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ABSTRACT

In 1981, North Texas State University (NTSU) conducted an experiment in sound sources which was made possible by a grant from the Apple Education Foundation. The culminating research of the grant was the testing of the AFL sound source and Micromusic sound sources, as well as the NTSU sound source, AMUS. Students participated in the experiment to determine relative effectiveness of the sound systems in an ear-training computer assisted instruction (CAI) environment. The experiment was designed over 2 semesters using 36 freshman students to test the three software sound sources in terms of their achievement and preference. It was found that, while students have definite preferences for differing sound sources in music CAI, their preferences correlated most closely with their achievement in a given curriculum area rather than with the sound source itself. The four appendixes contain printouts of lessons used in the experiment; a technical description of the headphones used, written by David Bradfield; a diagram of the Apple Grant Experimental Design; and a copy of the Apple Grant Experiment Participant Sheet. (Contains 9 references.) (ALF)

LISTEN AND LEARN: VARYING SOUND SOURCES' EFFECT ON EAR-TRAINING CAI, USING THE APPLE II MICROCOMPUTER

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In 1981, North Texas State University conducted an experiment in sound sources which was made possible by a grant from the Apple Education Foundation. The culminating research of the grant was the testing of ALF and Micromusic sound sources, as well as the NTSU sound source AMUS. Students participated in the experiment to determine relative effectiveness of the sound systems in an ear-training CAI environment. The article outlines in detail the procedure and findings of the experiment.

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Introduction and Background

In 1977, formal development of an ear-training computer-assisted instruction (CAI) system was begun at North Texas State University (NTSU). Voluntary research and development of an appropriate sound source had been undertaken for the three years previous to 1977 by Dr. D. W. Scott, then Chairman of NTSU's Computer Sciences Department.

In September 1977, 20 students of one section of first semester freshman music theory were given one-half hour per week drill on a prototype ear-training CAI system. They were matched with and presented with the same material as a control section, with the exception that the control class did not use the CAI drill. The median score score on the departmental ear-training midterm exam of the class using CAI was approximately 20 points higher than that of the control group (Hamilton and Scott, 1978).

The success of CAI as an educational medium confirmed previous studies and observations of ear-training instructors (Hofstetter, 1975; Killam and Lorton, 1976); the emphasis at NTSU shifted to system development and expansion. A new CAI software driver was implemented between the first and second semesters of the 1977-1978 school year; the new driver required approximately 10% as much file space for lessons as did the prototype system. Lessons on the prototype system were converted to be compatible with the new system. The one available prototype terminal was moved to the School of Music, and hours for student use were expanded to allow as many students as possible to use the one system.

Professor Killam was awarded a faculty research grant to develop low-cost music graphics during the summer of 1978 (Hamilton and Killam, 1979). During all of 1978, new courseware was being implemented under the direction of Professor Robert W. Ottman, then coordinator of music theory at NTSU. By November, 1978, four more terminals had been completed, and student use of the CAI system moved back to the Computer Sciences Department Lab, awaiting completion of the School of Music CAI Lab area. A head music CAI monitor was appointed, and CAI monitering assignments were formalized through expansion of theory teaching fellows' contracts. By the second semester, 1979, all eight terminals designed for student use were in operation.

In August, 1979, the Music CAI Lab was moved back to its permanent home in the School of Music. A graduate teaching assistant, Mr. Philip Baczewski, was appointed as Lab Operations Coordinator. He was given a crew of undergraduate work scholarship students as monitors. Mr. Baczewski undertook a wide variety of developments to facilitate students' use of the Lab and to provide liason activities with the theory faculty.

The Lab became even more popular with students, once they no longer had to walk across campus to the Computer Sciences Department to use the facilities.

Concurrent with the Lab's development, the NTSU School of Music received an ever-increasing stream of inquiries from other educational institutions as to how they could develop their own CAI facilities. Professor Killam and Mr. Hamilton, then of the Computer Sciences Department, applied for and received a grant from the Apple Education Foundation (now the Foundation for the Development of Computer-aided Education) to transfer the central portion of the CAI driver to the Apple II and to rewrite the software in Pascal. Additionally, the grant was for the development of a software interface between the new driver and two commercially-available sound generation boards--ALF and Micromusic. The culminating research of the grant would be the testing of these sound sources, as well as the NTSU sound source (AMUS), with a student population on prototype lessons, to determine relative effectiveness of the sound systems in an ear-training CAI environment.

The grant specifically excluded the following areas of the NTSU CAI system:

1. Conversion of courseware--the purpose of the grant was to provide other educational institutions with a means whereby they could develop their own courseware to meet their students' needs.

2. Conversion of the elaborate data keeping facilities which are a part of the NTSU system--the Apple system developed through the grant provides students with a summary of their achievement at the end of each lesson, but stores no permanent records. The current two-disk drive hardware configuration has no space for data keeping.
3. Conversion of NTSU's music graphics. Interactive use of music notation has not yet been thoroughly researched or developed. A number of problems remain to be solved before a pedagogically sound system of graphics can be implemented (Killam, Hamilton, and Bertsche, 1980). Such work is taking place at NTSU and other places, but not under the auspices of NTSU's original grant from the Foundation for the Development of Computer-aided Education.
4. Sale of NTSU's sound source (AMUS). Since the research and development of NTSU's sound source was undertaken by Dr. Scott, with no formal research grant assistance, while he was a faculty member of NTSU, the NTSU legal staff could find no way that NTSU could legally sell the sound source. This was the reason that two commercially-available sources were included in the research grant configuration.

The grant proposal detailed procedures for evaluation of the completed project as follows:

> The best evaluation of CAI is: how well does the student learn from it? In the case of music CAI, no equivalent method of learning, such as programmed texts, exists. . . .Selected

> curriculum in the areas of interval and chord perception (studied in all previous data) will be converted for the system configuration proposed, and measurement of student achievement will be made during first and second semester summer terms, 1980.

The completion date quoted from the original grant proposal in the previous sentence requires some explanation. Members of the original research team confidently expected to complete the grant by the end of 1980. A three-month delay in arrival of the hardware was the first in a series of delays in completion. The original co-principal investigator, Mr. Hamilton, accepted a position with Bell Laboratories in New Jersey in August, 1980. Dr. D. W. Scott accepted an appointment with Honeywell Information Systems in Phoenix, Arizona, in January, 1981. Professor Killam gave fleeting thoughts to application for acceptance at any institution for the emotionally disturbed during the course of all these personnel changes. Such latter thoughts varied inversely with the accomplishment toward completion of the grant.

The experimental design for final testing of the software in the CAI environment was changed from a longitudinal test encompassing two summer semesters, to a short-term test using subjects from both first and second semester freshman classes. The change was made for two reasons:

1. The grant was already nearly a year behind schedule.
2. NTSU offers only one section of first semester freshman theory in the summer (first summer term) and one section of second

semester freshman theory (second summer term). Subjects involved in such testing were likely to be the same students, exacerbating any skewness in subject population. Tests held at the end of the spring term, 1981, could draw from a much wider population of the nearly 20 sections of first and second semester freshman theory being taught that semester.

Experimental Method

A. Description of Facilities.

The hardware configuration used for the experiment consisted of:

1 48K Apple II computer, with Pascal Language board

1 black and white video monitor

2 ALF boards

1 Micromusic Synthesizer

2 pairs of Sony DR-S3 stereo headphones (test of headphones is described in Appendix B)

Additionally, one of the NTSU AMUS sound sources (Bales, Hamilton, and Scott, 1978) was interfaced, for the purpose of this experiment only, to the Apple configuration. Software interface of the AMUS sound source was done during the final days of the research by a research assistant. He was unable to eliminate a preliminary double attack of the AMUS sound source on the first sonority per question. The aural effect was that of a "grace note" preceding the first sonority of each example.

