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AUTHOR	Yens, David P.
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ABSTRACT

The objectives of this project were to develop an audiometer-type terminal to be used in conjunction with computer-assisted instruction, to write a computer program simulating subjects with normal and abnormal hearing, and to field test the terminal and program with students and practicing nurses. This report presents the development of the simulated audiometer terminal, engineering aspects of the interface between the terminal and telephone line computer, the development of strategy and content for the course of instruction and practice and the programing of course content. Some encouraging results from preliminary field tests are also reported. (EM 011 037 through EM 011 043, EM 011 046, EM 011 047, EM 011 049 through EM 011 058 are related documents). (SH)

R-20

INTERIM REPORT

The Development and Evaluation of a Computer-Based Audiometer Trainer

Prepared by David P. Yens

Principal Investigators:

Bruce M. Siegenthaler
and
Harold E. Mitzel

Introduction

The beginning course in audiology (SPA 430) at The Pennsylvania State University is typical of the beginning course taught in audiology at colleges and universities across the United States. Approximately 150 institutions of higher learning teach such a course. To the investigators' knowledge, all of these courses teach at least some pure tone audiometric test technique, and include at least some audiometric test practice.

The experience at Penn State in offering the desired amount of pure tone testing practice to the enrolled students is typical. A class enrollment normally is between twelve and thirty students, two terms per year. At the present time, the requirement is that each student do a pure tone air conduction audiogram, for six frequencies in both ears, of at least ten practice subjects. (This requirement of ten audiograms is a minimum for development of adequate audiometric testing skills.) For a class of twenty students, this requires 200 audiometric tests. The number of subjects available for testing is limited. It is typical for the students to be listeners for each other as they administer audiometric tests for practice. However, this exchange of time has a severe limitation in that nearly all students in the course have normal hearing. It is impractical to use clinic patients for student testing, both because of the responsibility for professional level of services to clinic patients, and because of the limitations on the time that can be demanded of a clinic patient for testing practice by students.

During their testing practice, students normally are unable to test subjects with a variety of hearing disorders or with a variety of patterns of response. A related problem is that, in order to do tests on human subjects, an

Note to accompany the Penn State Documents.

In order to have the entire collection of reports generated by the Computer Assisted Instruction Lab. at Penn State University included in the ERIC archives, the ERIC Clearinghouse on Educational Media and Technology was asked by Penn State to input the material. We are therefore including some documents which may be several years old. Also, so that our bibliographic information will conform with Penn State's, we have occasionally changed the title somewhat, or added information that may not be on the title page. Two of the documents in the CARE (Computer Assisted Remedial Education) collection were transferred to ERIC/EC to abstract. They are Report Number R-36 and Report Number R-50.

— Jaclyn Caselli, ERIC/EM

audiometric sound-isolated room is required for each testing station. These rooms not only take up considerable floor space, but are expensive to provide for student practice, and normally are not available in sufficient quantity with necessary audiometric test equipment.

It is clear that in order to provide students-in-training with adequate audiometric test practice experience, techniques not now available will have to be developed.

In addition to students-in-training, there is another large group of audiometric test practitioners. These are school and industrial nurses. In many states, it is required that each year school children receive pure tone hearing tests. Usually these are administered by the school nurse, although in some places speech therapists or technicians may be used. In industrual situations, the plant nurse very often is required to do the intake audiogram and monitoring audiograms of the workers employed in noisy environments. This group of in-service school and industrial nurses comprises a much larger group than audiology students-in-training.

In the typical nurse's training program no specific work is given in administering audiometric tests, or there is no more than a lecture or two about hearing testing. When the nurse finds herself on the job with the requirement to do audiometric testing, she typically is able to do little more than read the manufacturer's book about her audiometer and to talk to the hearing aid and audiometer distributor. These sources of instruction are woefully inadequate.

In some instances, the state department of health or education personnel are able to give school nurses some field instruction, but the situation in Pennsylvania is not atypical. In the Department of Health, which is charged with the responsibility for the statewide school testing program, there are two employees in the audiological and hearing conservation area. There are two state level employees in the Department of Public Instruction. Although they have attempted to instruct the school nurses in Pennsylvania on proper test procedures, they can do little more than make occasional contacts with the nurses. An automated program for providing school and industrial nurses with a short intensive course in good hearing test administration practice would help alleviate this serious problem.

