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ABSTRACT
              This summary of the first study of student
performance in the on-going CAI theory program at Stanford describes
the principal features of drill and practice CAI lessons, the
resistance to CAI by music faculty, and the objectives of the
project--to find the statistical correlations between student
performance in the CAI ear training program and data about the
participants' musical backgrounds, and to survey the students'
attitudes toward the program. Three Hypotheses were tested: (1) there
are correlations between the learning of intervals and chronological
age, sex differences, and musical background; (2) there is an order
of difficulty in which intervals are learned; and (3) students prefer
drill-and-practice CAI instruction to the traditional classroom
setting for repetitive drill. Statistical correlations were set up
between items from a background questionnaire and the systematic
errors recorded by the computer; students were surveyed again at the
end of the course to determine their attitudes toward CAI. Results
provided support for each of the hypotheses; however, it is
recommended that the findings be tested further with a larger number
of subjects and control groups. A description of the hardware and
software used is included, as well as the questionnaire used for
background information. (Author/JEG)

COMPUTER-ASSISTED INSTRUCTION: A STUDY

OF STUDENT PERFORMANCE IN THE STANFORD CAI EAR-TRAINING PROGRAM

A RESEARCH PAPER

PRESENTED TO

THE MUSIC EDUCATION RESEARCH COUNCIL

MUSIC EDUCATORS NATIONAL CONFERENCE

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By

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INTRODUCTION

A decade ago the use of computers as in▆▆▆▆▆l devices was an idea
that was being considered by a handful of s▆▆▆▆▆d educators. Today,
computer-assisted instruction, like other aspec▆▆▆▆tronic data pro-
cessing, ha▆ undergone a rapid development which m▆▆▆ attributed, in part,
to its potential for answering a current pressing need in education--the
consideration of the individual who is being taught.

The most popular kind of computer-assisted ins▆uction is the drill-and-
practice type which permits a teacher to set up quantitative or qualitative
problems which give his students practice sessions on materials requiring
much repetition for mastery. The advantage of this system over earlier
techniques is its capacity to accumulate information about each student's
performance so that the progress of his skill or concept development is
available to the instructor. This particular feature of drill and practice
has vast implications for educators. It greatly reduces the amount of book-
keeping traditionally required of instructors who attempt to keep detailed
records of students' progress, for when a student answers questions at a
computer terminal, it is possible to record a complete profile of his re-
sponses and the time he uses for each one. The collection of these responses
is automated and therefore invisible to the student--a feature which is a
bonanza for educational researchers who have been faced with serious diff-
culties in the past in investigating human learning and performance. Teams
of research workers observing in a classroom disrupt the process under ob-
servation. There has also been the problem of obtaining adequate samples of
subjects willing to work on problems solving tasks for protracted periods of

time. The advent of CAI makes it possible to circumvent these obstacles.

Although computer use is well established in business and industry and in the educational subject areas of mathematics and languages, its use in music has been limited to scattered projects throughout the country. The traditional poverty of music programs and departments is partly responsible; but so too is the suspicion with which many musicians regard any type of mechanical encroachment on music. Yet, music is a discipline which is spiral, requiring much drill and repetition for mastery of basic concepts. The President's Advisory Committee in Education has reported that while CAI has not yet become an important part of undergraduate work in such fields as English, history, music, and art, faculty members in some of these fields are making increasing use of computers in research and computers are beginning to find their way into undergraduate instruction in the humanities. Regardless of an apparent lack of interest by music instructors, the computer's possible potential should be examined carefully before its implementation is declared invalid in the teaching of their discipline.

I. Purpose of the Study

During the Spring Quarter, 1973, Stanford's music department began an experimental computer-assisted instructional program in ear-training under the direction of Professor Wolfgang Kuhn. Thirty-six students in undergraduate music classes were given access to drill-and-practice equipment to aid them in their study of intervals. Although the program was not a mandated part of the curriculum, the students were encouraged to take advantage of the opportunity made available to them.

The purpose of this project is twofold: to find the statistical correlations between student performance in the CAI ear-training program and data about the participants' musical backgrounds, and to survey the students' attitudes toward the program. The data was gathered in a questionnaire and survey administered to the group at the conclusion of the course. Information regarding student performance, i.e. errors, correct responses, and number of sessions and minutes per session, are stored in the computer and are available for evaluation of experimental CAI programs.