Subjects participating in the experiment found this effect to be most annoying. Many of them complained about it verbally and some wrote adverse comments about it in comments solicited at the end of each experimental session. Since Dr. Scott was in Arizona, he was unable to remedy the problem by experiment time, but on a subsequent return visit to NTSU described two ways that it could have been eliminated.

The experimenter decided to proceed with the tests, but recognizes that subjects' preference and achievement data may have been adversely affected by the initial double attack. The experimental sessions could be started no earlier than exam week of spring semester, 1981; any further delay would have meant dispersal of students at the end of school and a drastic reduction in the pool of potential subjects.

The "double attack" problem of the AMUS sound source had one possible favorable side effect, in that it further disguised from subjects the fact that one of the sound sources used for the experiment was the one they used on the NTSU CAI system. Only a few subjects recognized the AMUS sound source.

B. Experimental Design

To control the effect of any variable other than the sound source on subjects' achievement and preference, considerable effort was expended on balancing the experiment's design. The following factors were postulated to have some effect on subjects' achievement and sound source preference:

1. Position of sound source in experimental sequence:
   a. Since no introductory sessions with the Apple configuration were planned (so that subjects would not be introduced to a given sound source before the start of the actual session) the general unfamiliarity of the learning environment might lower their achievement on curriculum presented with the first sound source.
   b. Subjects might be fatigued by the end of the experiment and display lower achievement on the curriculum presented with the last sound source.
2. Relative difficulty of curriculum content--although all three areas of curriculum content were drawn from material presented during the first semester's classroom sequence, the areas might prove to be significantly different in difficulty, skewing achievement results and possibly prejudicing subject preference.

To control for these two effects, the following experimental design was implemented. The sound sources were ordered in each of the six different sequences possible with a set of three items. The lesson sequences were also ordered in the six sequences available from a set of three items. Each of the sound source sequences was used six times, once for each of the six different lesson sequences. The resulting number of experimental sessions totalled 36, and is shown as a six-by-six matrix in Appendix C.

Each of the 36 cells in the six-by-six matrix represents a unique combination of the permutation of the two three-item sets of sound source and curriculum. Thirty-six subjects were recruited, one for each cell of the matrix. Thus each subject represented a unique experimental session, but each subject used all three sound sources and all three curriculum areas.

Although each sound source was paired with a particular curriculum area 12 different times, the sound source's position in the presentation sequence was equally divided, into four presentations as first, second, and third source in the sequence.

The total 36 experimental sessions balanced each sound source, curriculum area, and position in the experimental sequence, controlling for effects of sequence position and curriculum area on totalled subjects' judgment of sound sources. The results obtained from this experimental design revealed considerable difference in subjects' achievement per curriculum area, and a correlation of preference for sound source with subjects' achievement. These effects will be discussed in the Results section of the paper.

C. Description of Subjects

Thirty-six subjects were recruited from the first and second semester freshman ear-training and sightsinging sections offered by NTSU during the spring semester, 1981. Subjects were not paid; some of their instructors gave extra credit toward ear-training final grades, for student participation in the experiment.

Nineteen subjects were members of first-semester sections; 17 subjects were members of second-semester sections. Twenty-five of the subjects were male; 11 were female. Table 1 shows distribution of subject population.

Table 1

Distribution of Subject Population by Sex and Class

	First Semester	Second Semester	Total
Male	12	13	25
Female	7	4	11
Total	19	17	36

No attempt was made to recruit subjects of equivalent achievement from their respective classes. Subjects' achievement results varied widely. Eight subjects achieved perfect scores on different curriculum areas, with one female first-semester freshman scoring perfectly on two of the three curriculum areas. However, one male first-semester freshman scored below chance on one curriculum area, and two female first-semester freshmen scored at chance level on one curriculum area.

Experiment results could be examined in greater detail than is presented in the current report had subjects been selected and matched from the available subject pools. In the time frame of one exam week during which the experiments had to be run, narrower recruitment and closer subject matching were impossible. A subject pool of equivalent breadth and training would not have become available until the close of fall semester, 1981, long after the grant's proposed completion date.

A case could be made for heterogeneity of subjects, so that all bands of the spectrum of freshman student achievement were represented.

Within the constraints of class membership in first and second semester freshman ear-training sections, such heterogeneity was certainly achieved, but the practical controlling factor was limited experimental time: that subjects be tested within a very short time frame so that classroom and CAI learning opportunities were equivalent, and the time constraint imposed by the end of the semester and students' dispersal away from experimental facilities.

Most of the subjects who volunteered for the experiment exhibited excitement at the opportunity to participate. Little anxiety was noted among subjects, since they had been informed that their achievement in the experiment had no bearing on their class grades, other than, in some cases, to give them a few extra credit points for participation.

All but two of the subjects had used the NTSU CAI system as a part of their studies, and all were familiar with the system. Use of the Lab is not required of students; the two who had not used it had deemed additional work outside of class to be unnecessary, and both scored well on the experiment. Subjects showed considerable curiosity about the experiment itself. Music majors have few chances to participate in formal experiments and are rarely so jaded or sophisticated as, for example, psychology majors. More than 36 students wanted to participate in the experiment, but could not fit it into their exam week schedule. Luckily, the thirty-sixth subject completed the experiment on the day before exam week ended.

D. Experimental Conditions

Subjects were informed that they were participating in an experiment to determine which of three sound sources was the most effective for CAI learning, and that their personal evaluation of the sound sources, after completing the experiment, would be appreciated. Upon completion of the experiment, subjects were given as much time as they cared to take to evaluate the sound sources and to write comments about their preferences.

The experiment was performed in NTSU's Music CAI Lab. The facilities previously described were arranged on one of the tables where the Lab's terminals were placed. Subjects were partially screened from the normal Lab activities by placement of a four feet high by eight feet long movable partition (on which a sign, "Experiment in Progress, Do Not Disturb" was hung) between them and regular activities. While the screen did little to filter out normal Lab noise, it warded off curious spectators and seemed to give subjects a sense of importance. The headphones described in Appendix B effectively eliminated most extraneous room noise interference.

After subjects filled out the Experimental Data Sheet (Appendix D), they were seated at the Apple terminal. The disks had already been placed in the disk drives and the driver program called up. Subjects were instructed that they would take three CAI lessons, one each in identification of soprano and bass in major and minor four-voice triads, interval identification and cadence identification.

(Each of these lessons was closely modelled on a lesson in the NTSU ear-training CAI sequence). Subjects were informed that a change of disks would have to be made by the experimenter between each of the lessons, and that they could relax during this period (which took only a minute or so). Also, subjects were informed of similarities and differences between the lessons in the experiment and the NTSU CAI lessons, as detailed below.

Similarities

1. lesson content;
2. presentation format: instructions first, then musical questions;
3. multiple hearings of each question were allowed before answering;

Differences

1. lesson format allowed subjects to review instructions before beginning to answer questions (this format has now been extended into the NTSU CAI lessons);
2. all answers used upper case, so that subjects did not have to hold down the shift key for upper case, but had to expand their answers in the Intervals lesson to MA and MI instead of M and m for major or minor seconds, sixths, thirds, and sevenths;
3. the instructions contained in each lesson included a statement that subjects should wait for the * to appear on the screen before answering. No similar answer cue is provided in the NTSU CAI lessons, where students may answer as quickly as they wish. Several subjects had initial difficulty adjusting to this answer format and typed answers before the appearance of the * on the screen. Although such answers were counted wrong in totals given

to students by the driver program at the end of each lesson, the experimenter observed and recorded each subject's answer, and counted right answers entered before the *'s appearance as right on the experimenter's tally sheet.

4. Lessons were not competence based, as is the NTSU CAI curriculum (which ends each lesson when a predetermined percentage of right answers is achieved), so that each subject would receive the same number of questions.
5. Only one answer per question was permitted by the experiment, in contrast to NTSU CAI, which allows multiple trials, but the program in the experiment gave immediate evaluation of each subject's answer.

