

## SENSORY AIDS

*Edited by*

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**Research on Audible Outputs of Reading Machines for the Blind**  
Haskins Laboratories, Inc.

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### **Introduction**

The objective of the research reported below is the improvement of the intelligibility and naturalness of speech produced by an automatic synthesis-by-rule system. Such a system would be a major component of a reading machine for the blind. Work is reported below on the development and testing of a synthesis program and of rules for synthesis, and on phonetic investigations in support of rule development.

### **Development of Rules with FOVE Program**

There has been further development and testing of rules for use with FOVE, the synthesis-by-rule program for the DDP-224 computer that calculates parameter values to drive the OVE III hardware synthesizer. A set of rules developed during 1976 has been subjectively tested. The subjects, students and staff at the University of Kansas, were asked to transcribe synthetic utterances which included both isolated words and connected sentences. The results can be compared with those from similar tests of the 1974 FOVE rules: intelligibility of sounds in isolated words remained the same (84) percent; intelligibility of sounds in sentences improved from 83 percent to 86 percent; the sounds /b, t, d, θ, h, w, c, ɔɪ, a/

appeared to have improved but /ŋ, ʃ, ʒ, j/ were poorer.

Meanwhile, a further revision of the FOVE rules took place in early 1977: changes were made in the frequency values of velar stops and nasals, in the amplitude values of nasals and voiced stops, in the durations of stops, fricatives and affricates, and in the frequency and amplitude values of affricates, fricatives, and releases of final stops. Materials for subjective testing parallel to those used in testing the 1976 rules were prepared.

### **Research Synthesis-by-Rule**

SYLSYN, the research synthesis-by-rule program for the PDP 11/45, has been expanded and improved. It now includes a software synthesizer consisting of a noise generator, a pitch generator, a vowel branch with five formants, and a nasal branch and consonant branch each having one formant and one antiformant. The part of the program that calculates articulatory influences and parameter values from a syllable-feature specification has been expanded so as to handle all the conventional manner classes (stops, fricatives, nasals, liquids, glides, and vowels). The logic of the program has been simplified somewhat, and its execution time has been reduced.

### **Temporal Variation and Speech Synthesis**

A series of experiments investigating the temporal patterns of syllables has been carried out. In each of these experiments, a speaker repeated a certain syllable 30 times in the sentence frame, "She was seen on ——— Street by her mother." To lessen tempo variation, each utterance was prompted by a click from a metronome. Waveform measurements of various segmental durations were averaged across the 30 tokens. Data have now been collected for a number of syllables with nucleus [ey] and varying initial and final consonant and consonant clusters, uttered by three speakers; some comparable data has also been collected for the nucleus [I]. The general finding — to which there are various exceptions — is that the increment to the syllable duration produced by an initial consonant is relatively uniform across the various cluster contexts, whereas the duration of the acoustic segment conventionally associated with the consonant varies according to cluster context. For final consonants, the situation is more complicated; a cluster such as [nd], for example, lengthens the syllable to an extent that is not obviously predictable from the lengthening effects of simple final [n] and simple final [d].

### Other Experiments on Duration

In an attempt to explore the importance of naturalness in duration, four semantically acceptable sentences and ten monosyllabic nonsense sentences were prepared in two versions. In one version the 1977 FOVE rules were used, and the durations of acoustic segments of each synthetic sentence were then modified to be equal to those in a natural utterance of the sentences; in the other version, the 1977 rules were used without modifying durations. Subjects were required to transcribe both modified and unmodified sentences. In the case of the semantically acceptable material, 79 percent of the words in the unmodified sentences and 86 percent of the words in the modified sentences were correctly transcribed; for the nonsense material, the corresponding results were 77 percent and 85 percent. However, the apparent advantage may have been a learning effect, since the unmodified sentences were always presented first.

Another study involved the manipulation of stop-closure duration in natural speech. In a pilot experiment, the utterance, "Uncle Tom took a long time telling the tale to two of the Thompsons" was recorded by two talkers. In these utterances the closure durations for [t] ranged from 20 to 80 ms. Using a computer program for waveform editing, three additional versions of each utterance were prepared, in which the [t] closures were adjusted to be uniformly 0, 30, and 100 ms, respectively. Five phonetically alert listeners judged both the originals and the 30-ms versions to be natural, the 100-ms versions to be unnatural and heavily stressed, and the 0-ms versions to be natural but very fast. This experiment suggests that closure durations are important cues to tempo. Inconsistency of tempo cues is probably a major deficiency of current synthesis-by-rule.

