboratory study, two canes have now been rebuilt with this feature and are being evaluated by several Orientation and Mobility Specialists and several blind C-5 users.

7. Extensive calculation and experimental time were spent verifying the laser power level of the three laser emissions from the C-5. A report was sent to the Bureau of Radiological Health, USPHS attesting to the C-5's safety in this regard.

Expenses for these visits were shared between Bionic Instruments and the VA. All time was charged to Bionic Instruments.

1974 TRAVEL

Date	Place	Meeting or Exhibit	Function
1/23	Detroit	Exhibit of Technical Aids for the Blind	Exhibitor
5/2	Boston	Conf. on Engineering Devices in Rehabilitation	Speaker
6/11	West Haven, CT	VA Eastern Rehab. Center	Visitor
6/12	Boston	Boston College	Visitor
7/21	Chicago	VA Contractors Conf.	Speaker
8/6	Denver	Blinded Veterans Assn. Conf.	Exhibitor and Speaker
10/30	Philadelphia	A.A.W.B. Regional Conf.	Exhibitor and Speaker

Research on Audible Outputs of Reading Machines for the Blind

Haskins Laboratories, Inc.
270 Crown Street, New Haven, Connecticut 06510
Franklin S. Cooper, Ph. D., A.M. Liberman, Ph. D., Jane H. Gaitenby, Ignatious G. Mattingly, Ph. D., Patrick W. Nye, Ph. D., and George W. Sholes, Ph. D.

Introduction

The research program being conducted at Haskins Laboratories has recently demonstrated the basic feasibility of automatically generating spoken English from printed texts. A prototype reading machine system

as been constructed that employs an Optical Character Recognizer OCR) and a group of computer programs to convert typewritten materials to speech with the occasional intervention of an on-line editor. Currently, research is being concentrated on two principal areas. The first area is concerned with improving the quality of the speech which, although quite intelligible for many purposes, nevertheless, still possesses an unnatural machine dialect. Meanwhile, in a second closely related area, work is being directed to listener evaluations of synthetic speech and to making detailed on-line comparisons of the outputs of different algorithms with natural speech.

Conversion of the orthography from printed materials into a phonetic script (in machine language) that is completely ready for synthesis is accomplished by a computerized dictionary look-up procedure. Some additional areas receiving attention include sounding rules to generate words not found in the dictionary and methods for deriving better prosodic data from the printed input. The ultimate goal of the research is the production of a reading machine system which can provide tape recordings from complete books at speeds much faster than a human being can speak.

Synthetic Speech Improvements

One of the major difficulties in the development of good synthetic speech revolves around the problem of achieving better intelligibility and that elusive quality which listeners describe as "naturalness." This problem is further aggravated by the fact that the experimenter's ear quickly adjusts to hearing the dialect of English produced in synthetic speech. His ability to detect those points where improvements are needed decreases rapidly, and he is led to believe that the speech is as highly intelligible to others. In such conditions, significant contributions can sometimes be made more easily by another investigator who brings a fresh ear to bear on the problems, as well as new perspectives.

Professor Frances Ingemann returned to the Laboratories from the University of Kansas after an absence of several years and devoted 6 months of her sabbatical during 1974 to work on speech synthesis. She concentrated her efforts on the tables of phonemic specifications and allophonic modifiers which are collectively known as "the rules." Taking the most recent synthesis-by-rule program, Dr. Ingemann began a substantial reworking of the rules following an approach she had used in 1957 (1 and 2) wherein the same, or very similar, specifications were used for all members of a natural phonetic class. Toward the close of this work in mid-1974, she collected their performances with one another and with natural speech using three listening tests. The first tests compared the intelligibility of running synthetic speech obtained before and after her rule revisions. The second test was focused on differences in

the intelligibility of initial consonants, vowels, and final consonants between the old and revised synthesis programs, while the third test contrasted intervocalic consonant intelligibility in the most recent algorithm using two revised sets of synthesis rules. Data on all three of these intelligibility tests were collected from listeners who were familiar with synthetic speech.

Comparisons of Synthetic Speech Intelligibility

In the first test, 24 listeners heard 27 sentences of peculiar lexical content, and were required to write down what they heard. The fact that the sentences were difficult to predict required correct recognition of all their phonetic constituents (i.e., there was little help to be had from context). The results showed that the listening performances on phonemes were marginally poorer with the latest synthetic speech rules (75 percent correct compared with 78 percent correct for the same algorithm with the old rules), although there are reasons to suspect that the sum total of several minor defects in the conduct of the testing procedure probably accounted for the low score of the revised rules. Grounds for this suspicion appear to be confirmed by the results of the second test which showed that for the 16 subjects employed, the new rules performed best in all three categories; initial consonants were 82 percent correct versus 73 percent correct, final consonants were 79 percent correct versus 76 percent correct, and vowels and diphthongs were 98 percent correct versus 97 percent correct. Finally, the third test which employed six listeners, showed that on intervocalic consonants the most thoroughly revised set of rules produced the best performances.

In addition to a new set of rules, Dr. Ingemann provided a number of suggestions on the structure of the synthesis algorithm. Several modifications implied by these suggestions have been made to the most recent algorithm. These include:

1. improving the range of fricative amplitudes relative to the vowel amplitudes,
2. discontinuing the use of a single parameter in the rules to specify the buzz, hiss, and fricative amplitudes during the release portion of a phoneme (the fricative amplitude is now separately defined),
3. using variable second fricative formant frequencies, and
4. eliminating the automatic production of syllabic consonants.