Subjects were not told that each of them would receive questions in the same order, to prevent possible passing of answers from one subject to the next. The NTSU CAI curriculum randomly accesses questions .or presentation, so that no two uses of the same lesson ever present material in the same order. Subjects were so used to random access that they seemed to assume an equivalent experimental design. No subject questioned the order in which material was presented.

Subject recruitment forms with sign-up times had been sent to all instructors of first and second semester freshman sections, during the final week of classes. Subjects were scheduled on an hourly basis, round their own semester exams and the semester exams being given by the experimenter, from May 5 through May 14, 1981.

The beginning of each session (the time the subject began interaction with the first lesson) was recorded on all subjects, as well as session end times (time subject completed last lesson). Unfortunately, the experimenter forgot to record exact completion times on five subjects. Mean experimental session time on the 31 subjects for which elapsed time was recorded was 41.26 minutes; the shortest elapsed time was 30 minutes, longest, 75 minutes. Only five subjects took more than 45 minutes to complete the experiment, so that the effect of hourly sessions was minimal in determining the amount of time subjects spent on the actual experiment. Subjects' general exam schedule may have been a factor in the amount of time which they devoted to written comments on sound sources.

The subjects were informed that each of the three different lessons would use a different sound source. An interesting side effect emerged: the NTSU Music CAI Lab uses inexpensive, low-quality headphones to discourage headphone theft. The higher quality headphones used in the experiment, plus the different Apple terminal, disguised from all but a few students the fact that one of the sound sources used was the one used in the CAI Lab. No doubt, this disguise was inadvertently aided by the double initial attack of the AMUS sound source described in the "Facilities" section of the report.

E. Experimental Session Content

Printouts of lessons used in the experiment are contained in Appendix A. Descriptions of the lessons themselves follow.

The chord quality lesson (CI) was adapted from the NTSU CAI lesson C10. Major and minor triads in all inversions and with all three possible soprano notes were presented to subjects. Random transposition of chords was performed by the software; this random transposition of each question was performed in each of the experimental lessons. Subjects were asked to enter the bass note first, as 1 or 3 or 5 of the chord, then the soprano, as 1 or 3 or 5. Possible right answers are given in Table 2.

Table 2

Possible Right Answers for C1 Experimental Lesson

Triads		
Root Position	First Inversion	Second Inversion
11	31	51
13	33	53
15	35	55

Thus, a total of nine possible right answers was available to the subjects. The number of questions was doubled by the presentation of each triad in both major and minor. With nine possible right answers, subjects had a one in nine or 11.11% possibility of answering correctly by chance.

The interval lesson (I1) was adapted from I15 of the NTSU CAI lessons. The interval lesson consisted of all melodic intervals including the octave, other than unison. Each interval was presented once ascending and once descending, for a total of 24 intervals. Possible correct subject answers are given in Table 3.

Table 3

Possible Right Answers for I1 Experimental Lesson

MI2	P4	MA6
MA2	TT	MI7
MI3	P5	MA7
MA3	MI6	P8

With 12 possible right answers, subjects had a one in twelve, or 8.3% possibility of answering correctly by chance.

The harmony lesson (H1) was adapted from the NTSU CAI lesson H3. The harmony lesson contained 24 questions, as did the interval lesson. Six types of cadences were presented: perfect authentic, imperfect authentic, perfect plagal, imperfect plagal, authentic half and plagal half. (Deceptive cadences were not included because they are not introduced in the NTSU classroom sequence until the second semester of the freshman year, in connection with the submediant triad). All cadences were constructed of root position triads. The tonic triad was played first, followed by a rest, followed by the two cadence chords. Two cadences of each of the six types were presented in both major and minor, with differing soprano lines, as illustrated in Table 4.

Table 4

Possible Right Answers for H1 Experimental Lesson

Subject Answer					
PA	IA	PP	IP	PH	AH
Major and Minor					
Soprano Line	Soprano Line	Soprano Line	Soprano Line	Soprano Line	Soprano Line
1-7-1	3-2-3	1-1-1	5-6-5	3-3-4	1-1-7
1-2-1	5-5-5	1-1-1	3-4-3	5-5-6	3-3-2

Note that each soprano line was used once for major and once for minor.

Although not all possible soprano lines were used, cadences were equally divided between major and minor, and among the six possible cadences. Since only six possible right answers were given for this lesson, subjects had a 16.67% possibility of answering correctly by chance.

To summarize the content of each experimental session, each subject received 18 chord quality questions (Lesson C1), 24 interval questions (Lesson I1), and 24 harmonic cadence questions (Lesson H1), for a total of 66 questions. The total number of questions for all 36 subjects was 2,376.

Results

The same 66 questions were presented to each of the 36 subjects; question order was the same in each lesson. Individual subject's answers have not been compared on a question-by-question basis for points of individual error or achievement, 66 being too small a question sample for such a comparison. Rather, the total percentage right for each curriculum area per individual subject has been examined and combined for analysis in a number of different ways.

The first area examined was whether the curriculum areas were of equivalent difficulty for subjects. Although the first semester freshman classroom instruction covers all three curriculum areas, they proved to be of significantly different difficulty for subjects. Overall subject accuracy per curriculum area is presented in Table 5.

Table 5

Percentage of Accuracy, Subjects' Answers Combined by Curriculum

Lesson	Curriculum Content	Accuracy	(Chance)
I1	Melodic Intervals	76.1%	(8.33%)
H1	Harmony (Cadences)	65.5%	(16.67%)
C1	Chord Quality (Soprano & Bass Id.)	46.3%	(11.11%)

The mean achievement for all subjects, combining their accuracy in all curriculum areas, was 62.3%. Although higher overall accuracy would have given a greater sense of pedagogical success to the experimenter, all success rates are significantly above chance, which is noted to the right of accuracy in Table 5. Comparison of subject accuracy on interval identification with that of a previous experiment (Killam, Lorton and Schubert, 1975) shows a very close correlation. The experiment reported in 1975 showed 75.6% accuracy on overall interval identification.

The 1975 study and the current study did not employ precisely the same experimental design, so that the close correlation of achievement of Stanford undergraduate students in 1974 and NTSU undergraduate students in 1981 produces no cosmic truth for accuracy of interval identification. The earlier Stanford study used only 15 subjects, all of whom had previously achieved greater than 80% accuracy on interval CAI lessons. Both harmonic and melodic intervals were included, and subjects were not allowed to repeat stimuli, as was available to subjects in the current experiment.

A subsequent experiment conducted at Stanford (Killam, Lorton and Schubert, 1976) has no equivalent in the current experiment, since it examined subjects' accuracy of identification of major, minor, diminished and augmented chord qualities. The 1976 experiment also required greater than 80% accuracy on previous CAI lessons of subjects. Some of the individual subjects in the 1976 study achieved so wildly below chance, that current data were examined for any individual achievement on a given curriculum area, at or below chance level.

On the C1 lesson, two first semester freshmen scored at chance level (11.1%) and one scored below chance level (05.6%), which led to separation of first and second semester freshman subjects, to check for achievement differences between the two groups. Mean percentage of accuracy combined over all three areas were compared, since subjects in the two subgroups were not assigned so as to balance sound source, session order, etc. Mean accuracy for the 19 first semester subjects was 57.34%; mean accuracy for the 17 second semester subjects was 69.08%--a gain in accuracy of 11.74 percentage points for second semester freshmen over first semester freshmen.

The data summarized in Table 5 showed that subject accuracy for chord quality (Lesson C1) was nearly 30 percentage points below that of intervals (Lesson I1), and nearly 20 percentage points below harmony (Lesson H1). These differences raised the possibility that the unequal number of questions in lessons might have affected subjects' accuracy. Lessons I1 and H1 each contained 24 questions, while Lesson C1 contained only 18 questions. Subject data were examined to determine whether a dramatic increase in accuracy within the last half of the questions presented, over the first half in each area, might have lowered achievement in Lesson C1, with its six fewer questions per lesson.

