recommended based on the results of the clinical tests. A few of the redesigned devices will be fabricated for distribution to clinics for final tests and evaluation.

Significance of this Project

Analysis of gait now follows one of two courses. In the clinic it is a visual estimate with the interpretations varying markedly according to the experience and observational skills of the examiner. The other extreme is detailed study at one of the few research centers in the country. Here sophisticated instrumentation offers precise data, but processing is so time consuming that the information is too delayed for individual patient application. Despite these limitations, definition of a patient's gait is the deciding factor in many clinical programs. Prosthetic fitting is a paramount example.

It is anticipated that the Clinical Gait Analyzer will overcome these limitations, providing a tool for clinical gait analysis much as the electrocardiograph has become an indispensable tool for cardiology.

Bed-Chair

The Professional Staff Association of the Rancho Los Amigos Hospital, Inc.
7413 Golondrinas Street
Downey, California 90242
Jacquelin Perry, M.D., and James R. Allen

Purpose

The purpose of this project is to investigate the feasibility of providing mobility for a high level spinal injury patient by means of a: 1. detachable self-propelled portion of a hospital bed, 2. a folding type self-propelled, or 3. any other self-propelled system that will decrease in width and place a patient in a position which will enable him to drive the mobile unit similar to that of an electric wheelchair.

The objective of the program will be to determine within 1 year the feasibility of the approach described above. At least one operating model will be in limited service for evaluation.

SENSORY AIDS

Edited by

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Fabrication of Obstacle Detectors for the Blind

Bionic Instruments, Inc.
221 Rock Hill Road, Bala Cynwyd, Pa. 19004
Thomas A. Benham, J. Malvern Benjamin, Jr., and D. Ridgely Bolgiano

Most of the Laser Cane effort during this period was directed toward building the new Model C–5 canes. The research and development effort was reduced to a "holding operation" on which a total of approximately four man months has been spent in the period reported. The time was used in the following ways:

1. *Repair of C–4 Canes*

In August 1971, eight C–4 canes were placed with veterans who had been trained in their use. Seven of the eight veterans are still using their canes in varying degrees despite the present unreliability of the canes. As may be remembered, in August 1971, when the canes were first placed with the veterans, they had already seen almost 3 years of experimental use by several subjects and instructors. They had undergone many revisions in circuitry and numerous mechanical changes. Had sufficient funding been available for this portion of the project, the C–4's would have been retired and new canes issued to the eight veterans. However, the old canes had to be pressed into service once more, with warnings and apologies in advance regarding their expected low reliability. During the period from 1971 through the end of 1973, the mean-time-between-failures averaged about 2 months per cane. Thus, a significant amount of time has been spent during the period keeping the C–4's in repair. We believe it to be a testimonial to the apparent usefulness of the Laser Cane that these veterans have been willing to put up with this type of performance and, with one exception, have not become totally discouraged.

A minimum mean-time-between-failures of 6 months has been set as a design criterion for the C–5 cane. Since this is a statistical matter, there is no real way to check it except to build canes, deploy them, and gather performance data.

In December 1973, two new C–5's were loaned to the two most active C–4 cane users to determine as rapidly as possible whether or not there were any serious unexpected reliability problems.

2. *Public Exposure*

Efforts were continued to introduce the cane to the professional community. To this end, 11 visits have been made to various regions of the country. Papers were presented at four conferences, and seven visits have been made to agencies for the blind.

Date (1973)	*Meeting or Institution*	*Location*	*Activity*
7/22–25	Am. Assoc. of Workers for the Blind Convention	Cleveland	Speaker
8/14–18	Blinded Veterans Association Conv.	Atlantic City	Exhibitor
8/27/29	Society of Photo-optical Instrumentation Engineers Conf.	San Diego	Paper
8/31	Wash. State Services for the Blind	Seattle	Visitor
9/2	Ira Clark (Cane user)		Interview
9/5	VA Rehabilitation Center	Hines, Ill.	Conference
1/19–21	Carnahan Conference	Lexington, Ky.	Paper
10/1–3	A.C.E.M.B.	Minneapolis	Paper
"	Minn. Society for the Blind	"	Visitor
10/5	Pittsburgh Guild for the Blind	Pittsburgh	"
"	School for the Blind	"	"
10/4	VA Rehabilitation Center	Hines, Ill.	Conference
10/24	The Seeing Eye, Inc.	Morristown, N.J.	Conference and deliver cane

3. *Documentation*

Some of the necessary working drawings were prepared to make it possible for others to make a Laser Cane.

4. *Performance Testing*

As several C–5 canes have become available, time has been spent checking the performance of one cane compared to another to measure uniformity. Batteries have been cycled many times, and canes have been subjected to temperature testing and mechanical shaking in efforts to make further evaluations of overall performance. Fortunately, in all of the tests performed the new Model C–5 has held up. No further design changes have been precipitated as a result of this check testing.

5. *Outreach*

The above report summarized the Laser Cane work performed under the Veterans Administration Contract. However, it seems pertinent to report additional activity undertaken and supported by Bionic Instruments, Inc. to introduce the C–5 cane to the civilian community. Three problems must be solved: a. training, b. deployment, and c. financing.

a. Training

An effort is being made to locate an Orientation and Mobility

Specialist to become part of the Bionic staff. He will work with other Mobility Trainers and will train blind people directly in the use of the cane. He will also followup cane users to make sure that the canes themselves are working properly and that each traveler is using his cane with maximum effectiveness.

b. Deployment

It would seem poor policy to allow any blind person to purchase a cane directly without making proper provision for his training. It is therefore anticipated that our Mobility Trainer will visit agencies for the blind across the country, training a mobility person at each agency and leaving one cane there. The agency mobility person will then be responsible for seeing that appropriate candidates are selected for training and that the cane is made available indefinitely to a blind person only after his training has been successfully completed.

c. Finances

The C–5 Laser Cane is presently priced at $1,950—a cost beyond the reach of most blind people. It will thus have to be subsidized in some way. Fortunately, the Lions Club in Pennsylvania, District 14R, have become quite interested in the cane, and have set up a committee to work on its introduction. They anticipate that, using the model of the guide-dog School, the effort will become national in scope as word of its successful use spreads.