The concept of developing a computer terminal and programing the computer to play the role of a person with hearing loss is consistent with the developing of concepts of using computers to simulate patients having various diseases and utilizing the computer to assist in medical diagnoses (Feurzeig and Swets). Not only does the student-in-training have the opportunity to be presented with a wide variety of symptoms, he also has the opportunity to have a wide variety of untiring "patients."

The computer-simulated subject for a hearing test provides several advantages. The actual duration of each tone given to a "patient" can be measured, and given to the student. Student audiometricians can follow a sequence of increasingly difficult patients to test. The student can report the results of his test findings to the computer, and immediately have them checked against the correct hearing status. He then can be led into a repeated series of tests of the same or different patient ears, depending upon his level of test competence. The computer simulation of hearing test situations can provide a student with as much practice as he desires upon his own demand, or as much as he needs according to his proficiency. It is well within the capabilities of the present computer state-of-the-art to provide such things as temporary threshold shift in an audiogram, variabilities in attention, patient fatigue, a wide variety of audiometric test patterns, responses typical of subjects with non-organic hearing loss, and responses for tests other than threshold (loudness balance, equal loudness contours, difference limen for loudness, short increment sensitivity index, and so forth.)

The specific objectives of the present project were:

1. To develop an audiometer-type terminal to be used in the computer-assisted instruction setting in conjunction with existing hardware.
2. To write a computer program simulating subjects with normal hearing and with threshold hearing losses, including the typical types of audiometrics patterns normally seen in clinical practice.
3. To make a field trial of the computer terminal and its associate teaching program, using University students-in-training and a sample of practicing nurses.

Procedure

The development and programing of the simulated Pure Tone Audiometer consisted of five phases:

1. Development of simulated audiometer terminal.

2. Engineering aspects of the interface between simulated audiometer terminal and telephone line/computer.
3. Development of strategy and content of course of instruction and practice.
4. Programing of course content for the IBM 1500 computer system using the Coursewriter II language.
5. Tryouts of material with audiology students and practicing nurses, with concurrent program corrections and modifications as necessary

At this time, Phases 1 through 4 have been completed and Phase 5 is in progress.

A diagram charting the development of each part of the project is found in Figure 1.

Development of Simulated Audiometer Terminal and Interfaces

American brand pure tone audiometers, although produced in a variety of sizes and models by several major companies, have several common features. A representative audiometer panel was designed that incorporates these common features.

The audiometer panel is mounted in a box similar to that of a standard clinical American pure tone audiometer. Dial labeling, knob size, and so forth, represent the generally accepted practice in the field. The essential features and typical characteristics of a standard pure tone American audiometer are included with labeling indicating International Standards Organization - 1964 calibration. The audiometer panel contains the standard audiometric elements of:

1. Frequency selector (octave frequencies and half-ocatve frequencies 125 through 8000 Hz as on most audiometers)
2. Hearing level dial (in five-decibel steps from minus ten through 110 decibels)
3. Tone interrupter switch
4. Power on · off switch and light
5. Masking sound level control
6. Right earphone, left earphone, bone conduction output selector switch
7. Patient signal light
8. Operational switch for SISI test administration
9. Operational switch for loudness balance testing

Activity	Time Devoted to Activity
1. Specification and location of typical audiograms	July 1967 - September 1967
2. Course objectives	September 1967 - November 1967
3. Design, production, testing of ATU by IBM	September 1967 - April 1968
4. Learning of material and sequencing of objectives	October 1967 - February 1968
5. Design of ATU panel	October 1967 - November 1967
6. Preparation of Part I frames, analysis procedures, and remedial sequences	November 1967 - May 1968
7. Installation of 1500 System	January 1968
8. Trial computer programs for panel analysis	January 1968 - April 1968
9. ATU debugging and modification	April 1968 - July 1968
10. Coding, testing, and revision of Part I	April 1968 - December 1968
11. Preparation of Part II frames	March 1968 - September 1968
12. Coding, testing and revision of Part II	August 1968 - March 1969
13. Design, coding, testing and revision of Part III	December 1968 - March 1969
14. Preliminary tests with subjects	March 1969 - April 1969
15. Program revision	March 1968 - May 1969
16. Final subject trials	April 1969 - May 1969

Fig. 1. Chronology of development and programming of simulated pure tone audiometer.