### Segmental Cues

In order to obtain information about the interaction of steady-state frequency values and formant transitions, and their effect on stop consonant perception, a series of experiments has been recently carried out. It is expected that the results of these experiments will provide useful information for calculating the feature target values and their influence functions to be used in the syllable synthesis program.

A series of four vowels with a fixed  $F_1$  at 840 Hz and a fixed  $F_3$  at 270 Hz, but with a varying  $F_2$ , were constructed.  $F_2$  frequencies for the four vowels were 1200, 1400, 1680 and 2100 Hz, and all of these vowels were perceived as falling into the [a]-[æ] range in a

vowel identification test. While  $F_3$  was held constant at a flat 2700 Hz, the starting-point of the  $F_2$  transition was varied in ten 200-Hz steps from 850 to 2650 Hz, creating a [b]-[d]-[g] continuum for each of the four vowels. Nine subjects listened to randomized sequences of these continua, and their data revealed the [b]-[d] and [d]-[g] crossover points for each vowel. A new series of continua were then constructed around [b]-[d] crossover points. A five-step, 100-Hz-per-step,  $F_2$  range (with the [b]-[d] crossover  $F_2$  transition value as the central point) was exhaustively paired for each vowel with a seven-step  $F_3$  starting-point range from 2100-3300 in 200-Hz steps (with a level  $F_3$  transition starting at 2700 Hz as the central point). Twelve listeners were then asked to listen to a randomized sequence of each of the original [b]-[d]-[g] continua, with flat  $F_3$ , as well as the [b]-[d] crossover series, with both  $F_2$  and  $F_3$  varying.

The results of this experiment will provide useful information for calculating the effect on stop consonant perception of independently changing  $F_2$  and  $F_3$  transitions. For example, it has been found (just as in the early Haskins Playback experiments), that the higher the starting point of the  $F_2$  transition, the greater the number of [d] or [g] responses and the fewer the number of [b] responses. For an intermediate range of  $F_2$  starting points, raising the  $F_3$  starting point increases the number of [d] responses; lowering it increases the number of [b] and [g] responses. Information such as this can be incorporated into the syllable synthesis program to produce more intelligible speech.

### **Research and Development in the Field of Reading**

**Machines for the Blind**

**Mauch Laboratories, Inc.**

**3035 Dryden Road, Dayton, Ohio 45439**

**Hans A. Mauch and Glendon C. Smith**

In a letter of July 21, 1977 to Mauch Laboratories, Mr. Glendon C. Smith, Senior Project Engineer of the Reading Machine Project, tendered his resignation from that organization to be effective September 30, 1977. This loss of a principal talent in the reading machine work caused the company to schedule withdrawal from the project after appropriate final documentation had been completed. A technical report dated October 5, 1977, "Final Report on Research and Development toward A High Performance Reading Machine for the Blind (Cognodictor)" comprising 121 text pages and a comprehensive set of drawings, has been submitted to the

Veterans Administration (VA). The VA is considering continuation of this project through publication of a Request for Proposals (RFP) by which means a follow-on contractor may be selected with the aim of carrying the work to a successful completion.

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

This ongoing, centrally directed project is concerned with the clinical evaluation of reading and other communication aids for the blind. During the current reporting period, the following work was done:

Mr. Lauer has rewritten portions of his proposal to evaluate the Kurzweil Reading Machine. The Kurzweil machine has a computer-controlled scanner, computer-assisted optical character recognition, and synthetic speech output. The first one purchased by the VA was delivered to VAH Hines, June 1, 1977. Kurzweil Computer Products personnel installed the machine and then instructed Mr. Harvey Lauer and other Hines staff in its operation. The machine was inspected by Mr. Lauer and Mr. Howard Freiburger of the Research Center for Prosthetics, New York. The instrument having essentially met its specifications, Mr. Lauer and others are currently working to gain skill in its use and are developing lesson plans and reading materials. Interest in the machine is such that several open house sessions are to be held for hospital staff and professionals who work with blind people.