The remaining suggestions have been absorbed into the planning of a new synthesis program to be completed later this year. These suggestions include:

1. expanding and generalizing the allophone rule environments,
2. changing the coarticulation of nasals and fricatives,
3. making initial and final amplitude transitions asymmetric,
4. expanding the inventory of prosodic symbols, and

5. improving the distribution of pitch changes over the syllable.

Much of the basic data needed to achieve these improvements must be btained from observations of natural speech. To facilitate these studies, ıe Laboratories have developed the hardware and a series of computer rograms that permit on-line sampling of large amounts of natural ɔeech (its spectrum and waveform) and the use of any selected portion f these data for immediate comparison with data generated by ynthesis-by-rule programs. Thus, spectrograms of natural and synthet- : speech can be compared on a storage scope, making it possible to spot asily bad formant trajectories, bad pitch lines, and bad amplitude alues in the synthetic speech. In addition the system is designed to btain synthesizer parameter values directly from natural speech, by racing storage scope data displays with a graph pen. Thus, natural peech can be represented in the same data domain that is used by the ynthesis algorithms and can be used to provide the exact values for naturalness."

This comparison program became available at the end of 1974. Al- eady the facility has made it possible to recognize the importance of owel formant bandwidths and small deviations in the calculation of first ormant frequency which had previously been thought inconsequential.

ynthetic Speech Comprehension

In recent years several intelligibility tests of the type described above ıad been carried out at the Laboratories and reported in the Bulletin ınd elsewhere (3 and 4). The results show that isolated words in natural peech are significantly more intelligible than corresponding words in ynthetic speech. However, because a variety of prosodic factors (stress, hythm, intonation, etc.) in addition to natural language redundancy ıre likely to compensate for losses in phonetic intelligibility, these data ɔn single words cannot be used to predict the comprehensibility of long ɔassages of continuous text. A preliminary comprehension test was herefore designed and carried out to compare the relative performance ɔf Ingemann's revised set of rules with those in earlier synthesis al- gorithms and with natural speech (5).

Two groups of 12 subjects listened to two equally difficult passages of ext which were selected from a reading test. Both texts were approxi- mately 12 min. in length. One text was spoken either in synthetic speech ɔy the revised algorithm or by one of two older synthesis programs, while the other text was recorded in natural speech. The synthesized speech was generated either from a phonetic text derived automatically from an orthographic input, or from a hand-edited phonetic script. Having been prepared with the aim of achieving the best possible output from the revised algorithm, the hand-edited script was expected to improve significantly its comprehensibility. After a single listening to a

text, a multiple-choice, 14-item questionnaire was administered to each subject, and the period of time taken to provide as many answers as the subject could recall was noted. The subjects were then allowed to replay all or parts of the text as many times as was necessary to allow them to fully complete the questionnaire. This additional time was also noted. The results showed that there were no significant differences between the aggregate times taken to answer questions at their first attempt on synthetic or natural speech. However, the subjects did take a significant 1¾ min. longer to complete their answers to the synthetic speech passages during the second exposure. An examination of the results obtained with the different synthesis algorithms indicated that the listeners performed somewhat better with the algorithms using the most recently revised rules than with its predecessors, and that their performances with the hand-edited text produced only slight improvement over that produced entirely by rule.

In conjunction with the comprehension study, a blind paired comparison preference test was conducted in which each subject selected his preferred form of synthetic speech from all possible contrasting pairs. The results of this test were that the various speech outputs ranked in the same order on the preference scale as they did in the comprehension study. This suggests that (at least at the present stage of synthetic speech development) there is a strong relationship between listener preference and listener performance; therefore, the greater the extent to which the speech can be made to sound *natural,* the greater the gain in listener performance.

In conclusion, the tests indicate that measurable progress toward more acceptable synthetic speech has been made. But, it appears that better rules for the conversion of orthography to phonetics are still desirable, and that we need to make increasing use of our developing facilities for analyzing natural speech.

References

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›search and Development in the Field of Reading Machines for the Blind

auch Laboratories, Inc.
'35 Dryden Road, Dayton, Ohio 45439
ans A. Mauch and Glendon C. Smith

The majority of Mauch Laboratories' work in the period covered by is report (July 1, 1974–December 31, 1974) was directed toward cometing a working breadboard of the improved Cognodictor.

In August, a model 33ASR Teletypewriter and acoustic coupler were ırchased to provide access to a large time-shared computer. This ›mputer is being used in the design of the Recognition Matrix of the ɔgnodictor. When completed, the Recognition Matrix will take each tter pattern (a skeletonized version of the letter scanned) from the ›cond Register of the Cognodictor and compare it with stored eleconic templates. There will be about five templates, on the average, for ıch uppercase and lowercase letter, ligature, and punctuation mark. he matrix does not have to find a perfect match to correctly identify the tter. A description of the Two-Dimensional Multiple Snapshot operaɔn up to the Recognition Matrix may be found in Mauch Laboratories' ımmary Report for June 3, 1971, or in U.S. Patent No. 3,827,025.

Computer programs were written to assist in preparing possible temlates, to test promising templates and select acceptable ones using ɔout 9,000 letter patterns from 14 different type fonts, and to prepare unched paper tapes needed to record acceptable templates in proammable read only memory integrated circuits. In this report period, rcuits which transfer letter patterns from the Second Register to a unched paper tape were added to the Cognodictor. The contents of ıis tape were then read into the computer's files. Initially, about 500 atterns were produced by 10 scans each of the lowercase letters from vo type fonts. These patterns were used to test the computer programs nd the procedures for developing templates. When these were operatıg as planned, 16 provisional templates were produced and transferred › one integrated circuit. This circuit and the additional integrated ircuits needed to compare each scanned and skeletonized letter with up › 256 templates stored in 16 such programmable integrated circuits ›ere added to the Cognodictor breadboard. The comparing with the ›mplates stops when a match is found. A search which extends to the ıst template (which results in an error signal) requires only 0.016 sec.