Greater accuracy was found in the second half of each curriculum area, as presented in Table 6. The slightly greater increase in subject accuracy on Lesson C1 from the first to the second half (with only 18 questions) might indicate that subject accuracy for all of C1 would have been slightly higher had an additional six questions been added to that lesson, to balance its number of questions with the other two lessons at 24 questions per lesson.

Table 6

Subject Accuracy Divided by First and Second Halves of Lessons

Lesson	Accuracy, First Half	Accuracy, Second Half	Increase in Accuracy
I1	74.3%	79.6%	5.3%age pts.
H1	62.5%	68.7%	6.2%age pts.
C1	43.5%	50.3%	6.8%age pts.

The difference in C1 and H1 accuracy increase, first to second half of lesson, was only 0.6 percentage points; C1 and I1 accuracy, first to second half of lesson, differed by 1.5 percentage points. This difference is insufficient to explain the overall difference in subject achievement on the three curriculum areas. Lesson C1, identification of the soprano and bass in major and minor four-voice triads, was significantly more difficult for subjects than the other two curriculum areas. Accuracy by curriculum area had thus to be taken into account on measurements of subjects' preferences for sound sources.

As described previously, the ordering of curriculum in each experimental session was postulated to have two possible (and conflicting) effects:

1. Lack of prior experience with the experimental facilities might cause a drop in subject accuracy on the first lesson presented. Accuracy might rise as subjects became more familiar and confident with the experimental facilities.

2. Length of experimental sessions might tire subjects, so that their achievement on the final curriculum area in the experimental sequence might decrease due to fatigue.

If either effect was present, a cancellation of the first by the second may have occurred. Percentage correct by order of presentation in each session was: first lesson, 62.71%; second lesson, 63.83%, and third lesson, 61.61%. These data are referred to again in relation to subject preference for different sound sources.

Examination of subject achievement, grouped by sound source and curriculum content, produced some significant differences.

Lesson C1, the curriculum area with lowest subject achievement (46.5%) was examined first. Subjects scored highest on the AMUS sound source (51.4%), second highest on the ALF sound source (48.6%), and lowest on the Micromusic sound source (38.9%).

Lesson H1, the harmony curriculum area of cadence identification, showed the least spread of subject achievement by sound source. Subjects scored highest on ALF (67.7%), second highest on AMUS (67.4%), and lowest on Micromusic (61.4%).

Lesson I1, interval identification, was the area on which sound source variance had its most significant effect. Subjects scored highest on ALF (84.7%), second highest on Micromusic (81.4%), and lowest on AMUS (62.1%). The AMUS sound source thus produced subject achievement of nearly 20 percentage points below the second highest, Micromusic. Subject achievement by sound source and curriculum area is shown in Table 7.

Table 7

Subject Achievement by Sound Source and Curriculum Area

Lesson and Content	Sound Source		
	ALF	AMUS	Micromusic
C1-Chord Quality	48.6%	51.4%	38.9%
H1-Cadences	67.7%	67.4%	61.4%
I1-Intervals	84.7%	62.1%	81.4%
Mean Achievement per Sound Source	67.0%	60.3%	60.6%

Subjects rated their preferences for sound sources with the numbers"1. 2 3" with the sound source they preferred most being rated "1", and the sound source they preferred least being rated "3" (see Appendix D). Subjects were not told the names of the sound sources. They were asked to fill in the preference part of the survey in terms of the sound source which they heard first, second and third, which the experimenter then matched with the actual sound source heard by each subject in each experimental sequence.

Not surprisingly, there was a direct correlation between subjects' achievement in a given curriculum area and their preference for that sound source, no matter what sound source was used. Table 8 presents mean subject preference by curriculum area (bear in mind that the lower number represents the higher preference).

Table 8

Subject Pr^ference for Sound Sources by Curriculum Area

Lesson and Content	Mean Subject Rating
I1-Intervals	1.68
H1-Cadences	1.94
C1-Chord Quality	2.20

Note that 1=most preferred, 3=least preferred

Subject prefe~ence by sound source also correlated directly with achievement by sound source, as shown in Table 9.

Table 9

Subject Preference for Sound Sources

Sound Source	Mean Subject Rating
ALF	1.86
Micromusic	1.88
AMUS	2.09

Note that 1=most preferred, 3=least preferred

One further check of subject preference was made, to see if order of presentation within the experimental session had any effect on preference. Subjects' sound source preferences by sequence of presentation correlated inversely with their achievement by sequence of presentation, as shown in Table 10, with reference to previous achievement figures.

Table 10

Subject Preference for Sound Sources by Sequence of Presentation

Sequence of Presentation	Mean Subject Rating
First Lesson	1.68
Second Lesson	2.14
Third Lesson	2.01

Note that 1=most preferred, 3=least preferred

Subjects least preferred the second sound source in the experimental sequence (no matter what the sound source or curriculum area), although their overall achievement was slightly higher on the second source presented in the experimental sequence.

Discussion

Subject achievement per curriculum area varied significantly. Interval identification, one of the first items taught in the classroom sequence, produced much higher subject achievement (76.1%), an effect not unexpected by those with classroom teaching experience. Greatest subject accuracy was achieved on the I1 Lesson, even though identification by chance (8.3%) was lower than the other two lessons.

The relative difficulty of the C1 lesson--soprano and bass identification of four-voice major and minor triads--at 46.3%, and of the H1 lesson--cadence identification--at 65.5%, was less expected. The C1 lesson presented only one chord per question. The subject had to make two judgments only: what chord tone was in the bass and what in the soprano. Further, soprano and bass identification of individual four-voice triads is heavily stressed in the NTSU first semester classroom sequence.

The H1 cadence identification lesson required a number of judgments by subjects: identification of chords in a tonal relationship, were chords arranged to produce half or full cadences, and what was the soprano line. Cadence identification is introduced later in the NTSU classroom sequence than the soprano-bass identification of lesson C1, yet the percentage of subject accuracy (65.5%) was nearly 20 percentage points higher than that of lesson C1.

With only six possible right answers for lesson H1, chance alone favored the higher achievement on cadence identification, as opposed to the nine possible answers for lesson C1. The experimenter thinks that other factors, as yet unidentified, influenced the difference in subject accuracy between lessons C1 and H1. The use of inverted sonorities in lesson C1, as opposed to root position only in H1, may be partially responsible for the achievement differential. Previous study in this area (Killam and Lorton, 1977) showed inversion to be a controlling factor in triad identification in melodic patterns. Further research is needed in this area.

The achievement differential by sound source is, simply, disheartening to the experimenter, but nonetheless interesting. The AMUS sound source developed at NTSU fared well in the two curriculum areas featuring multi-tone sonorities, but caused such a significant drop in achievement on the single-tone melodic intervals that, overall, it rated lowest in subject achievement, if only by 0.3 percentage points.

The problem described in the facilities section--the double attack on the first note of the AMUS sound source when interfaced to the Apple, might have caused some of the achievement drop, but if this were a significant factor, it should have operated in all curriculum areas. In any case, the NTSU sound source is not available commercially, due to legal restrictions by the state of Texas on the sale of hardware developed by its academic employees. The problem remains one of significance to NTSU, but has no bearing on the decision of those using the Apple and related software. Indeed, the restrictions on the sale of the AMUS sound source were the motivating factor in the original grant proposal's inclusion of the two commercially-available sound sources.

Achievement by lesson ordering within each experimental session showed no significant effect. This lack of effect is encouraging, for it indicates that students can adapt easily from one CAI system to another, and strengthens student opinion that CAI sessions longer than 30 minutes do not result in student fatigue. The NTSU CAI system automatically signs students off at the end of a half hour; many students are loudly and vehemently opposed to this limitation on their drill and practice time.