To facilitate handling of funds, they have established a special Foundation, called the Mobility Foundation, to collect and disburse money for the purchase of canes. The trustees of the Foundation include some persons skilled in the raising of money and others knowledgeable in problems of the blind. Canes purchased by the Mobility Foundation will be loaned indefinitely to blind travelers, so that when an individual no longer has need for a cane, it can be returned and loaned again to someone else. The Foundation has just been formed, so it is too early to report on its progress. Many demonstrations are being given at Lions Club meetings, and the interest in the project is very real.

Research on Audible Outputs of Reading Machines for the Blind

Haskins Laboratories, Inc.
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Franklin S. Cooper, Ph. D., Jane H. Gaitenby, Ignatius G. Mattingly, Ph. D., Patrick W. Nye, Ph. D., and George N. Sholes, Ph. D.

Introduction

The objective of the research at Haskins Laboratories is the generation of spoken English from printed texts on an entirely automatic

basis. A prototype system has been constructed which employs an Optical Character Recognizer (OCR) capable of reading typewritten pages, followed by a three-stage computer program which converts the machine readable orthographic text into speech. Stage one of the program uses a phoneme dictionary to convert the text, word-by-word, from its orthographic spelling to a phonetic spelling with appropriate stress marks. In addition the program inserts intonation marks according to rules which use the punctuation provided in the input text. Stage two permits editorial changes of the phonetic text when words are not found in the dictionary or when faulty punctuation or prolix sentence construction gives rise to otherwise long uninflected phrases. The fourth and final stage takes the marked phonetic string and computes the control parameters required to make a hardware synthesizer speak. Normally, the output speech is recorded on magnetic tape.

Active Areas of Research

During the past 6 months, progress was made in three principal areas:

a. The analysis of data obtained from an evaluation study employing meaningless sentences (as a testing procedure) was completed.
b. An Experimental Synthesis Program, described in the previous report, was used to synthesize nearly 1½ hours of speech from typesetter's tapes provided by a local newspaper.
c. Work continued on modifying the synthesis rules for the OVE synthesizer and on developing a suitable programing environment which will facilitate the process of devising new rules.

Synthetic Speech Evaluation

Results obtained from an intelligibility test using isolated words have been reported previously. These showed that 30 sighted students scored roughly 92 percent correctly for synthetic speech compared with 97 percent for natural speech. The data reflect the accuracy with which the synthesizer and the system of rules generate the individual phones during word production and achieve a realistic joining together or coarticulation of these phones. Coarticulation rules are applied to improve naturalness but their application often requires the modification of phonetic values and if this is not done very precisely, some degree of clarity in pronunciation may be sacrificed.

In natural speech, coarticulation phenomena also occur across word boundaries as well as within words, and in synthetic speech rules are applied for a corresponding effect. Thus words synthesized (or spoken naturally) in isolation do not sound the same way as they do in context, and isolated word scores, particularly in synthetic speech, cannot

be depended upon to predict performance on words embedded in context. However, care must be taken in choosing the contexts to be used in coarticulation tests. If meaningful contexts are used, the problem of analysis is complicated by the fact that the semantic content provides strong cues which can make poorly articulated words more intelligible than would otherwise be the case. Hence, meaningless sentences are to be preferred and these were used for the latest study.

Two groups of listeners were employed; one having no experience in listening to synthetic speech, the other having had previous exposure through participation in earlier tests. The "new" subjects made almost twice as many errors as the "experienced" listeners on initial consonants and more than twice as many errors in the case of consonants in final position. Both groups of subjects made more errors on the consonants in word initial position than in word final position. This fact is consistent with the earlier data from the Modified Rhyme Test (MRT) which employed isolated words; however, the proportion of errors made in the current test was much greater. A part of the reason for the higher error rate in the meaningless sentence test lay in the greater difficulty of the task—the subjects not only had to identify the intended words but also had to hold each nonsense sentence in memory long enough to write it down on the response sheet. An additional complexity may have been the tendency for occasional sentences to invite meaningful interpretation and thereby induce recognition errors.

The errors were analyzed into two main classes: Phoneme errors included *substitutions* of vowels or consonants for other phonemes (e.g., "fat" for "sat," "sat" for "sad" etc.), *insertions* of one or two phonemes in an otherwise correctly reported word (e.g., paved for paid) and *deletions,* or the omission of vowels or consonants in otherwise correctly reported words. Word errors were classified as words left unreported (i.e., *omitted* words) and *transpositions,* or words which were correctly reported but in the wrong position within the nonsense sentence.

Overall, vowel errors occurred very rarely and the greater interest lay in initial and final consonants. Both groups of subjects found [Θ] the most unintelligible phone overall with [tʃ], [ʃ] and [t] as the most common runners-up for high errors in initial position. The confusions for these voiceless sounds arose primarily over the discrimination of place of articulation. However, this performance did not extend to all voiceless phones because the least confused sounds by both groups were [f], [s], and [h] which are also voiceless. In final position the groups showed similar agreement on the most frequently confused sounds. The highest number of errors occurred on [p], [g], and [ŋ] in addition to [Θ]. Poor place discrimination accounted for most [p] and [ŋ] errors while failure to detect the voicing feature

caused a large proportion of the errors involving [g]. The least troublesome phones in final position proved to be [m], [f], and [l].