Also during this report period, a new Word Storage Unit capable of toring up to 64 letters was designed and built. At the end of December 974, a film drum-type Word Synthesizer was connected, and the Cogıodictor breadboard recognized those letters of the two type fonts which ound a match among the 16 provisional templates and produced the orresponding Spelled Speech letter sounds for the first time. Work was

then started on collecting letter patterns from 14 type fonts and entering them into the computer files.

A potential local Cognodictor test subject began low intensity Stereotoner training in October 1974. She will take the AIR training course at Hadley School in January 1975.

Two new Stereotoner accessories (Tracking Attachment and Paper Clamp) were developed, and prototypes of a new design Stereotoner probe cable were made. Both accessories were found useful in tests at the four schools participating in the Stereotoner evaluation study. The new cables will be tested over long periods to determine longevity and to investigate possible further improvements.

Clinical Application Study of Reading and Mobility Aids for the Blind

Central Rehabilitation Section for Visually Impaired and Blinded Veterans
VA Hospital, Hines, Illinois 60141
John D. Malamazian, Harvey Lauer, and James J. Whitehead

During this reporting period efforts have continued in teaching, field testing, and evaluating electronic mobility aids for the blind. Additional time was devoted to developing teaching materials and to transferring knowledge gained from research projects to other organizations serving the blind.

From January to March 1974, the last of the home visits to participants in the preliminary evaluation of the Binaural Sensory Aid (Mk I, Mk Ia) was completed. By late summer, data obtained from personal interviews, questionnaires, and videotapes were collected from the 16 blinded subjects, concluding the 3-year project. Although the writing of the final report has not been completed, the general tone of evaluation results indicates that the device, with further improvements, could substantially benefit a moderate segment of both the veteran and the civilian blind population. Mr. Russell Smith, chief engineer heading the BSA development program at Wormald-Vigilant, Limited, visited Hines during March 1974, to demonstrate the new Mk II model, gathering input on device changes and future deployment.

The Laser Cane project continued with the availability of the new C-5 model. Three veterans, utilizing the C-4 prototype, were issued the new model, and their general comments were positive regarding the number of improvements incorporated in the C-5 model. Two additional veterans were trained in the use of the device, while a teaching guide was jointly written by orientation and mobility research personnel at Hines and Palo Alto VAH. The final report prepared by APELC on the preliminary evaluation of C-4 Laser Cane was accepted and published by the National Academy of Sciences in August 1974. Both O&M Research Specialists from Hines attended a February conference at the Bionic Instruments, Inc., with Mr. Howard Freiberger, of the Research

Center for Prosthetics, and the company staff. Several aspects of device modification and deployment were discussed.

In a continuing effort to provide updated information and resource material, the Hines O&M Research staff hosted Mr. Peter Nelson, staff engineer, Subcommittee on Sensory Aids, CPRD, NRC/NAS, for 1 week in November 1974, to observe O&M instruction and to discuss the devices. Earlier in the fall, Mr. Robert Smith, an Orientation and Mobility instructor at Boston College, spent 1 week at Hines VAH working with the C-5 Laser Cane in preparation for teaching an electronic mobility aids course at his school. During September and October 1974, both O&M Research staff members assisted the Blind Rehabilitation Institute at Western Michigan University in teaching the first electronic mobility aids course to O&M teachers. The 6-week course, the first of several under Veterans Administration sponsorship, included three devices: the Laser Cane, the Binaural Sensory Aid, and the Pathsounder. Mr. Farmer also returned to instruct the Laser Cane section of the second course. These courses are open to both qualified VA and civilian O&M instructors. As of this date five staff members from Hines VAH have completed the training.

Several newspaper articles have been written concerning veterans using the mobility devices. An article, written by Mr. T. Seals of the Chicago Sun-Times, describing a blinded veterans' personal comments of the utility of the Laser Cane was published nationally. Mr. Arthur J. Snider, Science Editor for the Chicago Daily News, wrote a Chicago newspaper article on the electronic mobility and reading aids at Hines VAH; he is presently preparing a section on aids for the blind in World Book.

Clinical Trials of Reading Machines for the Blind

Central Rehabilitation Section for Visually Impaired and Blinded Veterans
VA Hospital, Hines, Illinois 60141
J. D. Malamazian and Harvey L. Lauer

There were six major activities during the current reporting period:

1. Mr. Lauer gave basic training of 3 to 4 weeks to three veterans in the use of the Stereotoner reading aid and to one veteran in the use of the Optacon reading aid. Former students were contacted, and tape recorded lesson materials were duplicated and supplied. Five persons were tested and familiarized with both reading aids. Several applications and a number of inquiries were processed.

2. Mr. Lauer continued to gather data for the Stereotoner Project conducted by the American Institutes for Research (AIR). He made two master tapes for teaching purposes preparatory to AIR's revision of the Stereotoner instructional course.

3. Mr. Lauer worked with Chester Lewis who is a reading machine specialist at the VA's Eastern Blind Rehabilitation Center. Mr. Lewis came to this center on a 2-week VA detail.

4. Mr. Lauer attended and participated in three conferences in Chicago. They were the VA Project Leaders Conference on prosthetic and Sensory Aids, the National Federation of the Blind Convention, and the American Council of the Blind Convention.