Of the three ways in which student preference for sound source was measured, the greatest differential occurred with correlation by curriculum area. No matter what the sound source, subjects preferred the one on which they achieved the highest accuracy: interval identification. After spending nearly ten years in the development of music CAI, this does not surprise the experimenter. Time and again, the experimenter has encountered students who insisted that their lack of achievement on CAI drill and practice was due to the sound source. The experimenter's classroom teaching has shown that many of these same students complain in a classroom situation of their inability to identify piano timbre, of the tuning of the piano, or of the supposed differences in the instructor's playing of dictation. Simply put, it's a lot easier and all too human for students to attribute their ear-training difficulties to anything but their own lack of skill development.

Subject preference by sequence in the experiment was slightly less differentiated than preference by curriculum area, but more differentiated than preference by sound source. This preference is puzzling. Previous experimental circumstances led to the expectation of subject bias against the first sound source in the experimental sequence, when the subject was faced with an entirely new and challenging experience. Perhaps the general principle of greater memory of the beginning and end of a sequence has some application here. Subjects may not have remembered so distinctly the middle source of the sequence and may have rated it lower, although overall, their achievement was slightly higher on the middle sound source in the experimental sequence. Research currently in progress comparing male and female attitudes toward ear-training CAI may shed some light on this area. Preliminary data indicate that, although females find CAI slightly more frustrating than males, they consider CAI to be a more interesting way to learn. The applicability of these preliminary findings to the current study may be marginal. However, the excitement of trying something new may have led subjects to prefer the first sound source in the sequence (Dillard and Killam, in progress).

Subject preference by sound source alone showed the least spread of the three preference measures. Unfortunately, the NTSU AMUS sound source was least preferred. Subjects' preference differential between ALF and Micromusic was only .02 on a scale of 1.00 to 3.00. Subject comments on the sound sources are presented in the following section of the report. The several negative comments on the double initial attack may indicate some of the source of subjects' low ranking of the AMUS sound source.

Anecdotal Data: Subjects' Written Comments on the Experiment

Subjects are identified only by their sequential position within the whole experiment. Misspellings and grammatical errors are retained in the comments' transcription. Since subjects were asked to identify any comments on sound source or curriculum by position in the experimental sequence, the actual sound sources and lessons to which they refer are interpolated into their comments in parentheses.

S. 1. (no comments)

S. 2. The machine is too pretty to be abused by the students. Switching discs might be bad because some students might drop them or mess them up. I think the student would understand intervals better if the computer would play each interval or chord and show what they sound like before the lesson starts. In other words, teach the student how to listen rather than have him or her guess blindly at the lessons.

S. 3. Sound source II (AMUS) and III (Micromusic) I had a hard time to recognize the notes seperate. Especially III (Micromusic, H1) the soprano and bass note. I (ALF, I1) was much clearer than the others.

S. 4. They were all good but I like the sound of the harpsichord. I don't like only hear the chord for a split second. Sometimes, like for a seventh chord or diminished chord lesson, I would want to hear the chords held out.

S. 5. Sounds are muddy and hard to distinguish, especially soprano lines, on sources w/ 4-part voicings (ALF, C1; AMUS, H1). My perception was confused by overtones.

S. 6. #2 (AMUS, C1) is great for low notes. #1 (ALF, H1) is great for highs, but it distracted me and I couldn't focus on bass notes. #3 (Micromusic, I1) is precise. Also, sound #1 (ALF) was rather irritating and made me "jump!" startle.

S. 7. Sound source #1(AMUS, C1) - very difficult to distinguish individual tones. Individual sounds blurred together Ugh! Especially bad bass! Sound source #2 (Micromusic, H1) - Easier to hear tones in treble. Bass is still very muddy and unclear. The tone by itself is aesthetically pleasing, however. Sound source #3 (ALF, I1) - By far the easiest sound with which to determine pitch. A bit buzzy and less pleasing than source #2, but more effective.

S. 8. #2 (Micromusic, I1) was pleasantly bright--I got more right with intervals on Apple than on Sam. #3 (ALF, C1): I liked the harpsichord sound and the quick decay. The fast decay forced me to listen immediately and not brood.

S. 9. The sopranos on #2 (Micromusic, C1) get shrill and kind of clash so that its' hard to distinguish tones.

S. 10. (no comments)

S. 11. #3 (ALF, C1) was difficult to hear because the chords had too much of a metallic sound. #'s 1 (AMUS, I1) and 2 (Micromusic, H1) were much clearer and easier to follow.

S. 12. Sound source #1 (AMUS, H1) is good for chord progressions, easy to hear seperate notes of chords. Sound source #2 (Micromusic, C1) was very hard to hear soprano & bass. Sound Source #3 (ALF, I1) made melodic intervals easy to hear but used with chords, I feel, would make soprano and bass very hard to hear.

S. 13. Great review!!! for final.

S. 14. #1 (Micromusic, H1) & #2 (ALF, I1) I didn't notice any difference. I didn't like the attack on the last lesson (AMUS, C1) and each pitch wasn't very clear. It sounded very muddy

S. 15. #3 (AMUS, H1) seemed more like the true "organ" sound so was maybe easier to relate to.

S. 16. (no previous CAI use) It is difficult for me to evaluate sound source #2 (ALF, I1) as compared with 1 (Micromusic, C1) and 3 (AMUS, H1) as the lesson dealt with single notes rather than chords. The soprano voice of source #3 (AMUS, H1) seemed to have a reedy quality without enough substance to the note; this made it harder to distinguish. Source no. 1 (Micromusic, C1) was better, but the voices seemed to be unequal in volume and therefore created some confusion in my mind as to what chord tone was actually in the soprano. The soprano voice could have been a little louder compared with the others, but I suppose that might reduce the challenge?

S. 17. Source no. 2 (ALF, H1) was very abrasive, metallic. Slightly jarring to my senses. Source no. 3 (AMUS, C1) sounded like the source being used presently for the CAI terminals. Isn't that bad but #1 (Micromusic, I1) is better.

S. 18. #2 (ALF, C1) sounded like a harpsichord. #3 (AMUS, I1) sounded like regular CAI to me. Maybe that made a difference in ability to hear. #1 (Micromusic, H1) I don't remember well, but it was not unpleasant.

S. 19. Source #3 (AMUS, I1) repeats when giving the tonic and tends to throw off on the intervals. The lower registers on source #2 (Micromusic, H1) are not as clear as the upper registers.

S. 20. I liked the first sound (ALF, H1) I heard because it sounded like a harpsichord. I could relate to this because I've had experience with harpsichord accompaniment.

S. 21. 3rd sound source (AMUS, H1) has a whistle, possibly a combination of overtones The whistle happens occasionally and is annoying. It is comparable to a situation where the teacher gives harmonic dictation on a piano of which the strings buzz.

S. 22. all are effective much more rapid response very effective

S. 23. The soprano was very hard to hear clearly, esp. in the chord quality (AMUS, C1) lessons. The bass was sometimes undetectable. Notes need more "throb" to hear each one clearly. They sometimes sound too "pure" & not natural. Need some "vibrato" in them. Otherwise, it's a great lesson & the idea of having a certain set no. of questions seems better than continuing a lesson over like the C.A.I. does. the organ-pipe sounding notes are easier to hear than the shrill, pure notes.

S. 24. (no comments)

S. 25. 3 (ALF, C1) was very hard to distinguish

S. 26. I wish that it would not stop after playing the first chord in the first lesson (Micromusic, H1). But the sound was good In the second lesson (AMUS, I1) the sound was fine but I wish it would not double the first note. The third lesson (ALF, C1) sounded like a harpsichord or maybe even a grandfather clock.--no good.

S. 27. Sound source 3 (ALF, H1) was almost as good as 1 (Micromusic, I1) -- Sound source 2 (AMUS, C1) had some very muffled low tones

S. 28. (no comments)

S. 29. I had trouble finding chord quality with the harpsichord (probably ALF, C1) because the tonal blend and decay made distinguishing the notes more difficult. Thanks

S. 30. #2 (AMUS, C1) lows sounded muddy On any section, repeating an incorrect answer might aid in the affectiveness. If it's played again a student can figure out what he or she did wrong.