Word location in the sentence was a factor in the number of errors produced. The sentences were all of the form, "The (adjective) (noun) (verb) the (noun)." A standard stress pattern (Low) (Mid) (High) (Mid) (Low) (High) was used, accompanied by a falling intonation pattern and a full terminal fall across the last stressed syllable. Classified on a word-by-word basis, fewest errors in synthetic speech occurred in identification of the adjectives (in initial position). The highest number of errors involved the words in second test word position—the nouns. These observations differed quite markedly from those in natural speech in which the verb proved to be the most frequently misheard word. The reasons for the difference are not yet clear, but it seems likely that they may have their origin in an interaction effect between memory load and the amount of extra attention that must be spent on interpreting the synthetic speech sounds. Further experiments will be necessary to examine this effect in more detail.

In summary, a comparison of the results of the MRT with the Meaningless Sentence Test (MST) shows that the margin of difference between listening performance for synthetic speech and natural speech increased significantly in the latter. The average error rate on the meaningless natural speech test was about 5 percent compared with the earlier figure of 3 percent and on synthetic speech it was 22 percent compared with the 8 percent found using isolated words. Having made this comparison however, it must be noted that the figures for the MST include errors of all kinds ranging from words totally omitted to minor phonetic errors that may well have been corrected had the words appeared in meaningful contexts. Moreover, the reporting requirements were different; the MRT used a closed response procedure while the MST demanded open responses. All of these considerations would lead one to expect higher error rates for the MST, but the important fact is that in these special conditions, errors increase at a faster rate for synthetic speech than is the case for natural speech. Thus, the results demonstrate the sensitivity of the testing procedure and the need to focus further attention on the improvement of methods of synthesis.

Synthesis from Typesetter's Tapes

Responding to our inquiries, veterans at the VA Eastern Blind Rehabilitation Center suggested that they would like to hear transcriptions of the syndicated column written by Ann Landers. This column appears daily in a local newspaper and accordingly, arrangements were made with the publisher to supply the punched paper

tapes that are used in typesetting. From the outset, a number of technical difficulties arose. Variations in mechanical tolerances among the machines which punched the tapes, created the most difficult problem. This caused numerous reading errors and a substantial amount of time had to be spent on correcting the text prior to initial input. As a result roughly 1½ hours of speech was generated during the project—less than had been anticipated. Nevertheless, the project was valuable for two reasons. First it provided extensive use of the Experimental Synthesis Program and gave an opportunity to evaluate duration as a supplemental cue for stress. Second, the informal style of the correspondence which is published in the Ann Lander's column posed a number of difficult syntactic problems. In some cases the sentences were ambiguous unless the main stress was applied to the right word. (The synthesis program allowed this to be done, where it proved to be necessary, by adding special marks to the orthographic input.) In other cases typographical devices such as bold face printing were used in lieu of punctuation. However, the alphabetic-to-phonetic spelling conversion program makes no distinction between type-faces and must depend entirely upon the formal punctuation to make stress and intonation assignments. Performance was therefore liable to be erratic when reliance was placed on the automatic mode of operation.

Informal listening sessions were organized by the Research Staff of the Eastern Blind Rehabilitation Center. The veterans and staff who listened to the tapes had not, with only one or two exceptions, previously heard long passages of synthetic speech. A poll conducted at the end of the sessions indicated that, on hearing synthetic speech for the first time, about one-third of the listeners understood almost all of the speech, a further third understood some portions and the remainder none at all. However, after additional experience the performance of all groups improved.

The veterans were also asked to take a comprehension test in which short general-interest passages dealing with tunnels and tunnel building were played in both synthetic and natural speech. The tapes were followed by a series of questions. Results returned for both types of speech were too few to draw any useful comparison, and it is now planned to repeat the study with a simpler battery of questions.

Rules for the OVE Synthesizer

The OVE III—a serial formant synthesizer, requiring simpler parameter controls than Haskins' research model—has been in operation since early 1973 using rules adapted from an earlier system. Progress has been made on refining these rules but it has since become clear that keyboard controlled display programs are required to assist in the examination and modification of computed parameters and the manip-

ulation of stored tables. The preparation of these programs has been in progress for several months and they are now nearing completion. These executive programs will provide significantly improved facilities tailored to meet our research needs in using the OVE Synthesizer.

The Development and Evaluation of a Personal Reading Machine for the Blind

Mauch Laboratories, Inc.
3035 Dryden Road, Dayton, Ohio 45439
Hans A. Mauch and Glendon C. Smith

During this report period (July 1–December 31, 1973), the circuits needed to make the black-white decisions for the new self-scanned photocell array were designed and added to the improved Cognodictor breadboard.

This photocell array consists of two columns of 32 photodiodes each, which are operated in the charge storage mode. The photodiodes are small, with a sensitive area 1.1 mils wide and 2.8 mils high. The vertical center-to-center spacing is 2.8 mils and the insensitive area between columns is only 0.6 mil. A shift register circuit on the same silicon chip as the photodiodes scans both columns at the same time, first sampling the two photodiodes at each level of the columns and directing their outputs to separate output lines and then recharging them to replace the charge which was drained by light induced currents.

The circuits which receive these analog voltage outputs compare the output from each cell with a preset fraction of the difference between the extremes of white and black sensed by that particular cell during a line scan. Whereas earlier circuits used only the maximum white level to automatically adjust the black-white switching point, this circuit takes both the background brightness and the print contrast into account. It should therefore provide better operation on low contrast print such as carbon copies.