Mr. Lauer began the evaluation of the Am-Bi-Chron Model LC, a speech compression module. The instrument is an accessory to be connected to Library of Congress cassette talking book player models C73 and C75. It uses the sound system and DC power supply of the players.

On February 24, Dr. Lawrence L. Scadden, researcher with Smith-Kettlewell Institute of Visual Sciences, San Francisco, California, visited the Hines Blind Rehabilitation Center. He conferred most helpfully with Mr. Leicester W. Farmer, Mr. Lauer, and other staff members regarding ongoing research efforts throughout the world. Plans were made for cooperation on the Kurzweil Project and other research.

Mr. Lauer presented the topic: "Reading Aids Research and Deployment" to a communications conference held at Hines May 4-6. It was attended by staff members who teach communications skills to blind people at VA facilities.

Mr. Leonard Mowinski (Blind Center staff member at Hines) continued to do most of the screening and teaching of reading aid use to veterans. Mr. Lauer and Mr. Mowinski shared the duties of lecturing and demonstrating the reading aids to guests.

**Clinical Study of Mobility Aids for the Blind  
Central Rehabilitation Section for Visually Impaired  
and Blinded Veterans**

**VA Hospital**

**Hines, Illinois 60141**

**John D. Malamazian and Leicester W. Farmer**

During this reporting period, two veterans received training and were issued electronic travel aids and three more veterans will be admitted for training prior to June 30, 1977.

Two light probes, the Bejed wrist model and the three-way amplifier model, were evaluated at Hines during February and March.

The wrist model is in a small plastic case containing transistors, electronic components mounted on a small circuit board powered by two hearing-aid batteries, and a capacitor. It is approximately the size of a wrist watch. It provides an audible signal to the user by means of a tiny earphone which plugs into the proximal side of the case. A semiflexible, light-conductive fiber optic probe plugs into the distal side of the case. The pitch of the tone emitted by the device is proportional to the intensity of the light. When the earphone is unplugged, the power is automatically turned off to save battery energy.

The three-way amplifier model is in a small plastic box  $3\frac{1}{2} \times 2\frac{1}{4} \times 1\frac{1}{4}$  inches in size, which makes it easy to carry. This model has a small amplifier and loudspeaker with a thumb wheel on-off volume-control switch. There are two jacks on top of the unit, one to accept a cord two feet long which has a sensor at the end of a ballpoint-pen-sized cylinder. The other jack can accommodate an earphone or a headset adapter cord (which can be used also with the wrist-model probe). When one of these output accessories is plugged in, the loudspeaker is automatically disconnected. This unit has been used effectively by blind switchboard operators and telephone receptionists to detect the light of telephone key sets or consoles.

The investigators found the three-way amplifier model light probe to be sensitive, compact, and well built, with good vocational potential as well as being useful in the home and elsewhere. They were not only impressed by the fact that the wrist model light probe was designed to be wrist-mounted, but also by its high degree of sensitivity and versatility. Like other probes on the market, it can be useful in many ways. In addition to detecting light sources such as lighting fixtures and those found on electrical appliances and electronic instruments, it can be used to check the liquid level in transparent containers, to test batteries with ordinary testing meters (both the kinds with lights to indicate the strength of battery charge as well as the ones with "needle" indicators), to differentiate among colors and identify light and dark clothing, to detect windows and open lighted doorways, to determine the proper floor in elevators with lighted buttons that go out when the desired floor is reached, and it can be useful in darkrooms where it helps the user to avoid ruining x-ray film.

The Bejed light probes are manufactured by members of Oregon Chapter No. 31, Telephone Pioneers of America, Portland, Oregon.

#### **Glucose Analyzer Tested**

From January to March, the Snipas Glucose Analyzer (Triformations Systems, Inc.) was tested and evaluated by the Blind Rehabilitation Center Orientation and Mobility staff and the Endocrinology/Diabetes Unit at VAH, Hines. The device has not been marketed, but has been distributed to selected agencies for field testing and evaluation. The purpose of the tests and evaluation is to determine the extent of potential use of the glucose analyzer, and to identify any possible limitations.