S. 31. (no previous CAI use) Upper notes difficult to discern from overtones or other gremlins in source no 1 (AMUS, C1) triad voicings. Bass seemed "too low" soprano, "too high". Either sources, 2 (ALF, H1) or 3 (Micromusic, I1) were fine, but 3 (Micromusic, I1) seemed somehow more "exact" than 2 (ALF, H1), even though 2 was more sonically interesting.

S. 32. #1 (AMUS, H1) sounded like the regular CAI lessons. Fairly clear, but muddy bass. #2 (ALF, I1) sounded like a harpsichord--very clear distinct tones, clear bass notes #3 (Micromusic, C1) sounded like an organ heard from a distance; very soft, and very muddy bass tones

S. 33. #1 (AMUS, I1) was easiest because it was what I was used to.

S. 34. I would have liked to have heard sound source #2 (ALF, I1) on a chord quality lesson to see if I still preferred #2 (ALF, I1) over the others.

S. 35. (no comments)

S. 36. I don't like source #1 (AMUS, H1) down low - it becomes muddled and indistinct. No. 2 (ALF, C1) sounds like a harpsichord - there is very little body to the sound and it fades too quickly for me to be sure of what I heard. This source is also fuzzy for me down low. Sounds very unusual. No. 3 (Micromusic, I1) reminds me of a small animal - that probably doesn't help. There doesn't seem to be enough body to this source either or perhaps not enough duration. I have trouble with this source too. #1 (AMUS, H1) is the best of the 3, but I'm not satisfied with 1 either. (indistinguishable) sounds like a piano - since testing takes place on a piano?

Summary and Conclusions

Students have definite preferences for differing sound sources in music CAI. Their preferences correlate most closely with their achievement on a given curriculum area, rather than with the sound source itself. The effect of position and sequence of a sound source within the experimental design on subject preference and achievement is puzzling.

Certainly, ear-training CAI has proved its educational value over the past decade. Educational institutions embarking on installation of a CAI system today have a much broader range of hardware, software and courseware from which to choose than did those of even five years ago.

The experimenter holds some biases after years in the field, both as a CAI developer and music theory classroom instructor. Even the most perfect of ear-training CAI systems will not please all students, although the vast majority of them are enthusiastic users of any system.

A good deal of student acceptance of CAI as a learning aid is determined by the students' sense of control of their learning environment. Initial student enthusiasm can wane if the CAI Lab is not properly managed, or if access to CAI facalities is not well scheduled. If lessons are poorly designed or the system is poorly maintained, student frustration will mount. Providing a choice of several different sound sources for well-designed music CAI will probably motivate students, by giving them a sense of more control of their learning environment.

The psychoacoustical research with which the experimenter is acquainted supports the concept that auditory perception is a complex, high-level brain function, involving comparison of incoming signals with precise, pre-stored auditory images. Ear-training CAI shculd be designed to encourage students to listen again and again to musical patterns, then to make a judgment on which they are given immediate feedback. Currently, the experimenter opposes ear-training CAI design which penalizes the students for requesting repetition of a question, but allows partial credit for partial answers.

Additionally, the experimenter opposes hardware design which allows students to adjust amplitude of one tone in a multi-tone sonority. Such amplitude adjustment allows students to continue the development of poor auditory pattern perception.

Until further evidence is presented to the contrary, the experimenter assumes that any well-tuned musical sound source will support good ear-training CAI. However, the experimenter is very much opposed to some of the "super-cheap" out-of-tune sound sources currently available. Development of precise auditory imagery is not supported by poor intonation.

Good instructional design and integration of the CAI system into the classroom learning sequence appear to be the central factors necessary for the pedagogical success of any system.