A self-scanned photocell array was installed temporarily in a Stereotoner probe which was then adapted to scan material attached to a rotating drum. The circuits described above operated well during initial tests. This arrangement will be used for further tests of the Cognodictor breadboard and for gathering data needed for the design of the Cognodictor's recognition matrix.

Arrays of light emitting diodes were added to the breadboard to display the contents of the last register and its match with tentative patterns which might be used in the recognition matrix. A power supply which supplies the correct voltages for the breadboard was also assembled and placed in service.

The Reflex Viewer, a teaching aid, was developed during this period.

It consists of a transparent plate (Plexiglas) located about 4 in. above a flat metal mirror. With the student's single sheet of reading material (printed on one side) placed face up on the top and held at its upper edge by a lip of the plate support, the illumination from the Stereotoner probe passes through the paper along with the image of letters in the lighted area about 1/8 in. wide and 3/4 in. high. Looking from either side into the mirror the teacher can see the letters in their normal orientation. In addition to rapidly identifying the letter giving the student trouble, the teacher can observe the position of the probe relative to the letter being scanned while listening to the tones through secondary earphones and thus see if mistracking or other problems exist.

Because tracking is a problem for beginners, Tracking Aid Clips were designed to hold the Stereotoner Tracking Aid firmly to the top of the Reflex Viewer. The Clips allow the Aid to be adjusted easily for skew and to be rolled from line to line without losing alignment. The Aid is held in place for repeated scans of a line without any need for steady finger pressure.

No significant problems have been reported and all users especially appreciated the firm guidance obtained by using the Tracking Aid clipped to the Reflex Viewer. This latter fact led to the addition of a narrow strip of magnetic material to the underside of the Tracking Aid so that it holds itself on line when used for single sheets placed on a flat iron or steel surface such as the dictation slide usually found in metal desks. With the modified Aid another flexible magnetic strip, 8 1/4 in. long and 7/8 in. wide, is supplied to hold the paper in place. Both the modified Tracking Aid and the Paper Holding Magnet fit into the leather case which snaps to the rear of the Stereotoner. All the Tracking Aids built to date will be returned to Mauch Laboratories for this modification. A single sheet containing operating instructions was prepared and one copy will be shipped with each modified Tracking Aid and Paper Holding Magnet.

Tracking Aids modified as described above were successfully used by teachers and students at both Hines VA Hospital and at The Hadley School for the Blind. It appears that students will be started using the Aid on the Reflex Viewer with Clips. They will probably use the magnetic holding capabilities next before moving to non-magnetic reading surfaces. The more dextrous Stereotoner users will soon advance to reading mostly without using the Tracking Aid. Some will prefer to continue using the Aid.

Along with the American Institutes for Research Teaching Manual in a spring back binder, the Reflex Viewer, two Tracking Aid Clips, and two Secondary Earphones comprise the Stereotoner Teaching Kit. The kit comes packed into a box approximately 4 x 9 x 12 in. which

also has ample room for a Stereotoner with Tracking Aid and charger. Ten Teaching Kits have been assembled for use in the VA—NAS sponsored Stereotoner evaluation program and additional Kits will be made available for those participating in the study and for other users.

Reading and Mobility Aids for the Blind, Centrally Directed Clinical Application Program
Central Rehabilitation Section for Visually Impaired and Blinded Veterans
VA Hospital, Hines, Ill. 60141
John D. Malamazian, Leicester W. Farmer, and James J. Whitehead

During the period covering July 1, 1973 to December 31, 1973, the last subject participating in the field evaluation of the Binaural Ultrasonic Sensory Aids program completed his training with the electronic mobility device in early September. At this point, in terminating the training phase of the study, concentration will be placed on a followup phase of onsite visits to the home areas of the veterans. To this end, the second and final onsite visits were made to the home areas of four veterans who live in Minnesota, North Dakota, and the Chicago Metropolitan area. During these visits, various materials in the form of interviews, questionnaires, and video tapes of travel performances were compiled.

Over the last 2 years, a total of 16 subjects have been trained in an ongoing Binaural Sensory Aid evaluation project. The subject population represents a diverse cross section of long cane performances, travel needs, and sociological and geographical backgrounds. Of the 16 subjects trained, 10 are productively utilizing the device and will constitute the followup population.

During this report period, the field work and related documentation involved in the evaluation of the C–4 laser cane were completed. A draft of the final report, edited by Dr. Patrick W. Nye, Chairman of the Advisory Panel for the Preliminary Evaluation of the Laser Cane, was circulated to panel members prior to his submitting it to the NAS/NRC.

Mr. James J. Whitehead lectured on electronic mobility guidance devices at the National Federation of the Blind Conference held in Chicago, Illinois, at the Palmer House on August 31, 1973.

Mr. J. Malvern Benjamin, Jr., of Bionic, Instruments, Inc., visited Hines VA Hospital on September 5, 1973, to discuss the C–5 Laser Typhlocane along with making tentative plans for training teachers and blind persons in the use of the laser cane. Mr. Russell C. Williams, Chief, Blind Rehabilitation, Veterans Administration, Washington, D.C., visited the Blind Section on September 20, 1973, and again

October 4, 1973. On these occasions, Mr. Williams discussed research, progress made in training and evaluating subjects, teachers, and electronic mobility devices as well as future teacher training courses for mobility aids.

Messrs. Leicester W. Farmer and James J. Whitehead gave demonstrations and lectured on electronic mobility guidance devices for the blind on the occasion of the Silver Anniversary celebration of the Blind Rehabilitation Section which was held on September 21, 1973, in the Blind Section at Hines Hospital.