10. Tone warble switch
11. Tone normal on - normal off switch

A photograph of the completed panel is provided in Figure 2.

Engineering design, development and production of the simulated audiometer terminal, or Audiometer Trainer Unit (ATU), and interfaces were done by the Federal Systems Division of IBM, Gaithersburg, Maryland, on a subcontract basis. The terminal was designed to interface with a telephone line to an IBM 1400 series computer system or directly with the IBM 1500 instructional system. Photographs and specific design. development, interface, and programing considerations are provided in the IBM publication included as Appendix A of this report. An instructional manual for the ATU by IBM is Appendix B.

The ATU was connected to the IBM 1500 Instructional System at Penn State on April 15, 1968. However, an additional modification had to be made to permit the timing of a "tone" given by a student. Consequently, the ATU was not fully operational until July, 1968, although it could be used to some extent for program development.

Development of Course Strategy and Content

One of the final objectives of a basic course in audiometry is for the student to be able to use specified techniques of threshold finding to obtain audiograms from subjects with a variety of hearing and response characteristics, and be able to be within ± 5 dB of the correct hearing level at each frequency.

The initial phase of this project consisted of analyzing the threshold finding task to determine the required skills and in what order they should occur. During all development phases, close cooperation with subject matter experts was maintained. From this analysis emerged a set of behavioral objectives that would form an initial framework for course development. They were placed in an initial sequence, based on the task analysis, that provides a stepwise learning experience in which primary skills are learned first. As proficiency in primary skills is developed, new skills are integrated in a pyramidal fashion until all skills are brought together and the desired proficiency is attained.

These objectives are listed in their approximate sequence in Table 1. It can be seen that the sequence is quite logical, and generally approximates the

Table 1

Sequence of Behavioral Objectives

Unit 1

The student will be able to:

1. Turn on the audiometer
2. Manipulate the tone switch in accordance with accepted procedure.
3. Manipulate the following and set them as directed:
    a. Channel 1 Output
    b. Channel 1 Hearing Level
    c. Channel 1 Frequency
4. Set the following to their off positions and leave them off during basic audiometric testing:
    a. SISI
    b. Tone Warble
    c. Tone Norm
    d. Channel 2 output
    e. Channel 2 Hearing Level

Unit 2

The student will be able to:

1. Recognize correct placement of earphones on a patient
2. Properly use the method of limts with limited direction for finding hearing thresholds.
3. Determine the estimated threshold for each pass and specify the final obtained threshold for a frequency.
4. Plot the obtained threshold on an audiogram form.
5. Describe the elements of the threshold finding technique.

Unit 3

The student will be able to use the method of limits to obtain hearing thresholds without guidance. He will test frequencies in the appropriate order and perform all activities required in testing.

sequence of learning provided in the classroom. However, in the classroom there is little opportunity for guided practice at each stage.

It was decided that the objectives be divided into three basic units, as indicated in Table 1. The first unit consists of familiarization with the audiometer panel - how each switch and dial works and what it does. The second unit consists of initial guided practice in threshold finding and specification of the specific techniques used. The third requires the student to work with little direction in finding thresholds (using the fading technique) and permits him to build proficiency in dealing with different types of threshold patterns. He is provided with the opportunity to check his work (obtained audiogram) at once.

Following the specification and sequencing of objectives, a program was written on paper that consisted of each display that would appear on the cathode ray tube (CRT) or image projector and the analysis of the logical responses that could be made, either correct or incorrect, with the results of each. This constituted a "dry run" program that could be reviewed, tested, and changed easily before actual computer programing was initiated. A portion of an early version of this type program is found in Appendix C. This type of program was very useful for Part 1, but less useful for Part 2, and of little use for Part 3, which is highly unstructured.