The Snipas Glucose Analyzer is a portable electronic device that measures  $7\frac{1}{4} \times 4\frac{1}{4} \times 3$  inches, and weighs approximately 1 lb. It is intended to be used by blind diabetics to determine the approximate percentage of glucose in their urine. It measures the shade of a test strip which has been dipped in a fresh urine specimen, and then generates a series of audible tones, the number of which indicates the shade of the test strip. A yellow strip (indicating 0 percent glucose) will cause it to produce one tone, and a dark green strip (indicating 2 percent or more glucose) will cause 5 tones. In-between shades generate 2 (1/10 percent), three (1/4 percent) and four (1/2 percent) tones respectively.

The glucose analyzer must be calibrated prior to use, and cleaned to remove urine traces after use.

Hines is one of probably 13 blind rehabilitation agencies involved in the evaluation of the glucose analyzer. Data collected from the

participating agencies will be analyzed to determine whether certain factors contribute to success in using the device or restrict its usefulness for certain persons. The information submitted by the agencies will provide the manufacturer with data needed to determine whether modifications of the prototype are necessary.

Mr. Leicester W. Farmer was one of the participants at the workshop on Sensory Deficits and Sensory Aids jointly sponsored by RSA and VA, which was held March 23-25, 1977, at the Smith-Kettlewell Institute of Visual Sciences, Pacific Medical Center, in San Francisco, California. He was a discussant in the session addressing current status, future trends, and priorities in basic and applied research on sensory deficits and sensory aids. The purpose of the workshop was to develop clear and frank recommendations on the goals and priorities for sensory aid research for later inclusion in a major RSA/VA summary statement on the outlook (plans, programs, and budget) for future research and service delivery for the handicapped.

Also during this reporting period, Mr. Farmer submitted a manuscript to the editors (two members of AAWB) which will be one of 19 chapters in a textbook, the tentative title of which is "Orientation and Mobility for Visually Handicapped Persons: Development and Fundamental Principles." Mr. Farmer's chapter will consist of two topics entitled, "Various Types of Canes and Walking Aids", and "Electronic Travel Aids and Systems." The textbook will be published this year by the American Foundation for the Blind.

### **Clinical Application Study of Reading and Mobility Aids for the Blind**

**Western Blind Rehabilitation Center**

**VA Hospital**

**3801 Miranda Avenue, Palo Alto, California 94304**

**J. Kenneth Wiley, Gregory L. Goodrich, Ph. D., Richard R. Bennett,  
and Stanley Paul**

### **Mobility Aids and Training**

During the current reporting period, the Western Blind Rehabilitation Center initiated a followup study of veterans who have received orientation and mobility training at that Center. The study was designed to obtain information for two purposes.

The first purpose resulted from findings of a previous research project on the utilization of ETA's (electronic travel aids) (Darling,

Goodrich, and Wiley 1977), which explored the travel patterns of veterans trained and issued ETA's by the WBRC. This study indicated differential employment of Laser Canes and Sonicguides, which may lead to more precise guidelines for matching a particular ETA with a particular user.

The same study also indicated that many ETA users employed the device for a relatively brief duration after returning to their home community. These veterans indicated that, while the ETA was initially useful for mobility purposes, its benefit was of a limited duration. Such results may suggest the need to provide ETA training and ETA's to some veterans with the explicit expectation that the aid may be returned (for re-issuance to another veteran) within 6 months to 1 year after ETA training. The results also suggest that such a procedure, even though of limited duration, could be of substantial benefit to selected veterans. Thus the present study was designed, in part, to assess the needs of veterans not receiving ETA training, in an attempt to estimate the number who would benefit from such a limited program.

A second purpose of the present followup is to provide evaluative information to the WBRC's orientation and mobility instructors. Such information was thought to be useful in assessing strengths and weaknesses of the current program so that necessary changes (if any) could be made. For example, the followup will provide verbal and photographic information about the home communities of a large number of veterans. Such information can then be used to select appropriate training areas for veterans, based on more detailed information than is currently available.