Mr. Lauer's article, "Reading Aids for the Blind Information for Consumers and Teachers," was published in *The Braille Monitor,* January 1975, and *The Braille Forum,* November-December 1974, and January-February 1975. Mr. Lauer lectured on and demonstrated reading aids to professional groups visiting this rehabilitation center.

5. Mr. Lauer taught several blinded veterans to operate the new speech compressors which they will use in their college work and professions.

6. Six inventors and developers presented the following electronic hardware and designs for hardware to serve blind people: calculators, speech output devices, and audio playback systems. These were examined, discussed, and reported upon.

Instruction In, and Evaluation Of, Reading Machine Techniques
The Hadley School for the Blind
700 Elm Street, Winnetka, Illinois 60093
Donald W. Hathaway, Margaret Butow, and Roger D. Rouse

In July 1974, the Stereotoner was demonstrated at the conventions of the National Federation of the Blind and the American Council of the Blind, both held in Chicago. Three students were taught to read with the Stereotoner—one in August, one in October, and one in November. They were all nonveteran students using machines purchased by the National Academy of Sciences, Committee on Prosthetics Research and Development. Instruction continues in 1975 with one student being taught in January and one in February. Another one is scheduled for the latter part of March. Details of this instruction were discussed in the paper presented by Margaret Butow at the Project Leaders' Conference in Chicago in July.

Clinical Application Study of Reading and Mobility Aids for the Blind
Western Blind Rehabilitation Center
VA Hospital
3801 Miranda Avenue, Palo Alto, California 94304
Richard Bennett, Nancy Darling, Alan Frost, Greg Goodrich, Ph. D., Rex Ward, and Alice Wood

Activity related to electronic reading devices for the blind increased significantly during 1974.

Seven blinded veterans, participants in the ongoing Stereotoner Evaluation Project, received individual Stereotoner instruction from Mr. Richard Bennett. Three of these veterans elected to discontinue project involvement, while the other four successfully completed training and were issued Stereotoners for continuing their study at home. Training for each of the successful candidates required 3 to 4 calendar weeks—approximately 75 to 100 hours of instruction. Of three other blinded veterans meeting the project criteria, one has been scheduled in to W.B.R.C. for training early in 1975, and decisions on the others are pending.

One nonveteran blind subject, a rehabilitation teacher judged to be a potential Stereotoner instructor for the future, received 68 hours of instruction from Mr. Bennett in May 1974. This subject's employer, the State of Nebraska Division of Rehabilitation Services for the Visually-Impaired, provided the Stereotoner.

Mr. Bennett maintained appropriate contact with all Stereotoner trainees by letter, tape recordings, and telephone. Additionally, Mr. Bennett participated in telephone conferences with fellow Stereotoner instructors and with Dr. Robert A. Weisgerber and other AIR (American Institutes for Research) project personnel. These conferences, held generally on a weekly basis, served as an excellent forum for the exchange of information and ideas related to the project, including instructional materials and methods and trainee progress.

One blind and two sighted W.B.R.C. staff members became Optacon instructors through training at Telesensory Systems, Inc., Palo Alto, California, early in 1974. Five blinded veterans, previously screened by T.S.I. as being potentially successful Optacon trainees, entered the center for Optacon instruction during 1974. Three of these veterans completed training satisfactorily and were issued Optacons for home study and use. Instruction of the other two veterans was discontinued by agreement of instructor and trainee.

Mr. Bennett attended the B.V.A. annual convention in Denver, Colorado, from August 6–10, 1974. He demonstrated the Stereotoner and Optacon for veterans and family members who wished information about the aids or the W.B.R.C. program for instruction in the use of the instruments.

During the early part of 1974, a pilot project was begun to examine the feasibility of gaining information on closed-circuit television (CCTV) users through onsite visits. The pilot project was designed to cover 27 veterans who had been issued CCTV's from the Western Blind Rehabilitation Center. Of this number 26 were interviewed in their homes (the 27th veteran was unavailable due to hospitalization).

Information gathered in these visits included near and distance visual acuity measures, reading speed, magnification used, working distance, and an estimation of comprehension. Also included were the veteran's estimate of amount of use of the CCTV, his estimation of reading duration, and his family's opinion of the CCTV. Additionally, the veteran was asked to rank the aids he used in terms of their value to him. In the latter, the CCTV is clearly the most important single aid; however, a variety of distance aids were also rated highly.

The uses of the CCTV by the veterans primarily concerned reading and writing tasks (e.g., letter writing, bills, college studies, filling out forms); however, a number of unusual uses were reported. These included viewing family photographs and tying flies for fly fishing. Of the 26 veterans interviewed, it appears that 24 are deriving significant benefit from the CCTV's. There is some question of the usefulness of the device for the remaining two veterans.

On the basis of this pilot study, a full-scale followup is being initiated. This will include visits to veterans (with CCTV's) from both the Western and Eastern Blind Rehabilitation Centers. This study will utilize an improved questionnaire, based on the results of the pilot project.

Development of Test Procedures for Evaluation of Binaural Hearing Aids

Northwestern University, School of Speech
Speech Annex Bldg., Room 41
Evanston, Illinois 60201
Raymond Carhart, Ph. D., and Lamar Young, Ph. D.

The research activities here reported have been directed toward seeking patterns of reproducing speech which will result in improved intelligibility for hearing-aid users, while avoiding the generating of signals that are disturbingly strong. A promising procedure which has been studied and will continue to be investigated is first to force speech into a narrow dynamic range. This range is then adjusted to be adequately audible, thus achieving proper intelligibility. The initial step in investigating the adequacy of this procedure was to compare the discrimination obtained, when speech signals were not modified, with the discrimination obtained when speech was high-pass filtered and also when it was both filtered and peak clipped. The test materials were of the closed-set variety. They consisted of monosyllabic words differing in final consonant. The results were that clipping plus filtering yielded the better discrimination at low sensation level. At high sensation levels clipping plus filtering produced as high intelligibility as either of the other two methods of presentation. These results were sufficiently encouraging so that preparation was made to start a study using much more sophisticated signal manipulation.