During this initial programing phase, an analysis of the entry skills and abilities of probable students was made to determine whether initial instruction or review was appropriate to each objective. Beginning students in audiometry would have attended an introductory lecture; for them most of the objectives would require original learning. However, a second source of students would be nurses who may or may not have had experience in audiometry. Consequently, an option to skip the introductory section was included but which required the demonstration of proficiency in setting the panel before the skip could be completed. Failure on this pretest starts the student at the beginning of the instructional material.

The written version of Unit 1 was tested with a limited number of students. As each frame (text display) was shown to the student, he responded verbally or on the ATU. The author simulated the computer by providing feedback and proper sequencing of frames based on the responses. This actually provided added data on student response characteristics, and allowed modification of the program prior to programing for the computer. The written version was useful for Unit 1 because this unit primarily consisted of instructional frames with a variety of branching possibilities. Unit 2 was basically guided practice in giving audiograms, for which written simulation was of little use.

Computer Programing of Course Material

The Coursewriter II language was used for programing. Much of the program input was done on-line to permit immediate tryout of the entered material, but card input was used when possible.

The terminal used for students consists of an IBM 1510 keyboard and display screen with light pen, an IBM 1512 Image Projector, and the Audiometer Training Unit. Computer control can be given to any of these elements, and inputs can be made from the 1510 or ATU. Output and source of input is under program control; an input cannot be made from more than one unit at the same time.

Although a textual representation of course material provides a framework which would greatly simplify the programing of ordinary instructional material, the use of the ATU required a much more complex program which required a great deal of programing time. Without the initial text, however, the course development would have been exceedingly difficult.

Problems Unique to This Program

It was decided to maximize student use of the ATU during all phases of the program. In order to monitor student responses, it was necessary to "read" and evaluate the ATU each time the student responded.

The ATU input to the computer is an eight bit word with each bit representing the setting of one switch or dial. An example of one word, with the meaning of each bit, is given in Figure 3. The correct answer can be easily determined by comparing the input with the correct word which was previously stored. However, it was considered important to tell the student exactly where he made an error if the panel setting was wrong. To do this, the input word had to be broken down into eight parts and each part compared with a conversion table. For example, if the word in Figure 3 was the correct "answer" but the student

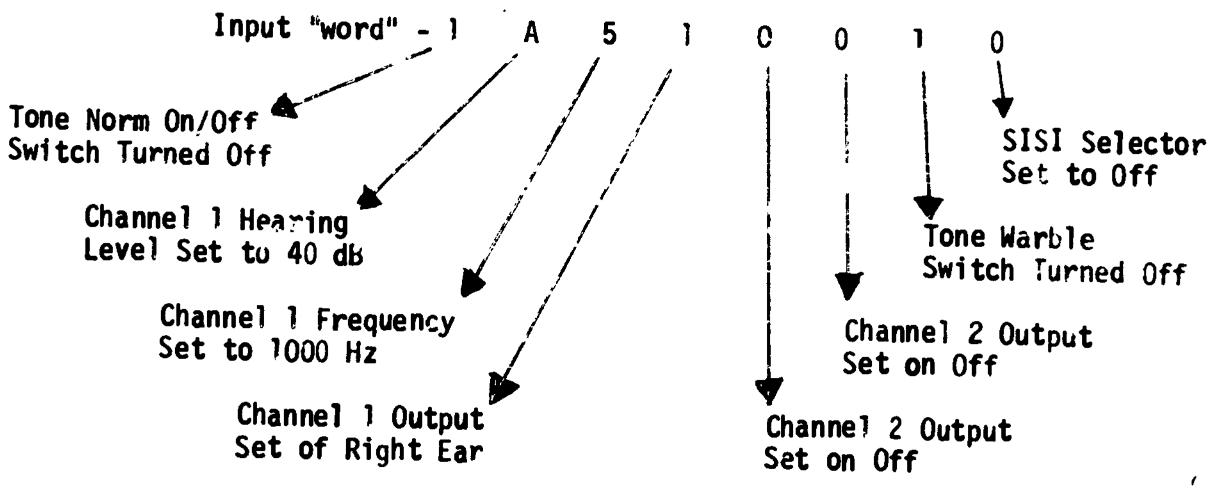

Fig. 2. Interpretation of the input to the computer from the ATU.

response was 1B510010, the computer would detect a mismatch of the whole word and then examine each part to determine where the mismatch occurred. In this case, it would detect a match on the first bit but a mismatch on the second bit. It would then enter a table specifically related to Channel 1 Hearing Level and look for a match for the input value (in this case, the B). When it found the match, it would store the associated value (45) in a location where it would later be used in a message to the student. The program would then test the remaining bits and find a match for each one. After the completion of the tests, a message to the student concerning a change in Channel 1 Hearing Level would be displayed. This process had to be repeated for each input through the ATU.