On December 14, 1973, Dr. Eugene F. Murphy, Director, Research Center for Prosthetics, Veterans Administration, New York, visited Hines Hospital and conferred with the Research Specialists on a variety of topics relating to research, evaluation, and training with electronic mobility devices and reading machines.

Mr. James J. Whitehead attended a conference on mobility aids in Washington, D.C., December 17–18, 1973.

Clinical Trials of Reading Machines for the Blind
Central Rehabilitation Section for Visually Impaired and Blinded Veterans
VA Hospital, Hines, Ill. 60141
John D. Malamazian and Harvey L. Lauer

The work of this project is instruction in the use of electronic reading aids and assistance in their evaluation.

The Stereotoner

Mr. Lauer assisted in the preparation of course materials for the project to evaluate the Stereotoner conducted by the American Institutes for Research under the sponsorship of the Research Center for Prosthetics (formerly PSAS). These instructional and test materials are currently being used at Hines and at the other three training centers in the project. Blind adults are now being trained to use the Stereotoner. Some of them have begun to use the home study materials of the course. The home study materials, which are used after basic training is complete, include a wide variety of print samples and constitute a welcome additional training tool. Mr. Lauer has made drill and practice tapes for the Stereotoner code and for special purposes such as currency identification. He participated in training Chester Lewis, the new Stereotoner instructor at West Haven VA Hospital.

The Reflex Viewer is a new visual display for sighted instructors of the Stereotoner. Made by Mauch Laboratories, which also makes the Stereotoner, the Reflex Viewer was tested and found to be useful and

practical. Mauch Laboratories also made modifications in the tracking aids which we found valuable.

The Optacon

This instrument and its accessories are manufactured by Telesensory Systems, Inc. Mr. Lauer instructed two veterans in the use of the Optacon during this reporting period. Other staff members are to be prepared to assist in this work. The new tracking aid Model T2A was tested and found to be a welcome accessory for beginners and some users.

The Varispeech Machine

Manufactured by Lexicon, Inc., the Varispeech is a compressed-speech tape machine which enables the user to listen to ordinary tapes at up to 375 words per minute without pitch distortion. Seven veterans who are college students and professionals were trained to use it during this period. Each received 10 hours of work with the instrument. The VA has issued several machines to veterans with large needs for recorded reading. Comprehension is good, and acceptance of the instrument as a study aid has been unanimous.

Travel

Mr. Lauer attended two conventions at which he demonstrated the Stereotoner: the National Federation of the Blind in New York and the American Association of Workers for the Blind in Cleveland, Ohio. He participated in the symposium on the employment of Visually Impaired Secretaries and Transcribers in Houston, Texas.

Development of Correspondence Courses for Personal Reading Aids for the Blind

The Hadley School for the Blind
700 Elm St., Winnetka, Ill. 60093
Donald W. Hathaway and Margaret Butow

From July 22 through 25, 1973, the Stereotoner was demonstrated at The Hadley School Exhibit Booth at the American Association of Workers for the Blind convention in Cleveland, Ohio.

From August 6 through 12, 1973, a training materials conference was attended at the American Institutes for Research, Palo Alto, California. They had drafted teaching materials to be used in the instruction of the Stereotoner. Harvey Lauer, Reading Machine Specialist at Hines, Richard Bennett, Reading Machine Specialist at Palo Alto, and Margaret Butow will be teaching the use of the Stereotoner to

students participating in the Research and Evaluation Project sponsored by the Veterans Administration. The training materials developed by the staff of the American Institutes for Research were read and discussed. Hadley School will be teaching 12 nonveteran students over several months in early 1974. The Stereotoner training manuals were delivered to The Hadley School in the first part of October. Meanwhile, local rehabilitation counselors were contacted to try and find local people who might be willing to participate in the research project. By the end of November, 12 nonveteran students had taken and passed the Stereotoner Auditory Selection test.

During the months of October through December, four people were taught to use the Stereotoner. Each student's course lasted 10 to 15 working days. Three of the students completed the course, and one discontinued because of inability to hear the code well. One reader is a senior in high school, and the other two are college graduates. All continue to use the Stereotoner in reading their mail, magazine articles in which they are interested, checking their own typing, etc. Training of students for the research and evaluation project will continue through the summer of 1974.

Mobility and Reading Aids for the Blind, Centrally Directed Clinical Application Program

Western Blind Rehabilitation Center
VA Hospital
3801 Miranda Avenue, Palo Alto, California 94304
Loyal E. Apple, Richard Bennett, William Ekstrom, and Donald C. Cooper

A final report on the evaluation of the Bionic C–4 laser cane was completed by the Advisory Panel for the Evaluation of the laser cane formed by the subcommittee on Sensory Aids of the CPRD, National Academy of Sciences and then submitted to the National Academy of Sciences for consideration for publication. A new Bionic C–5 laser cane has been developed, and a one day examination of this cane was possible when J. Malvern Benjamin, Jr., the designer of the laser cane, visited the Western Blind Rehabilitation Center. From a mobility standpoint the C–5 cane shows a very definite improvement in: reduction in weight (reduced from 1½ lb. to just over 1 lb.), reduction in diameter of the cane, cosmetic appearance (outside surface of the cane is much more streamlined). All of these features along with many internal changes should contribute to a much improved and more acceptable travel aid. The C–5 model should be delivered to the Western Blind Rehabilitation Center in early 1974 and then will be given a more thorough evaluation in travel situations. This evaluation

should take less than a month and then several blind veterans will be trained with the new cane.