This project grew out of the need to know how effective CAI drill-and-practice is when applied to the acquisition of musical skills. As part of this problem, there is need to establish the differences in learning that may be refelcted in the students' background, training, experience, and personal characteristics. Moreover, teachers have long wanted to know if there is a scale of difficulty in learning musical skills. This research is a beginning step in that direction.

II. Hypotheses Tested in the Research

This paper is an investigation of the performance of those students from music classes who have participated in the CAI ear-training program.

Relationships between the computer's data on students' performance and their musical backgrounds and training is the focal point of the study.

The hypotheses that are tested in this study are:

1. There are correlations between the learning of intervals and chronological age, sex differences, and musical background and training.

2. There is an order of difficulty in which intervals are learned.

3. Students prefer drill-and-practice CAI instruction to the tradi- tional classroom setting for repetitive drill.
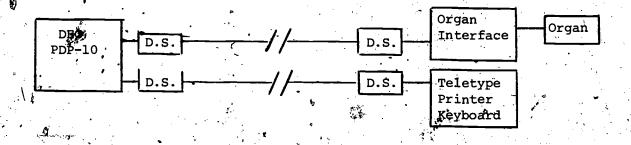
The steps of the project include: (1) formulation of the background questionnaire and attitude survey; (2) administering the questionnaire and attitude survey to the music classes; (3) setting up statistical correlations between questionnaire items and the systematic errors recorded by the computer; and (4) evaluation of the program by the students.

PART II

A DESCRIPTION OF THE STANFORD EAR-TRAINING PROGRAM

The hardware for this operation consists of a Digital Equipment
Corporation PDP-10 computer and a Thomas solid state electronic organ.
Communication between the two is over switched telephone cables. An organ
interface that allows the computer to "play" the organ is driven by the
program that resides in the PDP-10. A teletype printer and keyboard acti-
vates the various programs in PDP-10 to play the organ. Fig. 1.

```
+----------+   +------+              +------+   +-----------+   +-------+
| DEC      |---| D.S. |----//--------| D.S. |---| Organ     |---| Organ |
| PDP-10   |   +------+              +------+   | Interface |   +-------+
|          |   +------+              +------+   +-----------+
|          |---| D.S. |----//--------| D.S. |---| Teletype  |
+----------+   +------+              +------+   | Printer   |
                                               | Keyboard  |
                                               +-----------+
```

The student sits at the teletype printer where he gives and receives
information through the keyboard and the computer print-out. The organ at
the same site is played automatically upon receiving directions from the
computer.

In a typical lesson the student begins the lesson by typing X, where-
upon the computer greets the student with a typed "Hi;" and a request for
information from the student. The date and time are automatically typed
and recorded by the computer, as is the entire lesson. The student may be
returned by the computer to a previous lesson or be presented with a new
one. The student has the option of leaving a lesson at any time to termi-
nate the proceedings or to select another "strand."

Fig. 2 is the print-out from a typical session at the teletype terminal. The intervals to be identified by the student are major and minor seconds, and minor thirds. When the computer-directed organ plays an interval, the student identifies it by typing his answer. He has the option of typing Z to have the interval replayed before he attempts to identify it. When an answer is given, the computer responds with a positive comment if the answer is correct or a negative one if the answer is incorrect. In the latter situation, the student is given another opportunity to identify the interval. If he misses it a second time, the correct answer is given to him, and the interval is repeated.

At the conclusion of the strand, the number of problems answered, the number of minutes of the lesson, and the percent correct are given to the student. This print-out sheet may be kept by the student and provides him with a record of his work at the terminal. In this way he can evaluate his own work and measure his progress.

Fig. 2   A CAI Ear-Training Lesson

X

HI

PLEASE TYPE YOUR NUMBER AND NAME.
M102
JOB 5 ON TT1120   TUE JUL 17   73   9:02 AM-PDT

HELLO, JOHN

HERE IS MUSIC SESSION 5

THIS IS AN INTERVAL STUDY SERIES.
TYPE THE RETURN KEY AFTER ALL ANSWERS.
FIND RETURN AND TYPE IT NOW.

WELL DONE.