This new study has changed substantially in detail as it has evolved. To review its basic features, it uses NU Intelligibility Test No. 6 as the measurement vehicle. Re-recordings from a prototype version of this test were made: 1. by high fidelity reproduction and 2. after it had been filtered so as to give the speech signal an equal spectrum level across the range from 300 to 5,000 Hz. This latter shaping of the signal was done by differentially attenuating third octave bands with a General Radio Multifilter. Once the signal was thus filtered it was re-recorded five different ways: namely, without clipping, just on the threshold of clipping, and with clipping of 20, 30, and 40 dB.

The problem of assuring that the pattern of filtering to be used would in truth transform speech into a signal where spectrum level was constant across frequency proved difficult to solve. The same is true of the problem of maintaining calibration when shifting from one level of clipping to another. The equipment for the project was substantially revised in order to achieve these ends, and a set of satisfactory test tapes was achieved in due time.

The testing of subjects has recently begun with the obtaining of intelligibility functions for 10 normal-hearing young adults under each of the reproduction conditions just mentioned. The intelligibility functions are plotted from individual tests administered at sensation levels (re the SRT for the reproduction condition) of +4, +12, +20, and +28 dB. Results have not yet been analyzed, and it is too early to generalize beyond the following remark. Neither filtering alone nor filtering plus clipping causes deterioration of the intelligibility function, and they seem to improve it slightly.

After all the necessary normative data have been obtained, the performance of persons with sensorineural loss will be explored. Eventually, too, the project will move from the use of a high quality earphone to the use of a hearing-aid earphone, and to the study of performance when there are competing background sounds.

Development of Improved Techniques for the Analysis of Hearing-Aid Performance

BioCommunications Laboratory, University of Maryland
College Park, Md. 20742
G. Donald Causey, Ph. D., Earleen Elkins, Ph. D., and Lucille Beck

The Effect of Release Time in Compression Hearing Aids

A study of the effect of different release times of six compression hearing aids has been completed. The instruments employed were identical, with the exception of release times which were established at 7, 15, 35, 70, 150, and 350 msec. The purpose of this study was to evaluate what effects, if any, the different release times had upon the processed

speech waveform as perceived by normal-hearing listeners and listeners with sensorineural impairments.

Speech discrimination materials were recorded under identical conditions through each aid at a level sufficient to activate the compression circuit (75 dB SPL). These hearing-aid processed stimuli were administered to two groups of subjects. Twelve normal-hearing listeners received the speech stimuli with broadband noise at a 0 dB signal-to-noise ratio in the arbitrarily chosen ear. Nineteen subjects with sensorineural losses, who were hearing-aid users, composed the second group. They received the speech stimuli without noise in the ear in which they normally wore their aids.

The results, derived from mean values for each group, showed that the normal-hearing listeners had significantly (0.05 level of confidence) more correct responses to the speech processed through the aid with a 70 msec. release time than with the other five aids. However, the responses by the hearing-impaired group did not reveal any significant choice among the six release times investigated. There was a trend toward better speech perception by this group when the release times were 35, 70, and 150 msec. Additional work with compression instruments and speech perception would seem to be indicated.

The Use of High-Pass Hearing Aids

For the first time, the Veterans Administration placed three over-the-ear-type, high-pass hearing aids on contract for issue to its clinical population. The primary electroacoustic characteristic which differentiates these aids from the instruments generally selected is minimum amplification in the lower frequencies and maximum amplification starting at about 1,000 Hz or higher. Seventy-nine audiologists from 24 VA Audiology Clinics were questioned about their use and preference for selecting these instruments for issue to their patients. Of the three aids, Aid A was preferred over Aids B and C by almost 60 percent of the audiologists. This instrument provides about 20 dB of gain at 1,000 Hz, then rises to 40 dB at 2,000 Hz, and is maintained out to 4,000 Hz. Aid B, which was preferred by about 30 percent of the responders, has about 28 dB of gain at 1,000 Hz, increases to 44 dB at 2,000 Hz, and decreases rapidly after 3,000 Hz. The aid preferred the least (by about 10 percent of the audiologists) has about 38 dB of gain at 1,000 Hz, increases to 43 dB at 2,000 Hz, and does not decrease until 3,700 Hz. The relationship shown by this ranking, would indicate that the hearing-impaired veteran population requiring high-pass amplification prefers an instrument which has a band of maximum amplification between 2,000 and 4,000 Hz. Continued experience with these aids and additional feedback from the audiologists will provide us with valuable information upon which to base contract selection in future years.

Speech Intelligibility Materials

Work is continuing with the speech discrimination materials recorded by the laboratory to be used as stimuli for assessment of the auditory function and comparison of the performance of hearing-impaired listeners with different hearing aids. The normative study of the University of Maryland revised Central Institute of the Deaf (UMRCID) Sentence Lists has been completed.

In order to provide a more difficult listening task, we are collecting normative data on monosyllabic stimuli known as consonant-nucleus-consonant (CNC) 50-word lists. Each stimulus word is imbedded in the carrier phrase as opposed to currently used word list recordings which have the stimulus appearing at the end of the carrier phrase. This approach is unique in the field of speech discrimination testing and is an attempt to provide a task more related to signals encountered by the impaired listener in everyday situations.