Russell Smith, a representative of Wormald-Vigilant Co. of New Zealand, visited the Western Blind Rehabilitation Center and displayed the new model of the Ultrasonic Binaural Sensor. There is definite improvement in: the cosmetic appearance with better design of the frames, fold-up sideframes and a detachable cable from the frames contribute to user convenience, and an improved fitting system should greatly assist in ordering the new glasses. The new models will be available late in 1974 or in early 1975. Three more veterans were trained this past summer and fall in the use of the Ultrasonic Binaural Sensor.

Activity centered around several aspects of the Stereotoner evaluation project. These included continuing interaction with the American Institutes for Research Project personnel, identification and testing of blind veterans considered to be suitable Stereotoner trainees, and the instruction of the first two Stereotoner trainees at WBRC.

From August 6 through 10, 1973, Mr. Richard Bennett and other Veterans Administration Stereotoner instructors met at AIR with Dr. Robert Weisgerber and other AIR team members. Some results of this 5-day meeting were general agreement on the format and content of the AIR interim instructional manual for the Stereotoner, along with various tests and measures considered to be useful evaluation ingredients.

After the August meeting, weekly conference calls were generally held linking the AIR and VA team members. These sessions provided excellent opportunities for the exchange of information on project progress, training or testing procedural changes, manual revisions, and allowed the participants access to helpful suggestions and ideas from their colleagues.

Mr. Bennett worked with other WBRC and AIR staff to facilitate the preparation of a braille edition of the Stereotoner instructional materials by a local volunteer braille transcribing group.

Kits for administration of the Stereotoner Auditory Selection Test were sent to appropriate VA field personnel in six western states. Fourteen blind veterans who met other criteria for participation in the project were tested, with 10 candidates scored as eligible to become trainees. Two of these veterans received individual Stereotoner instruction from Mr. Bennett at WBRC prior to December 31, 1973. Trainee Number One received 75 hours of instruction between November 6, 1973 and November 29, 1973, and is continuing home participation in the project. Trainee Number Two received 68 hours of instruction from December 3, 1973 to December 20, 1973. However, he completed less than 80 percent of the basic training material and requested withdrawal from the project. Trainee Number Three was scheduled for

training in January 1974 and Trainee Number Four will be trained in either February or March 1974. The remaining trainees are not as yet firmly scheduled.

One blind veteran who had been screened previously by Telesensory Systems, Inc., for possible Optacon training, received this training at Peninsula Blind Center, Palo Alto, between November 14 and December 7, 1973. He has been loaned an Optacon Visual Display Unit to assist him to continue his Optacon study at home.

Mr. Bennett attended the annual B.V.A. convention in Atlantic City, New Jersey, from August 14 to 18, 1973, where he demonstrated the Stereotoner and took part in a panel discussion of sensory aids for the blind conducted by Mr. Howard Freiberger, Electronics Engineer, Research Center for Prosthetics, VA, New York, New York.

Development of Test Procedures for Evaluation of Binaural Hearing Aids

Northwestern University, School of Speech
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Raymond Carhart, Ph. D., and Wayne O. Olsen, Ph. D.

A. *New Laboratory.* During the current year, activities were transferred from the Medical School to expanded laboratories in the Department of Communicative Disorders. This move improves the potential for research substantially.

B. *Hearing-Aid Evaluation Experience.* During the current research year, the laboratory accumulated data on the hearing aids given clinical trial in the Medical School Hearing Clinics. There were 16 models involved. These 16 models had recommendation-to-trial ratios ranging from 12 to 62 percent. The electroacoustic characteristics of these 16 instruments were measured. A retrospective analysis of the relation between the performance characteristics of these instruments and actual recommendation for client use (recommendation experience) is in progress.

C. *Discrimination in White Noise.* Several years ago a study was begun to investigate whether individuals who are resistant to interference from white noise will adjust better to hearing-aid use, particularly in situations with background noise, than individuals who are susceptible to interference. A battery of formalized tests was developed and administered to hard-of-hearing subjects. The data which emerged are heterogeneous enough to warrant the conclusion that relative resistance to disturbance of discrimination by white noise was not a very useful predictor of subsequent success with hearing aids.

D. *Listening Efficiency Questionnaire.* Data were gathered on the efficiency with hearing aids achieved by monaural and binaural hearing-

aid users. The vehicle for obtaining the data was the Dirks-Carhart questionnaire (*J. Speech Hearing Disorders,* 1962, 27, 311–322), which was first revised to some degree. The accumulation of responses was completed during the current research year. Findings are now being analyzed.

E. *Analysis of Speech Discrimination Errors.* This study is designed to assess the types of speech discrimination errors made by normal hearers and sensorineural hearing loss cases when the speech signal is reproduced with good fidelity and when the speech signal is distorted by filtering and/or peak clipping, etc. For this purpose *Oklahoma University Speech Test No. 6* was adopted.

The various versions of the Oklahoma Speech Test No. 6 have been tape-recorded in the Auditory Research Laboratory in the Medical School. This gave the array of versions needed for the project. Then in the early fall, the entire activity was moved to the new laboratory.

The project is now testing the effect of high-pass filtering plus peak clipping on intelligibility as measured with the Oklahoma No. 6 test. Both intelligibility (as percent correct) and phoneme confusions are being evaluated in this experiment.

Influence of Input and Gain Values Upon Electroacoustic Properties of Hearing Aids

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The evaluation of new speech discrimination materials for use as stimuli to compare hearing-aid performance on hearing-impaired subjects was continued. Under study were the revised CID Sentence Lists recorded earlier by this laboratory. One investigation was conducted to evaluate interlist equivalency so that the different sentence lists could be used interchangeably for assessing different hearing aids with the same subject. Ten of the subjects received all 10 lists at 10 dB sensation level (SL) relative to the pure-tone average (PTA) of their better ear, and 10 subjects received the stimuli at 20 dB SL (re better ear PTA). Analyses of the results indicated no significant differences among the mean scores of the 20 listeners on all 10 lists. It is felt that the 10 sentence lists may be used interchangeably as stimuli for hearing-aid evaluations.