A second programing requirement was to time the duration of the tone given by the student with the audiometer. The tone switch (or interrupter switch) transmits the word describing the panel each time it is depressed and again when it is released. The real time in seconds between depression and release is measured with a complex process that minimizes the effect of activity at instructional terminals other than the ATU. The time measurement is displayed for the student and evaluated as a part of the instruction to him regarding audiometric technique.

The complexity and anticipated length of the program caused program efficiency and brevity to be major factors in program development. Because of the newness of the IBM 1500 system and Coursewriter II, it required many months before enough was known to insure an optimally efficient routine; many versions of cricical sequences were coded and tested before they ran with adequate speed. This was important to insure rapid feedback to the student. For example, much of Unit 2 consists of leading the student t[illegible] threshold finding procedures. To make this experience as realistic as possible, a patient is displayed on the terminal display screen (see the display screen contents in Figure 4). When the student gives a correct tone that the patient can hear, the patient's hand is raised. When the tone stops (release of tone switch), the hand is lowered.

It was essential that the patient's hand be raised within one second of the depression of the tone switch to simulate a realistic patient. However, in this interval the panel would need to be checked for correctness and the timing process started before the hand could be raised on the screen. Initially, this process was much slower than acceptable, and it took three months, many revisions of the program, and an investigation of alternatives to the raised hand to find a solution that was acceptable.

It was decided to write the patient's hand and time sections as subroutines because these same coding sequences were used by over one hundred frames. The length of coding of these sequences, if repeated over 100 times, would be excessive. It was determined that by proper placement in the sequence of frames, accessing time could be minimized and much space on the disk storage would be saved.

The complex coding to measure the duration of time between tone switch depression and release was necessitated by the fact that thirteen instructional terminals are attached to the computer on a time sharing basis. Each terminal is processed in turn, if processing is required; processing continues until, the program reaches an instruction (an ep) to look for a new response from that terminal, until a specified number of instructions have been processed, or until processing is interrupted by a job with a higher priority. At this point, the processing goes on to the next terminal. Because of computer cueing, the time being measured between two responses might be interrupted by the processing of information from other terminals. To overcome this it was necessary to read the computer's internal clock before each response request (ep), time the latency of each response, and then calculate the actual duration from these four measures.

The obtained time is tested against limits for tone duration (2 to 4 seconds is the acceptable limit); if it is within the correct range, the time is displayed to the student. If it is incorrect, a counter is incremented to store the error and the time is displayed with a message indicating whether it was too short or too long as well as a statement of the correct length.

The most difficult problem faced was the efficient analysis of the eight bit input word from the ATU. Because it is instructionally desirable to minimize the time between response and feedback, the initially obtained processing times of four or more seconds were unacceptable. As with the raising of the hand, a variety of programing techniques were attempted before an acceptable one was found.

The resulting method uses a drop through procedure. The input word is first tested for correctness. If correct, feedback is provided and the next frame in the sequence is presented. If incorrect, the bits in the word are sequentially tested. If a bit is correct, the program drops through to test the next bit. If incorrect, the bit is used to enter a table to determine what position on the dial or switch it represents. This position is stored for later use and the program goes on to look at the next bit. The program looks at each bit in this way until it reaches the end of the word, at which point a message is displayed that points out each of the errors made, states what should be done, and requests the student to try again.

This process was simplified somewhat when it was decided to group four of the bits, representing little-used functions, into one unit for analysis. Other shortcuts were taken where it was pedagogically feasible.

The Program of Instruction

The table of objectives (Table 1) provides a general overview of the program. Based on extensive classroom experience with students in audiology, it was decided to use a maximum of practical "hands-on" experience with the Audiometer Trainer, with as little theoretical explanation as possible. This is consistent with the view of experts in programed instruction that each frame should be objective-oriented and that unnecessary enrichment will tend to confuse the student and inhibit progress toward the objective.