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APPENDIX A

```
   C:  HH--ADAPTIATION OF H I P H3, HALF : FULL CADENCE;
C:  STARTED 4/28/81, UF ...  RNK
H:  PA = PERFECT AUTHENTIC
H:  IA = IMPERFECT AUTHENTIC
H:  AH = AUTHENTIC HALF
H:  PP = PERFECT PLAGAL
H:  IP = IMPERFECT PLAGAL
H:  PH = PLAGAL HALF
S:2
T:  $N, THIS LESSON HELPS YOU LEARN
T:       HALF AND FULL CADENCES.
T:  DO YOU WANT INSTRUCTIONS?
T:  TYPE  Y OR  N .
A:
M:Y;YES
JN:JUMPHERE
CS:
JUMPBACK T:  I'LL PLAY 3 CHORDS--
T:  THE 1ST CHORD IS  A L W A Y S TONIC--
T:  THE LAST 2 CHORDS GIVE THE CADENCE.
T:  $N, YOU TYPE THE CADENCE
T:       WITH THESE ABBREVIATIONS:
T:  PA = PERFECT AUTHENTIC
T:  IA = IMPERFECT AUTHENTIC
T:  AH = AUTHENTIC HALF
T:  PP = PERFECT PLAGAL
T:  IP = IMPERFECT PLAGAL
T:  PH = PLAGAL HALF
P:10
T:  $N,
T:  HERE'S A SAMPLE CADENCE & ANSWER.
T:  $R 4CD 3E 2G CUQ 4R 3R 2R RH 4C 3E 2G CQ 4G 3D 2G BDH ?
T:  $N, THE ANSWER WAS  AH --
T:  --THE CADENCE WAS  AUTHENTIC HALF.
T:  $N, NOW PRESS RETURN TO CONTINUE.
A:
T:  REMEMBER:
T:  AFTER I PRINT A  *, TYPE YOUR ANSWER
T:  TYPE  ?  TO REHEAR THE MUSIC.
T:  TYPE //H TO REVIEW THE ANSWER FORMS.
T:  TYPE //S TO STOP THIS LESSON.
T:  $N, DO YOU WANT TO REVIEW
T:     THESE INSTRUCTIONS? (TYPE Y OR N)
A:
M:N;NO
JN:JUMPBACK
JUMPHERE T:  LET'S GET STARTED, $N!
Q:24<D!D!N!1<$R 4DD 3F+ 2A DUQ 4R 3R 2R RH 4A 3A 2E C+Q 4D 3F+ 2A DH 4R 3R 2R RQ ? ! PA >
 $R 4DD 3F+ 2A DUQ 4R 3R 2R RH 4F 3F 2A- CQ 4C 3E- 2G CH 4R 3R 2R RQ ? ! PP >
<$R 4CD 3E- 2G CUQ 4R 3R 2R RH 4F 3F 2A- CQ 4C 3E- 2G CH 4R 3R 2R RQ ? ! IA >
<$R 4DD 3D 2F AQ  4R 3R 2R RH  4A 3C+ 2E AQ  4D 3D 2F AH 4R 3R 2R RQ ? ! PH >
<$R 4CD 3C 2E- GQ  4R 3R 2R RH  4C 3C 2E- GQ  4F 3C 2F A-H 4R 3R 2R RQ ? ! IA >
<$R 4DD 3AD 2D FQ  4R 3R 2R RH  4A 3A 2C+ EQ 4D 3A 2D FH 4R 3R 2R RQ ? ! PA >
<$R 4DD 3F+ 2A DUQ 4R 3R 2R RH 4AD 3A 2C+ EQ 4DU 3F+ 2A DH 4R 3R 2R RQ ? ! PH >
<$R 4CD 3GD 2C EQ  4R 3R 2R RH  4C 3G 2C EQ  4F 3A 2C FH 4R 3R 2R RQ ? ! IP >
<$R 4CD 3C 2E GQ  4R 3R 2R RH  4F 3C 2F AQ  4C 3C 2E GH 4R 3R 2R RQ ? ! AH >
<$R 4DD 3F 2A DUQ  4R 3R 2R RH  4D 3F 2A DQ  4A 3E 2A C+H 4R 3R 2R RQ ? ! PH >
<$R 4CD 3GD 2C E-Q 4R 3R 2R RH 4C 3G 2C E-Q  4F 3A- 2C FH 4R 3R 2R RQ ? ! PA >
<$R 4DD 3F 2A DUQ  4R 3R 2R RH  4A 3A 2C+ EQ  4D 3F 2A DH 4R 3R 2R RQ ? ! IP >
 $R 4CD 3GD 2C EQ  4R 3R 2R RH  4F 3A 2C FQ  4C 3G 2C EH 4R 3R 2R RQ ? ! IA >
 $R 4DD 3AD 2D F+Q 4R 3R 2R RH 4AD 3A 2C+ EQ 4DU 3A 2D F+H 4R 3R 2R RQ ? ! AH >
 $R 4DD 3AD 2D FQ  4R 3R 2R RH  4D 3A 2D FQ  4A 3A 2C+ EH 4R 3R 2R RQ ? ! IP >
 $R 4CD 3C 2E- GQ  4R 3R 2R RH  4F 3C 2F A-Q  4C 3C 2E- GH 4R 3R 2R RQ ? ! PA >
 $R 4DD 3F 2A DUQ  4R 3R 2R RH  4A 3E 2A C+Q  4D 3F 2A DH 4R 3R 2R RQ ? ! PH >
 $R 4CD 3C 2E GQ  4R 3R 2R RH  4C 3C 2E GQ 4F 3C 2F AH 4R 3R 2R RQ ? ! IA >
 $R 4DD 3D 2F+ AQ  4R 3R 2R RH  4A 3C+ 2E AQ  4D 3D 2F+ AH 4R 3R 2R RQ ? ! PP >
<$R 4CD 3E 2G CUQ  4R 3R 2R RH  4F 3F 2A CQ  4C 3E 2G CH 4R 3R 2R RQ ? ! IP >
<$R 4CD 3GD 2C E-Q 4R 3R 2R RH  4F 3A- 2C FQ  4C 3G 2C E-H 4R 3R 2R RQ ? ! AH >
<$R 4DD 3F+ 2A DUQ  4R 3R 2R RH  4D 3F+ 2A DQ 4A 3E 2A C+H 4R 3R 2R RQ ? ! PP >
<$R 4CD 3E 2G CUQ  4R 3R 2R RH  4F 3F 2A CQ  4C 3E 2G CH 4R 3R 2R RQ ? ! PP >
<$R 4CD 3E- 2G CUQ 4R 3R 2R RH 4F 3F 2A- CQ 4C 3E- 2G CH 4R 3R 2R RQ ? ! AH >
<$R 4DD 3AD 2D F+Q  4R 3R 2R RH  4D 3A 2D F+Q 4A 3A 2C+ EH 4R 3R 2R RQ ? ! AH >
CQ:
E:
`0
```

```
C: ADAPTED FROM H-F C10
C: STARTED 5/3, UP ..., RNK
C: MAJOR & MINOR 4-VOICE TRIADS, ALL INV
C:   BASS & SOPRANO SENSING
H: TYPE BASS, THEN SOPRANO AS 1  3  OR 5
H:    OF CHORD
H: TYPE BASS 1ST, THEN SOPRANO (EX: 15)
CS:
S:2
T: $N, THIS LESSON HELPS YOU LEARN
T:     SOPRANO & BASS NOTES
T:     OF 4-VOICE MAJOR & MINOR TRIADS.
T: DO YOU WANT INSTRUCTIONS ?
T: TYPE  Y  OR  N .
A:
M:Y;YE;YES
JN:JUMPHERE
JUMPBACK CS:
T: I'LL PLAY MAJOR & MINOR 4-PART CHORDS
T: CHORDS ARE PLAYED BLOCK STYLE
T: SOME CHORDS ARE INVERTED--
T: YOU TYPE--
T:      BASS NOTE:  1  OR  3  OR  5
T:      SOPRANO NOTE:  1  OR  3  OR  5
T: A SAMPLE ANSWER LOOKS LIKE--
T:   13  (1 IN BASS, 3 IN SOPRANO)
T: $N, NOW PRESS RETURN TO CONTINUE
A:
CS:
T: $N,
T: HERE'S A SAMPLE QUESTION & ANSWER:
T: $R 4CD 3C 2E- GW 4R 3R 2R RQ 4R 3R 2R RE ?
T: $N, THE ANSWER IS 15--
T:    --1 IN BASS, 5 IN SOPRANO.
T: $N, NOW PRESS RETURN TO CONTINUE.
A:
CS:
T: REMEMBER:
T: TYPE   ?  TO REHEAR THE MUSIC.
T: TYPE  //H TO REVIEW THE ANSWER FORMS.
T: TYPE  //S TO STOP THIS LESSON.
T: AFTER I PRINT A *, YOU TYPE YOUR ANSWER.
T: YOU DON'T HAVE TO HOLD DOWN THE
T:    SHIFT KEY, FOR CAPITAL LETTERS.
T: $N, DO YOU WANT TO REVIEW
T:      THESE INSTRUCTIONS (TYPE Y OR N)
A:
M:N;NO
JN:JUMPBACK
JUMPHERE T: LET'S GET STARTED, $N!!
Q:18<D!D!N!1>
<$R 4CD 3GD 2E- CUW 4R 3R 2R RE ? !11>
<$R 4GD 3G 2CU EUW 4R 3R 2R RE ? !53>
<$R 4CD 3GD 2C EW 4R 3R 2R RE ? !13>
<$R 4GD 3C 2E- GW 4R 3R 2R RE ? !55>
<$R 4CD 3C 2E GW 4R 3R 2R RE ? !15>
<$R 4E-D 3GD 2C GW 4R 3R 2R RE ? !35>
<$R 4ED 3C 2G CUW 4R 3R 2R RE ? !31>
<$R 4GD 3E- 2G CUW 4R 3R 2R RE ? !51>
<$R 4ED 3GD 2C EW 4R 3R 2R RE ? !33>
<$R 4E-D 3C 2G CUW 4R 3R 2R RE ? !31>
<$R 4GD 3E 2G CUW 4R 3R 2R RE ? !51>
<$R 4E-D 3GD 2C E-W 4R 3R 2R RE ? !33>
<$R 4ED 3GD 2C GW 4R 3R 2R RE ? !35>
<$R 4CD 3C 2E GW 4R 3R 2R RE ? !15>
<$R 4CD 3GD 2C E-W 4R 3R 2R RE ? !13>
<$R 4CD 3E 2G CUW 4R 3R 2R RE ? !11>
<$R 4GD 3G 2CU E-UW 4R 3R 2R RE ? !53>
<$R 4CD 3C 2E- GW 4R 3R 2R RE ? !15>
EQ:
E:
```

```
C:  ADAPTATION OF NT H-P 115 (1980)
C:  ALL MELODIC INTERVALS IN 8VA
C:  STARTED 9/25/80,  UP ........, RNK
H:  MA2 = MAJOR 2ND    MI2 = MINOR 2ND
H:  MA3 = MAJOR 3RD    MI3 = MINOR 3RD
H:  P4  = PERFECT 4TH P5   = PERFECT 5TH
H:  MA6 = MAJOR 6TH    MI6 = MINOR 6TH
H:  MA7 = MAJOR 7TH    MI7 = MINOR 7TH
H:  P8  = PERFECT 8VA TT   = TRITONE
S:2
CS:
T: $N, THIS LESSON
T:      HELPS YOU LEARN INTERVALS--
T:  DO YOU WANT INSTRUCTIONS?
T:  ---TYPE  Y  OR  N
A:
M: Y;YE;YES
JN:195
JUMPBACK T: I'LL PLAY  M E L O D I C  INTERVALS,
T:        --AN OCTAVE OR SMALLER:
S:1
T:  MA2 = MAJOR 2ND    MI2 = MINOR 2ND
T:  MA3 = MAJOR 3RD    MI3 = MINOR 3RD
T:  P4  = PERFECT 4TH P5   = PERFECT 5TH
T:  MA6 = MAJOR 6TH    MI6 = MINOR 6TH
T:  MA7 = MAJOR 7TH    MI7 = MINOR 7TH
T:  P8  = PERFECT 8VA TT   = TRITONE
S:2
L:2
P:10
T: $N, HERE'S A SAMPLE QUESTION--
T:      --(WITH ANSWER)--
T: $R CQ D-Q RE RE ?
P:4
T: $N, THE ANSWER IS MI2.
T: $N, NOW PRESS RETURN TO CONTINUE.
A:
S:2
T: REMEMBER:
T: MI = MINOR  MA = MAJOR
T: P = PERFECT TT = TRITONE
T: TYPE  ?  TO REHEAR THE INTERVAL.
T: TYPE  //H TO REVIEW ANSWER FORMS.
T: TYPE  //S TO STOP THIS LESSON.
T: AFTER I PRINT A  *, TYPE YOUR ANSWER.
T: $N, DO YOU WANT TO REVIEW
T:      THESE INSTRUCTIONS? (TYPE Y OR N)
A:
M:N;NO
JN:JUMPBACK
195 P:5
T: LET'S GET STARTED, $N!!
Q:24<D!D!N!1>
< $R CQ CUQ RQ ?!P8>
< $R D-Q CQ RQ ?!MI2>
< $R CQ DQ RQ ?!MA2>
< $R DQ AQ RQ ?!P5>
< $R CQ E-Q RQ ?!MI3>
< $R A-Q CQ RQ ?!MI6>
< $R CQ EQ RQ ?!MA3>
< $R C+UQ DDQ RQ ?!MA7>
< $R CQ FQ RQ ?!P4>
< $R AQ CQ RQ ?!MA6>
< $R CQ F+Q RQ ?!TT>
< $R CUQ DDQ RQ ?!MI7>
< $R DQ CQ RQ ?!MA2>
< $R GQ CQ RQ ?!P5>
< $R CQ A-Q RQ ?!MI6>
< $R E-Q CQ RQ ?!MI3>
< $R CQ FQ RQ ?!P4>
< $R AQ CQ RQ ?!MA6>
< $R DQ CUQ RQ ?!MI7>
< $R F+Q CQ RQ ?!TT>
< $R D-Q CUQ RQ ?!MA7>
< $R EQ CQ RQ ?!MA3>
< $R CQ C+Q RQ ?!MI2>
< $R CQ CUQ RQ ?!P8>
CQ:
E:
```