The performances of two groups of subjects, normal-hearing listeners and those with sensorineural hearing losses, are being evaluated with the 10 CNC word lists. Each subject receives the word lists at specified sensation levels (SL) above the Speech Reception Threshold (SRT) of his test ear in order to obtain a descriptive performance-intensity (P-I) function for both groups of listeners.

The P-I function derived from preliminary data on 42 normal listeners exhibits a linear function to about 16 dB SL, rising at a rate of almost 4.5 percent correct responses per decibel increase in intensity. As this SL is the highest one employed at this stage of the investigation, it is not possible to make statements regarding the P-I function at higher sensation levels. Additional data will be collected for this purpose.

The data from 18 sensorineural subjects show a P-I function quite different from the one for normal listeners. The linear portion which terminates at 20 dB SL, rises at a rate of 2.5 percent correct responses per decibel increase in intensity. Beyond 20 dB SL, the function becomes flatter and does not reach saturation as is characteristic of P-I functions for most other recordings of monosyllabic stimuli. From this incomplete data, indications are evident that our CNC recordings will provide sensitive material for separating normal listeners from impaired listeners on the basis of this speech discrimination ability. Further data will be reported next year.

KEMAR and Behavioral Gain Measures

Burkhard and Sachs (1973) reasoned that an appropriately proportioned and designed mannequin could provide life-like conditions and experimental flexibility. Therefore, KEMAR was constructed as a test and evaluation tool that gives wearer simulation for all types of hearing-

aid fittings. It was the purpose of this pilot study to determine the relation between gain as measured by KEMAR and gain as determined with the hearing aid in position on individual wearers.

The subjects were five male veterans selected from the clinical population of the Audiology and Speech Pathology Service, Veterans Administration Hospital, Washington, D.C. They ranged in age from 42 to 59. Each subject had a moderate-to-severe sensorineural hearing loss with no greater than a 35 dB difference in threshold between ears at any frequency in the range from 500 to 4,000 Hz. Subjects were selected using the following criteria in addition to those cited: minimum of 1 year hearing-aid use; ownership of a standard, nonvented, hard plastic, custom-fitted earmold with metal bushing; and no greater than 25 dB threshold difference between any frequencies in the ear tested. A behind-the-ear hearing aid was used as the test instrument for all subjects. The aid was selected by reason of its broadband frequency response and front-facing microphone. The length and diameter of the tubing was 18 mm. and 3 mm. respectively. The same tubing was used in all measurements.

Unaided and aided thresholds were determined in the sound-field for six fixed frequencies. For both aided and unaided conditions the nontest ear of the subject was effectively occluded with an insert-type earplug and circumaural earphone. Subsequent to the establishment of aided sound-field threshold measurements with the interrupted test signals, the hearing aid was removed from the subject and care was taken to insure there was no alteration of gain control setting. The volume control was then taped to secure an identical volume control setting for the electroacoustic measurements which followed each behavioral measurement. Using KEMAR and the Zwislocki coupler, a frequency response was obtained with the test hearing aid.

All five subjects had a tendency toward closer approximation of gain on KEMAR in the lower frequency region than in the higher frequency region. It must be emphasized that these results are based on only five subjects. It is evident that more data must be gathered on a larger and more diverse hearing-impaired population before any conclusions can be reported.

Shelf Life

The effects of shelf life were examined on 20 hearing aids submitted for the Veterans Administration Fiscal Year 1974 Hearing-Aid Program. These hearing aids were kept in their original packaging and stored in a metal file cabinet at temperatures ranging from 68-72 deg. during a 1-year period from January 1974 to January 1975. During this time, they were electroacoustically evaluated three times. Two sessions

involved the procedures used in this study, and the third evaluation was conducted at the Sound Section of the National Bureau of Standards according to their specified procedures for testing VA hearing aids. This involved transporting the hearing aids by automobile approximately 25 miles to and from NBS. Inasmuch as the hearing aids were not utilized for any purpose (aside from NBS electroacoustic evaluation) during the 12 month interval from January 1974 to January 1975, the differences in results were considered representative of the effects of shelf life on hearing aids. Electroacoustic measurements of Saturation Sound Pressure Level, Gain, and Total Harmonic Distortion were obtained.

The results obtained in this study indicate that a shelf life of 1 year did not have a significant effect on electroacoustic performance of the 20 hearing aids tested in this study.

The Reading of Printed Material by the Blind
Behavioral Science and Technology Program
American Institutes for Research (AIR)
Palo Alto, California 94302
Robert A. Weisgerber, Ed.D.

During the period July-December 1974, progress was made in several research and development areas related to the evaluation of the Stereotoner.

Home Visits

The project has reached a stage in which certain of the trainees became eligible for followup home visits. The study design is such that evaluation of trainee performance is to take place not only at the completion of concentrated training at the various VA Blind Rehabilitation Centers and at the Hadley School, but also in the trainees' homes or offices a number of months afterward.

The main purpose of this followup evaluation was to ascertain whether the students progressed, remained level, or decreased in their ability to use the Stereotoner over time. This is a very meaningful question since the real utilization issue is not how many people are exposed to training, but how many eventually master the Stereotoner to a functional level. It should be noted that all trainees receive specially prepared home study materials (Home Study Units), which were meant to guide them in exploring variations of print in real life applications and in developing their basic reading speed on typical narrative material. These materials comprised 48 lessons. They were accompanied by tapes providing information and quasi-feedback. Home study units were viewed as *elective* self-instructional experiences, being recom-

mended but not required for all trainees, with no expectation that the contents would be equally important for all trainees.