The plan of the course consists of a main-line sequence of frames with remedial branches from each frame contingent upon the student's response. Extensive student control of the program is provided through giving the student the option of review or repetition of material at several points and through permitting him to skip sections if he desires. If he skips a section unwisely, however, the remedial branching capability will provide him the opportunity to learn what he missed. At the end of major instructional units, the student's performance for that unit is displayed and recommendations are made concerning his continuation (e.g., go on, review, or go through the section again.) However, the continuation option is left to the student.

Unit 1

It was determined that all familiarization with audiometer panels and learning of threshold-finding techniques should be done with the ATU, although it would be preceded by one lecture concerning the topic. Unit 1 provides familiarization with the functions of each of the elements of the ATU panel and provides graded experience in the use of the commonly used ones.

The student initially learns how to turn on the panel power switch and how to use the tone switch. The concept of giving a tone for a specific duration is introduced during the use of the tone switch, and the tone duration is timed and displayed to the student after each tone input. Practice in giving tones for the correct duration is provided at the student's option after initial familiarization.

Use of and practice in setting the major switches and dials are provided one by one in order of importance. Practice with each one is provided before the introduction of the next, then practice with all those learned is given. Finally, the student is given instructions to set the panel in different ways using all the elements of the panel. Upon successful completion he goes on to Unit 2.

Instruction is provided primarily by the display screen; instructions are given concerning where to find and set the panel elements. However, upon unsuccessful solution of a problem, a slide (frame of film on the image projector) is displayed showing the panel and the way it should be set. Although it would have been feasible to introduce each panel element with a picture, it was decided that subjects would gain better familiarity with the panel if they had to look for each element.

After learning the elements of the ATU panel, the subject is given the opportunity to use a standard portable audiometer in order to hear for himself what the different switches do and how the tones sound.

Unit 2

Unit 2 consists of training in the threshold finding technique. It is introduced by a review of the placement of earphones, with slides used to demonstrate correct and incorrect placement. The student is introduced to the method for determining the starting hearing level of a test, and he is then directed through a test procedure of all frequencies of the right ear, with a variety of thresholds and patient responses represented. During this series the student interacts with a patient on the display screen which raises its hand if the tone is above the programed threshold. The student is directed to give a specific hearing level each time; a running account of the levels tested and the response is provided on the display screen, and at appropriate points the student determines the estimated or final threshold. All panel elements are monitored so that if the student makes an error he receives a message telling him what he should have done and giving him the opportunity to repeat the tone correctly.

Toward the end of the testing of the right ear, the student is successively asked to guess what the next hearing level for a frequency will be, and finally types each hearing level value before he gives the tone. In this way, he gains familiarity with the process being used before he actually has to reproduce it on his own.

After each frequency, the student uses the light pen to plot his obtained threshold on an audiogram form displayed on the display screen. For the right ear, a circle is placed on the screen after successfully indicated by the student. After plotting the point on the screen, he marks it on a standard form. Thus, he completes the form as he would during the normal testing of a patient.

Following the test of the right ear, the student's performance is displayed and options for review or further practice are provided. This is followed by a review of the techniques used in which the student specifies the specific step-by-step procedure he used, indicating his responses on the keyboard. In this way, specific knowledge of the steps can be assessed and any misconceptions corrected before the student progresses to Unit 3.

Unit 3

In this unit the student is introduced to the need for a limited interval between tones. He is then allowed to test the left ear of the subject with a minimum of direction, using the procedures learned in Unit 2. Thresholds are programed for each pass (ascending and descending) within each frequency, and those thresholds usually differ slightly within each frequency so that a third pass will usually be needed. Further audiometric patterns are used in this test, which simulates more closely the testing of a live patient. If the student desires, he may obtain information on the duration of his tones and pauses.

After completing the test of the left ear, the student enters his obtained thresholds via the keyboard, and may then compare his audiogram with the correct one.