Currently, followup visits have already been made to 22 veterans who have received orientation and mobility training from the WBRC. During the remainder of the current fiscal year an additional 28 veterans will be visited. In the next fiscal year an additional 20 veterans will receive followup visits, and 30 veterans who have not received ETA training will also be visited to complete the present study. The total number of veterans for the followup study will be 100.

During this report period, one veteran received instruction with the Pathsounder and a second veteran received instruction with a Sonicguide. Both veterans were issued these respective aids.

#### **Reading Aids and Training**

A preliminary evaluation was initiated of the intelligibility of the output of the Votrax voice as programed by Mauch Laboratories. A  $3 \times 2$  analysis of variance (speed by pitch) is being employed. To date, 17 veterans have participated in the study. Upon

completion of work with the Mauch Laboratories output, it is expected that a similar design will be used in conjunction with Mr. Harvey Lauer's research at the Central Blind Rehabilitation Center (Hines, Illinois) on the Kurzweil Reading Machine. At the appropriate time, the possibility of similar work with the reading machine currently being developed by Telesensory Systems, Inc., will be explored.

In May, an Am-Bi-Chron (model 402) unit was received. This is used in conjunction with the Library of Congress model C75 cassette player. Plans are also being initiated for purchase of a Variable Speech Control A-6 speech compressor. Recordings from these instruments will be used, with material recorded from a Lexicon Varispeech II and General Electric American Printing House Cassette Player/Recorder with a VSC Module, in a paired comparison-study of speech compressor outputs.

During the current reporting period two veterans received Optacon instruction and were subsequently issued Optacons. One of these veterans (instructed by Mr. Richard R. Bennett) is employed by a large electronics manufacturer and is often required to read computer printouts. Several additional hours of orientation to printouts were included in this training schedule. The veteran felt the ability to read these would allow him to move into other, better-paying, positions with his employer.

#### **Conferences Attended**

In March, Dr. Goodrich, Mr. Bennett, and Mr. Paul attended the "Workshop on Sensory Deficits and Sensory Aids" at Smith-Kettlewell Institute of Visual Sciences. The Conference was jointly sponsored by the Veterans Administration and the Rehabilitation Services Administration. Following the workshop, Mr. Howard Freiburger visited the WBRC. Also during the report period, Mr. Neil Greiner and Mr. Ronald Fenchak attended a "Seminar on Blindness and Diabetes" conducted at the Orientation Center, Albany, California. Mr. Neil Shulman, Chief, Written Communications, and Mrs. Patricia Wagstaff, Blind Rehabilitation Specialist, participated in a Conference on Communications sponsored by the VA at VAH Hines, Illinois. Additionally, Dr. Goodrich was an invited participant in the "Workshop on Rehabilitative Engineering in the State of California," sponsored by the State of California, Department of Rehabilitation, in San Jose, California, on June 28.

#### **Papers and Publications, 1977**

Ault, C.: Diabetes and Blindness. Inservice Training at the Renal

- Dialysis Unit, VAH Palo Alto, California, June 15 and 29, 1977.
- Darling, N. C., G. L. Goodrich, and J. K. Wiley: A Preliminary Followup Study of Electronic Travel Aid Users. *Bull. of Prosthetics Res.*, BPR 10-27: 82-91, Spring 1977.
- Goodrich, G. L., R. R. Bennett, and J. K. Wiley: Electronic Calculators for Blind and Visually Impaired Users: An Evaluation. *J. Visual Impairment and Blindness*. 71(4): 154-7, 1977.
- Goodrich, G. L., E. B. Mehr, R. D. Quillman, H. K. Shaw, and J. K. Wiley: Practice Effects Upon Performance with Low Vision Aids. *Low Vision Abs.* 3(1) 22, Spring 1977.
- Goodrich, G. L., L. E. Apple, A. Frost, A. Wood, R. Ward, and N. Darling: A Preliminary Report on Experienced Closed-Circuit Television Users. *Excep. Child Educ. Abs.*, (in press).
- Goodrich, G. L., E. B. Mehr, R. D. Quillman, H. K. Shaw, and J. K. Wiley: A Preliminary Report on Practice Effects with Low Vision Aids. *Am. J. Opto. and Physiol. Optics*. 54(5), May 1977, (in press).
- Quillman, R. D.: Use of Monocular Devices. Presented to San Mateo County Schools, San Mateo, California, January 1977.
- Wiley, J. K., G. L. Goodrich, R. R. Bennett, and N. C. Darling: Clinical Application Study of Reading and Mobility Aids for the Blind. *Bull. Prosthetics Res.*, BPR 10-27, Spring 1977.