INTERVAL NAMES USE NUMBERS 1-7

```
INTERVAL QUALITY ABBREVIATIONS:
     MA=MAJOR
     MI=MINOR
     PE=PERFECT
     AU=AUGMENTED
     DI=DIMINISHED
TYPE MA NOW, AND LESSON PROCEEDS.
```

NOW YOU WILL HEAR A GROUP OF MI2'S, MA2'S, and MI3'S.
AFTER HEARING EACH INTERVAL, TYPE ITS NAME.
REMEMBER: TYPE Z IF YOU WANT TO REHEAR BEFORE ANSWERING.

```
*MA2
    WELL DONE
*MI3
    SPLENDID
*MI3
    WONDERFUL
*MA2
    TOO BAD
    LISTEN AND TRY AGAIN
*Z

*MI2
    BETTER
*MI2
    SPLENDID
*MA2
    TOUGH LUCK  LISTEN AND TRY AGAIN.
*MI3
    MISSED IT  THE ANSWER IS MI2  LISTEN AND TRY AGAIN
*MI2
    BETTER
*MA2
*MA .NICE GOING
*MA2
    WONDERFUL
*MA2
    NO  LISTEN AND TRY AGAIN
*Z

*MI2
    MAKE SURE YOU SEE YOUR ERROR
```

The lesson continues until the student signs out. Each strand concludes

with a summary of the lesson, i.e.

```
22 PROBLEMS ATTEMPTED IN 30.15 MINUTES WITH 77%
CORRECT   CORRECT ON:
TRY 1  =  17
TRY 2  =   4
TRY 3  =   1
```

PART III

CORRELATIONS BETWEEN STUDENTS' BACKGROUNDS

AND DATA STORED IN THE COMPUTER

The PDP-10 computer recorded data for one quarter about the students' performance at the CAI terminal, including the percentage of systematic errors, the percentage of correct responses, and the proportion of repeat requests. Also stored in the computer is information concerning the number of ear-training sessions per student, the total amount of time per session and for the quarter that each student spent at the terminal.

Each of the 25 questionnaire items (See Appendix A) regarding musical background was subsequently correlated to the performance variables, i.e. computer time and types of intervals. From the results of statistical analysis it appears that some aspects of musical background have a bearing on the relative difficulty or ease with which one learns intervals, whereas others are insignificant, at least within the scope of this study.

Those questionnaire items which correlate significantly with performance variables include: (1) age; (2) sex; (3) age of beginning musical training; (4) pre-college private study; (5) number of years of private study; (6) keyboard experience; (7) voice range; and (8) family attendance at concerts. The other questionnaire responses have a minimal or insignificant correlation to the performance data.

The chronological age of CAI participants has a high negative correlation to percentages of correct responses in identifying intervals; that is, the younger they are, the more correct responses they make. We found, however, that the older they are, the greater amount of time they spend at the CAI terminal.

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The second significant item is the sex of the subject; women performed slightly better than men in all performance variables except that of descending intervals. Women have more·sessions at the terminal than men, but men show slightly more time per session. It was also determined that women make their greatest percentage of errors in identifying descending intervals, whereas men have more difficulty with ascending ones.

The age at which the student began his musical education has a significant correlation to the percentage of correct answers he gives the computer, and an extremely high correlation to the amount of time devoted to CAI during the quarter. The younger the student was when he began his musical education, the greater were his number of correct responses in CAI.

Pre-college private study is the fourth item that correlates significantly with performance. Those with such study predictably performed better in all categories; those without asked for more repeats. Students who indicated that they had fewer years of such instruction spent more time at the terminal.

The range of the student's voice correlates significantly with his performance in the interval identification process. Higher voices made fewer errors than those with lower voices.

Participants who indicated that their families attended concerts frequently or often performed better in the program than those whose families seldom attended live performances. The study also determined that the number of years of keyboard experience correlates significantly with time spent per lesson at the terminal: the fewer the years of study, the more time the student elected to spend at the CAI terminal.

Available data concerning the percent of incorrect responses in each of seven categories shows that ascending and augmented intervals are easiest for

the students; descending intervals are the most difficult.

The rank order of types of intervals from easiest to most difficult is:

1. ascending

2. augmented

3. perfect

4. major

5. diminished

6. minor

7. descending

The results of this study have implications for future research. As the number of subjects for this initial evaluation of the program is quite small, another study might be undertaken to add to the data already collected. Control groups could be set up according to the aspects of musical training and background for which statistically significant correlations to performance are already shown. Response time and repeat requests could conceivably be topics for investigation. And since the data collected on the subject of student attitudes and performance did not result in statistically significant correlations, this seemingly important topic might warrant a research study which involves more subjects and more detailed questions.