This unit is currently undergoing some revision to improve the monitoring capability. It was initially used to determine how well students learned from the first two units, with the result that some additional correction capability is needed, especially for a frequency that has a threshold significantly higher than the preceding ones. As indicated in the following section, students are generally successful in finding the correct thresholds, but observation of their behavior indicated that some correction of their technique is occasionally needed.

Examples of the programing of the preceding units are provided in Appendix D.

The threshold finding technique taught is essentially the method of limits, with a descending loudness-of-tone to cross threshold, an ascending loudness-of-tone to cross threshold, and another descending loudness-of-tone to cross threshold again. The lowest dB level at which two of the three estimates of threshold agree (one estimate for each threshold crossing) is taken as threshold. Decible steps are 10 dB initially, and 5 dB when operating near anticipated threshold.

Results of Preliminary Tryouts[1]

Subjects

1. Six of the ten subjects were upperclass students in speech and hearing and were taking a class that taught the use of the audiometer. (One male, five females.)
2. Two subjects were registered nurses, although they were not presently involved in nursing and had no experience with an audiometer.
3. One subject was previously a speech and hearing technician.
4. One subject was completely naive to audiometry.

Summary of Performance During Unguided Testing (Part III)

Table 2

Per Cent of Students Who Found Correct Hearing Level or Were Within 5 dB of Being Correct N=10

	125	250	500	1000	2000	4000	8000
Students that found exact hearing level	60%	80%	60%	20%	60%	50%	60%
Students that found hearing level within 5 dB	20%	10%	20%	70%	40%	10%	30%
Total	80%	90%	80%	90%	100%	60%	90%

N. B. 1. Audiometricians are considered correct if they are within 5 dB of exact hearing level; therefore, the students usually found the correct hearing level.

2. 1000Hz is the first frequency tested. This may account for the fact that only 20% of the students found the exact hearing level at this frequency because the students had to adjust to testing the patient without the aid of the computer program.

3. After testing at 1000Hz, students progressed rapidly to more correct responses at different frequencies.

4. The completely naive subject had four (out of seven) correct responses on his audiogram within the 0-5 dB category

[1]This section prepared by Mrs. Irene Cashell.

Table 3

Added to Table 2 is the Per Cent of Students Who Were Incorrect in Their Response by 10 dB or More

	125	250	500	1000	2000	4000	8000
Students that found exact hearing level	60%	80%	60%	20%	60%	50%	60%
Students that found hearing level within 5 dB	20%	10%	20%	70%	40%	10%	30%
Students that established hearing level at 10 dB or more	20%	10%	20%	10%	00%	40%	10%
Total	100%	100%	100%	100%	100%	100%	100%

N. B. On the average only one subject missed each frequency by 10 dB or more.

Student Attitudes

A summary of student attitudes toward the audiology program of instruction and the ATU is provided in Table 4.

Table 4

Per Cent of Students Agreeing or Disagreeing With Questions Regarding the Procedure

	Liked computer method of learning	Course paced correctly	Course was easy to understand	Prefer CAI to human practice	Liked variety of thresh-holds	Subject matter was taught correctly	Liked panel on simulated audiometer
Subjects agreeing	70%	40%	70%	80%	90%	90%	100%
Subjects disagreeing	10%	60%	10%	20%	10%	00%	00%
Noncommital subjects	20%	00%	20%	00%	00%	10%	00%

N. B. 1. The verbal questionnaire encouraged the subjects to discuss the program.

2. The majority of subjects liked the CAI method.

3. Most subjects thought the course was not paced correctly, although it was actually a self-paced course. Thirty percent thought it was too fast. (One subject said she was a slow reader; and another one said that since she was from a foreign country, she had some difficulty with the vocabulary.) Thirty per cent of the subjects thought it was too slow.

4. Seventy per cent thought the course was easy to understand.

5. Eighty per cent of the subjects prefered computer practice to practice with humans, although many of these said they preferred to use the computer practice as a review after some techniques were taught in the classroom.

6. Practically all subjects liked the variety of thresholds and felt the content of the course was taught correctly.

7. All subjects liked the panel of the simulated audiometer.

Future Work

Units 1 and 2 are essentially complete, although some minor changes may be made if warranted by the performance of future students. Unit 3 is being revised to improve its monitoring capability, but efficiency here, as before, is a major consideration. New analysis procedures are being developed that permit maximum flexibility in student responses.