### **The Development of Improved Techniques for the Analysis of Hearing Aid Performance**

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G. Donald Causey, Ph. D., Jerry L. Punch, Ph. D., Howard C. Schweitzer, Ph. D., Earleen Elkins, Ph. D. and Lucille Beck

### **Hearing-Aid-Quality Judgments**

Initial studies have been completed on hearing-aid-quality judgments. Test and retest data were collected on listeners having normal hearing and on a group of listeners having audiometrically homogeneous sensorineural hearing loss of mild to moderate degree. Stimuli, including speech of a male talker, speech of a female talker, and music, were processed by five hearing aids exhibiting a variety of electroacoustic characteristics. A paired-comparison tech-

nique was utilized since it represents a method adaptable to a clinical procedure. The pertinent findings of this work are that: (i) the test-retest reliability for the male and female voice (speech) conditions was found to be excellent among both normal and sensorineural listeners, while the reliability for the music stimulus failed to reach statistical significance within either group, (ii) hearing aid preferences assigned for one stimulus, in spite of the basically poor reliability for the music condition, were statistically associated with preferences assigned for either of the other two stimuli, (iii) normals and sensorineurals assigned similar rankings to the hearing-aid-processed conditions, and (iv) there was a lack of hearing-aid-listener interaction within either group of listeners when individual subject data were considered.

Overall, the results suggest that quality judgments of hearing-aid-processed speech provide a differentiating and reliable index of performance with hearing aids differing only subtly in electroacoustic characteristics.

### **Transient Distortion**

In addition to the phased-array technique already developed for use in measurement of transient response in hearing aids with dynamic compression circuitry, we are currently attempting to adapt a spark-gap technique for use in transient distortion measurements. The latter technique precludes altogether having to use a loudspeaker as the signal source, allowing the production of an acoustically undistorted rectangular pulse. Heretofore, the inability to produce a suitable signal has been the major obstacle to successful measurement of this particular characteristic of hearing-aid performance.

The spark-gap technique will be employed in measurements of decay times in a variety of hearing aids for the purpose of deriving step response values. These values will be incorporated in the design of a proposed digital microprocessor circuit. This circuit, in turn, will be used to manipulate step-response in studies of the isolated effects of transient distortion on speech intelligibility and speech quality, in both normal and hearing-impaired listeners.

### **Determination of Formant Transition Thresholds as a Function of Compression Hearing Aid Processing**

Data on the processing of sound formant transitions (critical elements of the speech signal for understanding) by commercially available compression hearing aids are now being collected. Compression aids comprise an increasing proportion of all hearing aids

manufactured. There are several operating features of these aids which have undetermined significance for the user. The effects of the compression ratio and the stage of compression activation (input or output stage) are being examined in this project.

Using equipment obtained on loan from Gallaudet College for the Deaf, a technique has been developed for determining the influence of the compression features of interest on the threshold of detection for second formant transitions. This work has important clinical ramifications since many arbitrary design decisions have been incorporated into the commercially available compression aids.

#### **Investigation of Transient Response for Compression Aids**

In conjunction with the National Bureau of Standards, the attack and release times of 81 compression aids were measured. Until 1976 there was no standardized method for these important determinations. The current operating characteristics of 27 different models of compression aids were measured and reported. This information is of notable interest to the developers of the standard, to audiological clinicians, and to hearing-aid engineers. The majority of the total of 81 aids tested had attack times equal to or less than 10 ms. Slightly more than one-half had release times (according to the new measurement protocol) of 50 ms or less. The range of both characteristics was rather large.

#### **Effects of Distortion on Intelligibility-in-Noise Study**

A followup study to an experiment on tonal perception in hearing aids with high and low distortion involved evaluating the influence of the distortion on speech intelligibility in noise. Using a Modified Rhyme Test, we collected data on 30 subjects. The results indicated that nominally high harmonic and intermodulation distortion could not be shown to relate directly to a reduction in listener performance in noise. This work underscores the importance of the test arrangements in predicting the effects of non-linear distortion in hearing aids.