Performance-intensity functions were also determined using the RCID Sentence Lists with 100 normal and 42 hearing-impaired subjects. The differences between the two populations may be summarized by the following comparisons. First, the slope of the linear portion of the

curve for the hearing-impaired subjects was more gradual: approximately 4.5 percent per decibel as opposed to 9.3 percent per decibel for the normal-hearing subjects. Furthermore, the linear portion for normal-hearing subjects terminated at a sensation level of 4 dB (re SRT) where about 76 percent correct responses were obtained; but for the hearing-impaired subjects, the linear portion was extended through to the 12 dB SL where subjects made about 85 percent correct responses.

The second difference between the two groups of subjects was observed where the nonlinear portion of the performance-intensity function approached saturation. Again, the difference between the two groups was 8 dB; the normal group attained this level at 12 dB SL and the impaired group reached it at 20 dB SL.

The third difference betweeen the normal and hearing-impaired subjects was reflected in the subject variability within each group. As indicated by the standard deviations, the normal-hearing group had less variability throughout the sensation levels examined than the hearing-impaired group. This would indicate that the impaired group was more heterogeneous in the speech discrimination task than was the normal-hearing group. Additionally, the variability of the normal-hearing group decreased progressively as the signal intensity increased to the point where almost perfect responses were made, but the same type of pattern of intersubject variability was not evidenced by the sensorineural group.

The recordings of the RCID Sentence Lists were employed as stimuli to measure the message-competition (cafeteria noise) ratio obtained through hearing aids with directional microphones. Each aid evaluated was mounted on the left ear of a specially designed mannequin to simulate real-life conditions. The cafeteria noise signal was presented from a loudspeaker at the rear of the mannequin and the speech stimuli were presented from a loudspeaker in front of the mannequin. Both signals were attenuated to produce a 0 dB signal-to-noise ratio at input to the hearing aids. The hearing-aid-processed signals were then recorded in a uniform manner for all hearing aids. The message-competition ratio calculated for the eight hearing aids under study, ranged from +1 dB to +17 dB, with six aids having a ratio of 13 dB or better. These results indicate that under the conditions simulated for this study, the directional microphone aids do enhance the reception of speech in an environment of competing noise.

The Reading of Printed Materials by the Blind
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During the period July 1–December 31, 1973, project staff concentrated on the following tasks:

Completion and reproduction of the basic Stereotoner course materials was accomplished, comprising an introduction section and 40 lessons in 14 units.

Following the conference with the instructors, held in Palo Alto August 6–10, a number of modifications were made in the draft instructional materials. Among the changes were: expansion of the orientation unit to include lessons on equipment familiarization, tone practice, and tracking techniques; alterations in the page formatting and cueing; different versions of enrichment materials for certain lessons; additional field usage exercises; and an altered approach to the remediation unit decoding strategy.

Certain changes were also made regarding operational instructions following discussion with Mauch Laboratories.

Each instructor then received a master copy of the materials. These included a major section with comments and guidelines for the instructor, the tests to be used and the instructional sheets for students. They also received 12 copies of the instructional materials for students (bound separately). With the help of the staff at the WBRC, VA Hospital Palo Alto, and the Sixth District Braille Transcription Project, brailled sets of these materials were also prepared.

A log has been maintained of further desirable changes in the materials when these have been identified during the course of instruction. In some instances where errors appeared, replacement instructional pages were prepared and sent to the instructors.

The development of followup Home Study Units was initiated.

Catherine Taylor, the AIR staff person with primary responsibility for Home Study Unit development, has visited with Richard Bennett in Menlo Park, and Harvey Lauer and Peggy Butow in the Chicago area, and has received very valuable feedback on draft Home Study materials. As of the end of December the introduction section to the Home Study Units series had been prepared both in print form and as an audiotape. It was agreed that four Home Study Units would be prepared and that they would be concerned with:

A — Personal Affairs
B — Leisure
C — Social Affairs and Mobility
D — Business Affairs

Unit A, Personal Affairs, had also been prepared by the end of December. It consists of a tape which gives directions and 12 lessons comprised of specimen materials and/or criterion exercises related to personal affairs. The topics dealt with in Unit A are:

Letters You Receive at Home
Envelopes and Mailing Labels
Postcards and Notices
Typing and the Stereotoner
Reading and Paying Bills
Computer Printed Bill
Checking Account Statement
Reading a Pamphlet
Reading Labels
Details on Labels
Reading Cooking Instructions and Recipes
Criterion Exercise

Procedures were established for the trainees to make taped examples of their performance and to mail these to their instructors for critique. Sufficient copies of the Introduction and Unit A were prepared to send them to all trainees after they complete the basic instructional manual.

Work is proceeding on the remaining three Home Study Units and they are expected to be completed by the end of March 1974.

Auditory Selection Test tapes were prepared and scores obtained for a number of potential trainees. As of the end of December, Auditory Selection Tests were actually being administered in the catchment areas for the Menlo Park VA Hospital and the Hines VA Hospital, but had not yet been administered in the East. Civilian candidates were being tested through The Hadley School for the Blind. During the period July–December, a total of 77 Auditory Selection Tests were sent to AIR and scored.

While it is premature to discuss the utility of the test for predictive purposes, it is evident that a wide range of scores have been obtained. This should be helpful at the time of analysis.