PART IV.

A SURVEY OF STUDENT ATTITUDES ABOUT THE PROGRAM

The students were asked 12 questions about the CAI ear-training program and were requested to use numbers from 1-7 to indicate their responses. The scale of possible answers ranged from 1 = "strongly agree" to 7 = "strongly disagree." A response of 4 indicates that the student is uncertain about responding to a particular question.

When asked if they worked as hard in the CAI program as they do in classroom situations, the mean of 2.4 on the scale reveals that most students responded positively to this question. Only two of the 28 students who completed the evaluation/attitude survey disagreed. The average CAI student also indicated that he learned as well from CAI as he does in the classroom. The mean of 2.9 shows that students agree with this statement.

A particularly strong feature of the ear-training program in the respondents' opinions is that it offers each one the opportunity to work at his own pace. The mean rating of 1.5 shows that this is the most valued aspect of CAI training for these music students.

The students questioned in this survey would rather undertake training practice in CAI than in competition with their peers in the classroom. A mean rating of 5.7 indicates that students tended to disagree when asked if they prefer classroom competition.

Yet they do not consider the CAI program to be very much like having a private tutor, as the mean rating of 3.2 shows that the average student only slightly agrees that the ear-training program at the computer terminal is like private study with a teacher.

CAI students feel that they are challenged by the program, as indicated by their mean response of 5.3 when asked if they found the program too easy. They disagree that the program is too hard by rating that category in identical fashion with a mean of 5.3.

Students tended to slightly agree that the program is exciting, assigning it a mean score of 3.4 on the scale of 1-7. Conversely, they disagreed moderately that the program is more frustrating than worthwhile, and agreed that there is more feedback in CAI than in the classroom. (mean = 3.1)

The evaluation survey, then, shows a decidedly positive reaction to CAI by the participating students. It is therefore not surprising that the average student agreed that he would like to be involved in another drill-and-practice course of this type. (mean = 3.1)

APPENDIX A: QUESTIONNAIRE

1. Name .... CAI # ....

2. Age......

3. Home Address ,...

4. Sex ....

5. Name and location of high school attended ....

6. Colleges attended other than Stanford ....

7. Your class at Stanford: Fr.... Soph..... Jr..... Sr. .... Grad...

8. At what age did you begin your musical training? ....

9. Parents' musical history:

    Is your mother a musician? ...... professional? ....

    What instrument(s) does she play? ....
                            (instruments or vocal range)

    Is your father a musician? .... professional? ....

    What instruments does he play? ....

10. Did you study music privately before entering college? ....

11. How many years? .... Which instruments (or voice)? ....

12. During your elementary school years did you perform in the
    school orchestra ...... band ...... chorus ......

    During your secondary school years did you perform in the
    school orchestra ...... band ...... chorus ......

13. During these years did you perform with groups outside of school:
    school: "pop" ...... church ...... summer camp ...... other ......

14. Did your elementary school classes sing: daily ...... often ......
    seldom ...... never ......

15. How would you rate the quality of music instruction in your schools?
    (excellent, good, fair, or poor)
    elementary .... jr. high .... high school ....

16. Do you play organ? .... piano? .... harpsichord? ....

17. What is your own vocal range?   sop..... alto ..... ten..... bass .....

18. Did you learn to read music: in school .... from private
    teacher .... at home .... other ....

19. Did you listen to recorded music in your home:
    frequently? ...... sometimes? .... seldom? .... never? ....

20. Was this recorded music primarily:
    "pop" .... "serious" ....

21. Was this recorded music primarily:
    orchestral .... vocal ...... chamber groups ......

22. Did you and your family attend musical concerts or recitals
    frequently ...... sometimes ...... seldom ...... never ....

23. Are you right-handed .... left-handed ....

24. Did your mother or father sing to you when you were a child?
    mother ...... father .... both ...... neither ......

25. What are your plans after graduation in regard to your musical
    training? teaching music .... performing ....
    composing .... going to grad. school ....

26. Are there other comments you would like to make regarding your
    musical background and training? ....
    ....
    ....