#### **Collection of Three-Band Listening Level Data**

Considerable interest has recently emerged in multiple-band compression systems for the acoustically handicapped. The rationale is that different compression ratios are required in different frequency regions and these should be "custom" designed for the individual. In the absence of psychoacoustic data which support the widespread need for such complicated signal processors for

hearing-aid users, collection of suprathreshold data (most comfortably loud and uncomfortably loud levels) in three frequency regions on a large population of sensorineurally-impaired patients has begun. The frequency regions are similar to those which some investigators have for multi-band compression circuits.

Data from this study will help predict the percentage of patients who may be candidates for multi-band compression applications. Without such basic information clinicians may be persuaded that all patients are potentially to benefit from such sophisticated systems when, in fact, only a small portion may qualify.

#### **Analysis of the Effectiveness of Dichotic Signal Processing**

Initial efforts have been completed in the area of dichotic amplification for the acoustically impaired. This mode of amplification (dissimilar frequency bands to the two ears) has intriguing theoretical advantages which have been inadequately explored. Progress has now advanced past the design stage and efforts are directed toward the complicated instrumentation phase. Using intelligibility materials in multi-talker competition, a comparison of performance in the dichotic mode versus conventional monaural and binaural modes will be conducted. Behavioral data are expected by late summer, 1977. This work may have a significant bearing on the nature of future amplification devices for hearing-disabled veterans.

#### **Binaural High-Frequency-Emphasis Amplification**

Although patients with hearing loss of ski-slope type have good hearing in the low frequencies, a recent study has demonstrated that they can benefit significantly from use of a hi-pass hearing aid in each ear. With one aid only, one might expect the good hearing for low frequencies on the unaided side to serve satisfactorily in providing a binaural effect. However, this was not the case. There was a 12 percent mean improvement when two aids were employed. In another study using patients with similar high frequency hearing loss, the contribution of various competing messages with three signal/noise ratios to the evaluation of hearing aids is being measured. The results can influence the development of a standardized hearing-aid evaluation technique badly needed within the VA.

**Clinical Application Study of Reading and Mobility Aids  
for the Blind  
Eastern Blind Rehabilitation Center**

**VA Hospital**

**West Spring Street, West Haven, Connecticut 06516**

**Donald E. Garner, William R. De l'Aune, Ph. D., and**

**Patricia D. Gadbaw**

During this reporting period a seminar on Low Vision and Mobility was held at the Eastern Blind Rehabilitation Center. Mobility instructors from the Connecticut State Agency for the Blind, the New York Association for the Blind, and from the Veterans Administration participated. At this seminar Ms. Gadbaw presented information about the Center's research on the use of prisms by blinded veterans with restricted visual fields. Dr. De l'Aune spoke to the group on research in general and its particular applications to the problems of the peripatologist.

A paper entitled "Optacon Skill Acquisition by Blinded Veterans" by Ms. Gadbaw, Ms. Mary T. Dolan, and Dr. De l'Aune was published in the *Journal of Visual Impairment and Blindness*, 71(1):23-28, Jan. 1977. This paper summarized much of the data on this device that has been accumulated in the past 4 years, and compares the EBRC findings with data obtained from other published Optacon projects.

Two papers by EBRC authors emphasized the importance of psychological attributes of the user of sensory aids in the efficiency of this particular man-machine interaction. The papers were: "Speech Compression: Personality Correlates of Successful Use" (*J. Visual Impairment and Blindness*, 71(2):66-70, Feb. 1977) and "Correlates of Successful Speech Compression Use by Blinded Veterans" (*in Proc. Third Louisville Conf. on Rate Controlled Speech*, Emerson Foulk, ed., New York, American Federation for the Blind, Inc., pp. 219-229, 1975). The authors in each case were Dr. De l'Aune, Mr. Chester Lewis, Dr. Walter Needham, and Mr. James Nelson. The papers also stressed the great potential of speech-compression systems as a communicative aid for the visually impaired.