Even among the few trainees so far visited, there is a sharp variation in terminal performance, with some advancing since completion of formal study while others have stayed level or even declined in ability. The factors, motivational and other, which account for this variation should prove an especially interesting aspect of our future investigation as we continue to obtain data on the remaining trainees.

Data Collection

Other data collection (not related to home visits) has continued with the receipt and scoring of a number of Auditory Selection Tests (used for screening of candidates) as well as various performance measures and trainee-descriptive information generated during training at the cooperating centers. Also, phone calls are being made to all trainees approximately 1 month following the completion of their formal training. This phone call is valuable as an information gathering step. Moreover, this contact also serves to remind the trainee of his continuing responsibility for practice and study. Whether he *does* study, of course, is up to him and almost certainly impacts on his subsequent success in using the Stereotoner.

Materials Development

During this 6-month period a certain amount of effort was put forth in developing new instructional materials, which we have termed "pretraining materials," since they would normally be used *prior* to the trainee's receipt of tutorial training from a qualified Stereotoner teacher.

Although these pretraining materials (tapes) will not have a bearing on the outcome of the present evaluation per se, it is expected that future training will be accomplished more efficiently by having students report for training with a greater degree of familiarity and readiness for the task at hand.

The content of these pretraining tapes is still considered tentative; however, it is being validated by pilot tryout and use in the field during the next quarter. The current version of these materials introduces these main points:

1. Orientation to the training program and to the Stereotoner equipment.
2. Explanation of the tones and tone combinations.
3. Examples of reading by novices, moderately trained persons, and skilled users.
4. Listening for differences in tones and tone patterns.

5. Meaningful differentiation of letters, words, and sentences.

6. Practice material on the lowercase and uppercase alphabet and numerals.

7. Space for feedback and questions to the instructor in advance of formal training.

Clinical Application Study of Reading and Mobility Aids for the Blind

Veterans Administration Hospital
West Spring Street
West Haven, Connecticut 06516
George Gillispie, William De l'Aune, Ph. D., Patricia Gadbaw, and Chester Lewis

Parameters of Lateral Obstacle Detection

A national conference on ambient acoustic cues for obstacle detection in blind mobility, sponsored by the American Foundation for the Blind and hosted by the Eastern Blind Rehabilitation Center (EBRC), was held on November 14-15, 1974. Dr. William De l'Aune and Dr. Walter Needham of the EBRC discussed the psychoacoustic and psychometric research in this area currently underway at the EBRC. Dr. David Perrott (California State University at San Diego) covered the psychoacoustic aspects of spectral shape difference detection, Dr. Arthur Niemoller (Central Institute for the Deaf, St. Louis) discussed related architectural acoustics, and Dr. Donald Harris (Chief, Audiology Research, U.S.N. Submarine Base, New London) discussed training methodologies. Also attending this meeting were George Gillispie (EBRC), Dr. Gregory Goodrich (WBRC), Howard Freiberger (RCP), Dr. Milton Graham (AFB), Leslie Clark (AFB), Robert Robinson (AFB), Rembert Aranda (CIL), Dr. Derek Rowel (MIT), Dr. Gustav Haas (NAS), Dr. Peter Comalli (VAH, Philadelphia), Kathryn Gillispie (U. Mass., Amherst), and Dr. Newman Guttman (Bell Labs). The proceedings of this conference are being transcribed and will soon be available.

Work is being continued in this area with emphasis on duration of training effect and generalizability of performance increments. The psychoacoustic parameters of detecting intensity changes in narrow frequency areas of broadband noise are also being investigated. The possibility of transfer of evaluation techniques developed in this broad area of study to the evaluation of mobility devices used by blinded veterans is also being studied.

Speech Compressor Usage Among Blinded Veterans

The scope of this area of investigation has narrowed from the broad population of blinded veterans originally sampled to a smaller population of those blinded veterans interested in speech compression for vocational or avocational needs. When tested by methods developed for

the first series of experiements, 79.5 percent of this sample (n=39) were able to comprehend the test material at criterion level at a rate of approximately 500 words per minute. Most of the Center's research in this area is now concerned with ongoing evaluations of patients as potential users, evaluations of currently available devices, and development of training techniques which could be used in the field.

Normative Personality Data for Blinded Veterans

Scale scores for EBRC patients on various psychological tests (MMPI, CPI, and WAIS IQ) are currently being statistically analyzed. It is hoped that this analysis will provide normative data for blinded veterans, against which individual psychometric data can be more meaningfully compared.

Patient Satisfaction Survey.

The responses to this survey are currently being analyzed.

Orientation and Mobility Performance in the Blind

Several aspects of mobility performance are currently being studied for possible relationships with psychometric variables, methods of improvement through training techniques, and methods of quantitatively assessing performance itself. Measures of veer and velocity in sightless ambulation and study of the consistency of ranking data on mobility skill performance are the most active projects.

Use of Prisms by Veterans With Visual Field Restrictions.

Preliminary analysis of data seems to indicate that younger, more flexible veterans will tend to make the best candidates for prism therapy. Data are currently being studied to ascertain effects of prism placement, visual acuities, nature of field restriction, and type of pathology on the probability of successful prism use.

Effective Use of Low Vision Aids Survey

Responses to this survey are still being received and coded.

"Standard" Sensory Aids Training

Three mobility instructors received training at Western Michigan University in electronic travel aids during the period covered in this report. These instructors, Patricia Hammond, Gregory Kevorkian, and Phillip Giers, are now qualified to teach the Laser Cane, the Pathsounder, and the Sonicguide.