It is believed that the program as it currently exists provides more than adequate initial training in the techniques of threshold finding, as indicated by the performance of the students who have been through it. However, in order to provide a greater variety of experience with audiometric patterns, sixty additional audiograms are being added. These have been drawn from the files of the Speech and Hearing Clinic at Penn State University and will provide authentic problems to enrich the experience of student trainees in audiometry.

Reference

Swets, J. A. and Feurzeig, W. Computer-aided instruction. *Science*, 1965, 150, 572-576.

Appendix C

Example of a "Dry Run" Program

2.

dt: The device you will work with most is the Pure Tone Audiometer simulator which you see to your right. It is similar to commercial Pure Tone Audiometers but it is connected to the computer. In this computer-assisted course you will learn its basic operation and will use it to practice giving hearing tests. The first thing you'll get is a basic introduction to the use of the audiometer panel.

If you have used an audiometer before, you can skip the introduction (if you can pass a test)

If you have never used an audiometer before - press the light pen here. If you have used one to some extent and want to skip ahead, - press the light pen here:

ep:

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ca: (none) - #3

aa: (used) - Branch Br 1

un: Message C [light pen error - try again.]

3.

dt: 1. POWER SWITCH

Look at the audiometer panel. As you might expect, the first thing to do to the machine is to turn it on. The power switch is located in the upper right-hand corner of the panel. Turn it on now, then do the following:

If the light next to the power switch came on, press the light pen here:
If the light did not come on, press the light pen here:

---

ca: Light on - #6
wa: Light not on - #4
un: Light pen in undefined areas - Message C

4.

dt: You indicated that the light did not come on.
The light may not be working properly, or you may have the wrong switch. The light is just under the word POWER in the upper right-hand corner, and the switch is just to the right of it.

Flip the power switch up.
If the light still does not come on - press the light pen here:
If the light does come on - press the light pen here:

ep:

---

wa: Light still off - #15
ca: Light on - #6
un: Response not in allowable area - Message C

5.

dt: Apparently you are still having a problem. The switch you should be working with is highlighted on the display screen. Try it again.

If it works this time, press the light pen here:

If it still does not work, press the light pen here:

Slide of the audiometer panel. Highlight "on" switch.

---

ca: YES - #6

wa: NO - proctor message (machine malfunction)

un: Message B

6.

2. TONE NORM ON/OFF SWITCH

dt: The TONE NORM ON/OFF switch (near the center of the panel) determines whether a tone in the earphone is normally on, or normally off. If you wanted the tone to be normally on, you would set the switch to TONE NORM ON. To have the tone normally off, you would set the switch at TONE NORM ____________________ [type the answer.]

ep

---

ca: OFF - #7

wa: ON - #6a

un: Message B

6a

dt: You said that you would set the switch at TONE NORM ON. This would be correct if you wanted the tone to be usually on, but to have the tone normally off, you would have to set the switch at TONE NORM________________________.

ep:

---

ca: OFF - #7

un: #6b

6b

di: The tone is normally off when the switch is set to TONE NORM OFF

dt: #7

7.

dti: Right

3. TONE SWITCH

dt: When you are giving hearing tests, you will usually have the tone normally OFF (tone normally ON has special uses.) You will present the tone to the patient by pressing down the TONE switch, located in the lower center of the panel. In other words, when the TONE NORM ON/OFF switch is set to TONE NORM OFF, you can turn the tone on by pressing the ____________________ switch.

ep:

---

ca: TONE - #8 with dti_1 8

aa: INTERRUPTER - 7a

ab: T* - 7b

un: 7c

Addendum

Due to production costs and the time element, the following figures and appendices are omitted from this file copy:

Figure 2: Photograph of the ATU panel

Figure 4: Photograph of a student using the ATU. The image of the man with his hand up is on the display screen; an inset shows the man with his hand down.

Appendix A: IBM report on the ATU: Theory and Maintenance Instructions

Appendix B: IBM report on the ATU: Instructional Manual

Appendix D: Printouts of the following course sections:

Part 1 - FR1 through FR7A
Part 2 - FR52 through FR69 and RECAP through FR170