APPENDIX B

Description of Headphones

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The Sony DR-S3 Stereo Headphones are standard "discrete stereo" headphones with two 8-ohm speakers for the left and right channels. They are size adjustable and made from molded plastic. They have a padded foam surface, surrounding each ear speaker, and thus help to isolate the wearer from ambient room noise. They interface into a playback system with a standard stereo phone jack which is molded into the cable.

Two audio tests were performed on the headphones to determine their response to signals of measured frequency. The tests sent tones of known frequency and overtone content, with subjective evaluation of the performance.

Test 1 applied a computer-generated sine tone at a fixed amplitude across the entire range of frequencies tested. Starting at 440 cps. and lowering the frequency, there was no appreciable change in performance until the tone was at 70 cps.; at 50 cps, the tone was extremely difficult to discern; the pitch of the signal, although the existance of the signal was still audible.

Beginning again at 440 cps. and increasing the frequency, the performance was once again good with a noticeable increase in apparent loudness at 700 cps. This increase in apparent loudness continued through to 1000 cps. At 1760 cps. there was a rolloff in the discernability of the frequency content of the signal. This continued to 5280 cps., where the test ended because of limitations of the testing equipment. At 5280 cps., the pitch content of the signal was still discernable but the quality of the signal had decreased.

Test 2 was identical to test 1 except that the test signal was a more complex tone containing 100% of the fundamental, 50% of the first overtone, 25% of the second overtone, 12.5% of the third, 6.7% of the fourth, and 3.4% of the fifth overtone.

The performance at the lower end of the frequency spectrum was increased, with the apparent loudness decrease not occuring until 50 cps., and then decreasing linearly until 30 cps. At 30 cps., the signal was still audible, but its pitch content was not discernable.

At the upper end of the frequency spectrum, an increase in apparent loudness was encountered at 900 cps., continuing linearly to about 1200 cps. From 1760 cps., there was a gradual decrease in signal amplitude to about 5280 cps, where the test ended, with pitch content still discernable but quality of the signal decreased.

APPENDIX C

APPLE GRANT EXPERIMENTAL DESIGN

	1	2	3	4	5	6
1	1 A B C 1 2 3 S. [illegible] 5/5 [illegible]	2 A B C 2 3 1 S. [illegible] 5/ [illegible] [illegible]	3 A B C 3 1 2 S. [illegible] 5/5 [illegible]	4 A B C 1 3 2 S. Ranson 5/5 21:15-21:45	5 A B C 3 2 1 S. [illegible] 5/ [illegible] 15:[illegible]-16:[illegible]	6 A B C 2 1 3 S. [illegible] 5/6 16:05
2	7 B C A 1 2 3 S. [illegible] 5/ [illegible]	8 B C A 2 3 1 S. [illegible] 5/ [illegible]-20:30	9 B C A 3 1 2 S. Galpin 5/6 20:55-[illegible]	10 B C A 1 3 2 S. [illegible] 5/7 17:00-17:35	11 B C A 3 2 1 S. [illegible] 5/ 18:10-18:45	12 B C A 2 1 3 S. Angelo 5/7 20:00-20:[illegible]
3	13 C A B 1 2 3 S. T.[illegible] 5/7 21:05-[illegible]	14 C A B 2 3 1 S. [illegible] 5/8 9:10-9:55	15 C A B 3 1 2 S. H[illegible] 5/8 13:[illegible]-13:[illegible]	16 C A B 1 3 2 S. Campbell 5/8 14:25-15:05	17 C A B 3 2 1 S. Frederick 5/8 15:[illegible]	18 C A B 2 1 3 S. [illegible] 5/8 [illegible]
4	19 A C B 1 2 3 S. Thompson 5/ 10:55-11:40	20 A C B 2 3 1 S. V.Tr[illegible] 5/ 14:20-15:10	21 A C B 3 1 2 S. M[illegible] 5/9 15:15-15:50	22 A C B 1 3 2 S. Dry 5/9 [illegible]-17:[illegible]	23 A C B 3 2 1 S. Nelson 5/10 18:00 [illegible]	24 A C B 2 1 3 S. Wells 5/10 15:05-15:[illegible]
5	25 C B A 1 2 3 S. Koger 5/10 15:40-[illegible]	26 C B A 2 3 1 S. Burkett 5/12 19:10-20:00	27 C B A 3 1 2 S. Shepherd 5/10 20:[illegible]-20:35	28 C B A 1 3 2 S. Fudge 5/11 19:05-20:05	29 C B A 3 2 1 S. Flores 5/11 20:10-21:[illegible]	30 C B A 2 1 3 S. Grossi[illegible] 5/12 [illegible]
6	31 B A C 1 2 3 S. Yoder 5/12 20:05-20:50	32 B A C 2 3 1 S. Vosburgh 5/13 21:00	33 B A C 3 1 2 S. Francis 5/13 14:[illegible]-14:[illegible]	34 B A C 1 3 2 S. L[illegible] 5/13 16:00-	35 B A C 3 2 1 S. Johnson 5/14 14:15-14:50	36 B A C 2 1 3 S. Meade 5/14 15:15-15:50

A = ALF B = AMUS C = Micromusic

1 = C1 2 = H1 3 = I1

APPENDIX D

APPLE GRANT EXPERIMENT PARTICIPANT SHEET

Student Name________________________________

Soc. Sec. No.________________________________

E.T. Class & Section____________________

Date of Participation___________________

Sound Source Sequence______________________

Lesson Sequence______________________________

Please fill in the part below after participating in the experiment:

1. I liked sound source #_____ best.

2. I liked sound source #_____ least.

3. I want my scores reported to my ear-training instructor. Yes___ No___

Any additional comments?