Training was begun at three of the four main training sites and data were collected on initial trainees. Seven trainees began training during the 6-month period. Of these, five have completed initial training and are in home study. Test data have been sent to AIR on all the trainees during the period, and weekly conference calls between AIR and the instructors give all parties an awareness of project progress and particular needs.

As the students have progressed, it is clear that some of them find the 3-week instructional period to be insufficient to complete the basic course materials. On the other hand, for some of them the upper limits of study efficiency have already been reached or exceeded by 5- to 6-hour study sessions. Therefore, some students necessarily go home with instructions to continue their study in the basic study material before proceeding with the Home Study Units.

Followup phone calls were initiated to individuals who had com-

pleted training as of November. These trainees also began the process of mailing bimonthly postcards to AIR indicating their elapsed study time at home.

A pilot study has been undertaken with a sighted instructor, blind public school teacher, and blind 5th grade student to explore certain training variations beyond the scope of the main evaluation study. In particular, we wanted to explore the feasibility of a sighted, relatively inexperienced (i.e., code unfamiliar) teacher using the new reflex viewer as a means for guiding a blind adult through the training course. This has proved to be successful in this instance.

We are also interested in the feasibility of training in a school situation where the available time for training is intermittent and does not exceed 1½ hours a day as a rule. This, too, seems to be practical so far.

The blind trainee is a special education teacher and he will attempt the third aspect of the experiment, namely, the instruction of a blind 5th grade student during the spring school semester.

Eastern Blind Rehabilitation Center
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1. *Parameters of lateral obstacle detection.* Various acoustic, psychoacoustic, organic, and psychological parameters of a quantifiable lateral obstacle detection task were examined in a series of experiments. It was found that there was no significant correlation between a blinded veteran's ability to perform the task and his standard pure-tone audiometric results for .250, .500, 1, 2, 4, and 8 kHz (De l'Aune, et al., 1974a). Performance of blinded veterans was compared to that of sighted high school students and no significant differences were revealed (De l'Aune, et al., 1974b). Within the blinded veteran sample no correlation with age was seen (De l'Aune, et al., 1974c). (Physical acoustic analysis of recordings made in the test situation revealed spectral intensity differences at frequencies of less than 200 Hz, and at 0.8, 1.0–1.3, and 1.8 kHz (De l'Aune, et al., 1974a).) The major conclusion reached from this data was that extreme high frequency hearing was not a necessary condition for success in this type of task. Intelligence, as measured by the Wechsler Adult Intelligence Scale, and the extent of the veteran's visual impairment also showed a lack of correlation with performance in the experimental task (De l'Aune, et al., 1974d). In looking at the relationship between performance in this task and personality traits of blinded veterans as measured by the Minnesota Multiphasic Personality

Inventory (MMPI) and the California Psychological Inventory (CPI), striking relationships were found. Blind veterans who performed better at the auditory task displayed significant indications of more adequate emotional and interpersonal adjustment (De l'Aune, et al. 1974e). A training technique, utilizing samples of recordings made binaurally through an artificial head, was shown to improve performance significantly in the test environment. The training used in this experiment took approximately 300 seconds to complete (De l'Aune, et al., 1974f, 1974g.)

2. *Various parameters of successful speech compressor usage among blinded veterans.* In this study various physical and psychological aspects of blinded veterans are being examined for possible relationships with comprehension of verbal test material presented at varying rates of compression. Although the research is still in progress normative data from the veterans already sampled can be presented. It would appear that 48 percent of the blinded veterans can comprehend the material at criterion level at a rate of 500 words per minute, 81 percent can comprehend at 400 words per minute, and 96 percent can meet the criterion comprehension levels at 300 words per minute. These data have far-reaching implications in terms of the broad applicability of speech compression systems to the blinded veteran population (Nelson and De l'Aune, 1974).

3. *Type-font parameters affecting reading device usage.* An extensive survey of various publishers of magazines and books was carried out to determine if any patterns of type-font selection could be conveyed to the users of reading devices. Various facets of the fonts in use were evaluated and teaching schemes were developed for use with students. Evaluation of the success of the techniques is currently underway. (Gadbaw and De l'Aune, 1974).

4. *Patient satisfaction survey.* A short questionnaire was sent to all patients who completed or were discharged from the EBRC after a stay of 3 months or longer. Items sampled: perceived adequacy of training in mobility, manual skills, communications, braille, social work and psychology services, low vision programs, and techniques of daily living skills. Also included were measures of overall life satisfaction, employment history, vocational training, living arrangements, extent of current blindness and other demographic data. The data will be analyzed in terms of responses to individual items, indices based upon a combination of questions including a global Satisfaction Index, demographic items, and the relationships between these variables (Needham, et al., 1974).

5. *Normative personality data for blinded veterans.* Compilation of scores on various psychological tests (MMPI, CPI, and WAIS I.Q.) for a large number of blinded veterans is currently underway. It is hoped

that this will provide normative data for blinded veterans, against which individual data can be more meaningfully compared (Needham and De l'Aune, 1974).

6. *Relationships of perceived adjustment and personality variables.* The staff of the EBRC was asked to rank blinded veterans on their "adjustment to their blindness." These rankings were analyzed for possible correlation with personality variables as measured by the MMPI and CPI. Significant correlations were found between the MF and PT scales of the MMPI and the average staff adjustment ranking. Agreement between staff personnel was extremely high (De l'Aune, 1974).

7. *Prosthetic device evaluations.* A large number of prosthetic devices for the visually impaired is currently being taught by the research staff and other members of the EBRC. Along with training and observations during training, followup of users and examination of various aspects of successful users is continually underway. This includes work with devices concerned with mobility, optical magnification, electronic magnification, modality transformation, and miscellaneous communicative skill areas.

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