A paper, "Personality Determiners of Successful Prosthetics and Sensory Aid Use", was presented by Dr. De l'Aune at the Fifth New England Bioengineering Conference in Durham, New Hampshire. It was subsequently published in the *Proceedings* (Michael Cannon, ed., New York, Pergamon Press, pp. 111-115, 1977). In this paper, based on the computerized accumulation of demographic, psychological, and medical data on EBRC clients, the personality characteristics of blinded veterans seen at the EBRC and the effects of these characteristics on their use of currently available aids were covered.

Dr. De l'Aune spoke about "Special Aids for the Blind" at the East Coast Visual Impairment Service Team (VIST) Training Seminar held in New Haven, Conn. He also served as a participant in a joint RSA/VA conference on sensory aids, which was held in San Francisco, Ca.

The research staff of the EBRC cooperated in the analysis of data obtained from a national survey of agencies participating in an RSA evaluation of the Snipas Glucose Analyzer. Through coding and computer processing, a statistical breakdown was provided to Mr. Howard Freiberger for use in this evaluation. Further analysis of this information at RSA is anticipated.

Research into the effects of hearing-aid use on the mobility performance of the visually impaired veteran is being continued by the research and mobility staffs of the EBRC. Because of the sharp increase in the number of blinded, hearing-impaired veterans participating in the blind center programs, the sample size is slowly being expanded to the point at which statistical analysis of the data can begin.

Ms. Gadshaw and Dr. De l'Aune were both involved with the training of a totally deaf and blind veteran to use and program an HP-25C calculator with the aid of his Optacon. The training was judged as successful and the client intends to use his new skills in pursuit of his engineering interests.

Preliminary meetings have taken place to evaluate the feasibility of a VA-sponsored series of meetings to design an inexpensive set of manuals and devices intended to provide a sensorially "normal" person with a simulation of visual and auditory impairments of varying types and degrees. While it was acknowledged that the truly realistic simulation of a great number of pathologies could not be accomplished, it was believed that with careful writing of the accompanying text, careful analysis of the tasks to be undertaken, and thorough understanding of the limitations of these simulators, such devices could be of great value.

**Compression Amplification and Speech Intelligibility in Noise**  
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The initial phase of this study is an investigation of the influence of various methods of compression amplification on speech intelli-

gibility, and an evaluation of the effectiveness of compression amplification in reducing tolerance problems when loud sounds are encountered. The three types of compression amplification systems under study are the automatic volume control (AVC), the fixed-ratio (2 to 1), and the variable-ratio compression systems. (Comparisons are also to be made between compression and conventional linear amplification systems in terms of speech discrimination ability in noise, and in measures of tolerance.)

A wearable master hearing aid with switch-selectable controls was designed and built by a hearing aid manufacturer for this study. The hearing aid is housed in a pocket-size package which is connected, via a miniature cable, to a post-auricular module. This module contains a forward-facing omnidirectional microphone and a receiver. The pocket package houses the battery, volume control, electronic circuitry and selector switches. An 18-inch cable connects the two units.

Measurements of the electroacoustic characteristics of the master hearing aid were obtained using the ANSI 1976 standard. Included in these measurements were the full-on gain, the HF-average of Saturation Sound Pressure Level 90 (SSPL 90), the frequency response, and the transfer function of the four different types of amplification systems. Furthermore, the amplitude non-linearities of the four systems were measured using three different distortion measurements: harmonic, difference-frequency, and intermodulation distortion.

Twenty-four subjects with bilateral sensorineural hearing loss will be used in this study. The Northwestern University Auditory Test No. 6 will be used as test material to assess subject's discrimination ability.

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

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**Digital Systems Applications to Hearing Aid Research**

Work performed at the Electrical Engineering Department of Colorado State University under the VA project on Digital Systems Applications to Hearing Aid Research, over the period January 1, 1977 to June 30, 1977 was as follows:

1. Design of a harmonic distortion tester — to facilitate controlled tests of harmonic distortion with controllable amplitudes and frequencies.
2. Design of a transient distortion tester — to facilitate controlled tests of transient distortions with controllable frequencies and overshoot rate.
3. Preparation of hardware and analog/digital interface system for final testing of a microprocessor staircase-approximation digital filter for use in hearing aids, where up to 6 discrete, controllable, frequency ranges are separately controllable, and completion of test procedure for above.