Mr. Chester Lewis, Research Health Scientist, conducted two Sensory Aids Seminars at VAH, Altoona, Pa. The purpose of these seminars was to provide information about the VA Sensory Aids program at the EBRC to groups of blinded veterans and VIS team members.

Ms. Patricia Gadbaw, Low Vision and Electronic Reading Aids Specialist, attended an Experienced Optacon Teacher's Seminar conducted in Palo Alto, California, and presented some preliminary data on personality parameters as related to acquisition of skill in Optacon use. While in California, Ms. Gadbaw visited several of the CCTV suppliers to facilitate future interaction between EBRC's low vision department and these manufacturers. A visit was also made to the WBRC.

Constant screening of applicants, training, and evaluation of device utilization are underway at the EBRC and through followup. A data bank consisting of names, addresses, aids, visual pathology, and other variables of interest is being prepared to facilitate evaluation of the devices in the field.

Papers and Publications

Papers presented at meetings of scientific and professional organizations during the period July 1 to December 31, 1974:

1. Gillispie, George and William de l'Aune: Research at the Eastern Blind Rehabilitation Center. Conference of Prosthetics and Sensory Aids Research Project Leaders, Chicago, Illinois, July 1974.
2. De l'Aune, William: Technology and Blindness, Today and Tomorrow. New England Chapter, American Association of Workers for the Blind Conference, Hartford, Connecticut, October 1974.
3. Gadbaw, Patricia: Technology and Reading Devices for the Totally Blind. New England Chapter, American Association of Workers for the Blind Conference, Hartford, Connecticut, October 1974.
4. Dolan, Mary: Technology and Orientation and Mobility. New England Chapter, American Association of Workers for the Blind Conference, Hartford, Connecticut, October 1974.
5. De l'Aune, William, James Nelson, and Walter Needham: Successful Speech Compression Use by Blinded Veterans. 88th Annual Meeting of the Acoustical Society of America, St. Louis, November 1974.
6. De l'Aune, William: Indoor Acoustics and Mobility in Blinded Veterans. Conference on Hearing and Blindness, West Haven, Connecticut, November 1974.
7. Needham, Walter: Personality Measures and Acoustical Assessment Performance in the Blind. Conference on Hearing and Blindness, West Haven, Connecticut, November 1974.
8. Gadbaw, Patricia and William De l'Aune: Correlates of successful Optacon learning. Experienced Optacon Teacher's Seminar, Palo Alto, California, November 1974.

Publications in professional and scientific journals originated from the center during the period July 1 to December 31, 1974:

1. Gillispie, G. and W. De l'Aune: Research at the Eastern Blind Rehabilitation Center. Bull. Prosthetics Res., BPR 10-22:463-468, Fall 1974.

2. De l'Aune, W. and G. Kevorkian: A Methodology for Measuring and Reducing Veer in Sightless Ambulation. J. Int. Res. Commun. Syst., 2/1546, 1974.
3. De l'Aune, W., J. Nelson, and W. Needham: Successful Speech Compression Use by Blinded Veterans. J. Acoust. Soc. Am., 56(6):54, 1974 (abstr.).
4. De l'Aune, W., W. Needham, P. Scheel, and G. Gillispie: Correlates of Parallel Wall Detection for Blinded Veterans. Rev. of Sens. Dis., 16:22, 1974 (abstr.).
5. De l'Aune, W.: Rehabilitation of Blind Veterans. Rev. of Sen. Dis., 17:25, 1974.
6. De l'Aune, W., ed.: Proceedings of the 1974 West Haven Conference on Hearing and Blindness. American Foundation for the Blind, New York (in press).

Development of a Hearing-Aid System with Independently Adjustable Subranges of Its Spectrum Using Microprocessor Hardware

Department of Electrical Engineering
Colorado State University
Fort Collins, Colorado 80523
Daniel Graupe, Ph. D.

BioCommunications Laboratory
University of Maryland
College Park, Maryland 20740
G. Donald Causey, Ph. D.

Work on the present study, started at the end of November 1974, is concerned with a microcomputer design of a discrete sequential filter to adjust the amplification of a hearing aid to the characteristics of the user at up to 20 frequency bands of the speech spectrum without the shifts of phase and frequency characteristic of conventional amplifiers. The above filter is to be subsequently interfaced with a conventional hearing aid and is to fit the pocket of the user and eventually to fit behind the user's ear. At present, a computer simulation comparison was made of two alternative approaches to achieve such noninteractive filtering. The filtering approaches considered are based on an array of Chebychev filters and on an array of Fast-Fourier-Transform (FFT) filters using Hanning windows. It was shown that both designs can be realized in a sequential manner via an autoregressive-moving-average (ARMA) formulation to yield fast filtering as required for hearing-aid applications (to avoid phase or frequency shifts).

The ARMA model of both filters was subsequently shown to be obtained via off-line identification of the Chebychev or the FFT/Hanning-window filter array, whereby the ARMA parameters are obtained for the final sequential hardware realization. It was further shown that once the ARMA filter parameters are available (via identification), then it can be realized by presently available compact microprocessor or discrete tapped-analog-delay (TAD) hardware, which can meet most speed, cost, weight, and volume requirements related to hearing-aid applications, as long as six bands are considered. Extension to a higher number of bands should be possible if certain noise problems

in the TAD hardware are overcome by constructing adequate preamplifier chips based on well-known theories, or once a new microprocessor hardware, already announced by various manufacturers, is available.

Work on the hardware realization of the six-band design is presently underway, as is work on preparing preprogramed packages of the off-line filtering and identification algorithms, to facilitate the use of the sequential filters (that must be derived from the above algorithm) by audiologists who have no computer programing experience.