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Aural Skills, Pedagogy, and Computer Assisted Instruction - Past, Present, and Future

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Reviews

Aural Skills, Pedagogy, and Computer-Assisted Instruction: Past, Present, and Future

Reviewed by Deron McGee

In his 1959 book, *The Sleepwalkers*, Arthur Koestler states:

> The symptom that a particular branch of science or art is ripe for change is a feeling of frustration and malaise, not necessarily caused by any acute crisis in that specific branch. . .but by a feeling that the whole tradition is somehow out of step, cut off from the mainstream, that the traditional criteria have become meaningless, divorced from living reality, isolated from the integral whole.[1]

The essence of this statement resonates deeply with many of our students with respect to aural skills classes. When asked about their individual aural skills experiences, a large proportion of students "admit that they disliked it, thought they were bad at it, and have found it largely irrelevant to their subsequent engagement in music."[2] As George Pratt points out, "either many musicians should have taken up other careers. . .or else the content and methods of aural training and testing are inappropriate to their presumed purpose of developing musical perceptions."[3] This sentiment is not new as Paul Hindemith observed in 1946:

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[1]Arthur Koestler. 1959. *The Sleepwalkers* New York: Macmillan, p. 520.

[2]George Pratt. 1998. *Aural Awareness*, revised edition. New York: Oxford University Press, p. 1.

[3]ibid.

> Sometimes excellent musicians are not able to write down even comparatively simple dictated examples, while frequently musicians of inferior quality easily reproduce elaborate dictations. This shows that the ability to follow musical dictation is not necessarily an index of the degree or quality of musical talent, any more than the memory of numbers, the gift to imitate others' actions, or the sense for spatial direction are essential for general intelligence.[4]

Developing the ability to "think in music" is one of the stated goals of many aural skills programs. Just as a poet cannot forego an understanding of grammar and syntax, theory provides a similar foundation for music. In turn, as a poet's words are comprehended by an individual listener, so should the musical sounds and their relationships received by a trained musician. Terms such as "the hearing eye" and""the seeing ear" embody this concept and dictation plays an important role in this process. Hindemith continues:

> On the other hand it cannot be denied that the complete absence of such ability [taking dictation] is at least an unfavorable indication of the state of a musician's amount of knowledge. It is therefore necessary to develop it—whatever its amount or quality may be—to the utmost, just as all other parts of his gift must be developed.[5]

A primary challenge for us as instructors is to provide opportunities for students to transfer the skills from one area of learning to another. Based on the comments of Pratt's students, this is something we do not do well. Howard Gardner notes that it is not a problem only in music when he states:

> Researchers at Johns Hopkins, M.I.T., and other well-regarded universities have documented that students who receive honor grades in college-level physics courses are frequently unable to solve basic problems and questions encountered in a form slightly different from that on which they have been formally instructed and tested.[6]

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[4]Paul Hindemith. 1946. *Elementary Training for Musicians*, New York: Associated Music Publishers Inc., p. 185.

[5]ibid.

[6]Howard Gardner. 1991. *The Unschooled Mind*. New York: Basic Books, p. 5.

Transfer is not automatic. Knowledge and skills developed in one context will not necessarily carry over into another without instructors developing a rich series of connections for the students. Scholarship in the cognitive sciences and brain research from the past two decades is beginning to illuminate some of the basic operations of the brain, yet few musicians have attempted to bridge that research with teaching aural skills. A notable recent exception is Gary Karpinski's book, *Aural Skills Acquisition*,[7] which draws on such research and starts building such a bridge. By understanding how the brain operates, we can begin to develop more sophisticated theories of learning and by extension refine our materials and methods of teaching.

The Past

With the advent of microcomputers in the late 1970s and their widespread dissemination in the early 1980s, many educators became enamored with the possibilities of this new tool. Historically, educators have been drawn to the light of new technologies, often with amazing predictions of how such technologies will revolutionize teaching and learning. Whether we are discussing the role of textbooks, film, television, or computers, great expectations regarding their impact on teaching have been the rule rather than the exception.

Some of the earliest computer-assisted instruction software, based on a simple drill-and-practice model, began to emerge in the late 1970s with basic ear training exercises as subject matter. Intervals and chords have clearly identifiable right and wrong answers, a quality that lends itself to automation. However, the vision of many early instructors was limited by the capabilities of the computer. Rather than creating a vision for teaching and then implementing it on the computer, most instructors (I count myself among them) were woefully limited by the computers in terms of memory, storage options, and processing speed. My first computer (a TRS-80) had 8K of RAM and a cassette tape for storage. Within the first few years, the Apple II sported up to 64K of RAM and limited processing speed. With

[7]Gary Karpinski. 2000. *Aural Skills Acquisition*. New York: Oxford University Press.

these tools, it is no wonder that instructors developed programs to fit within these constraints, since the higher order processing required to identify shades of gray in student responses was not possible.

In the middle and late 1980s, several computer programs became available for ear training. Programs such as *Music Lab, Practica Musica, MacGAMUT, Melodic Dictator,* and *Ear Training Expert* were in use. One serious problem when writing software "in the good old days" was the incompatibility of Macintosh and Windows computers. Programs written on one platform were not easily translated to operate on the other. All of the programs listed here were written for a single platform.

As we move through the 1990s, compatibility between the Macintosh and Windows platforms became easier with new development tools and the widespread use of the internet. The internet essentially neutralizes all platform issues, since any computer with a browser can connect and interpret data from a specific type of server, which brings us to today.

The Present

For this review, I have selected four current cross-platform programs. Some of them have been around for some time, such as *Practica Musica* (Ars Nova Software) and *MacGAMUT* (Music Software International, Columbus, Ohio), while others are relatively new to the scene, such as *CASPAR* (W.W. Norton, New York) and *Music for Ear Training* (Wadsworth, Belmont, CA). The philosophies behind the programs can be spilt into two groups. First, *Practica Musica* and *MacGAMUT* each expand on the initial drill and practice model by developing computer-based assessment of the student work and providing additional feedback during the process. They also both build on a mastery learning model. The other two programs return to a philosophy of creating prepared examples to dictate for students, much like the practice tapes that accompanied ear training texts of the 1970s, and one provides a series of quizzes for which the student cannot be shown the answers. The grading of the dictation exercises becomes the responsibility of the instructor, rather than the computer. Each philosophy has merit and can be effective based on the context in which it is used.

One conspicuous absence from this review is *Auralia* (Rising Software). My review copy of *Auralia* was damaged and a replacement did not arrive before the deadline. Further, a quick search of the internet reveals literally hundreds (if not thousands) of ear training programs that drill aural skills for Windows, Macintosh, and general web browsers. A definitive survey of all available programs would be immense; therefore this review has been limited to four currently available, cross-platform programs.

Practica Musica

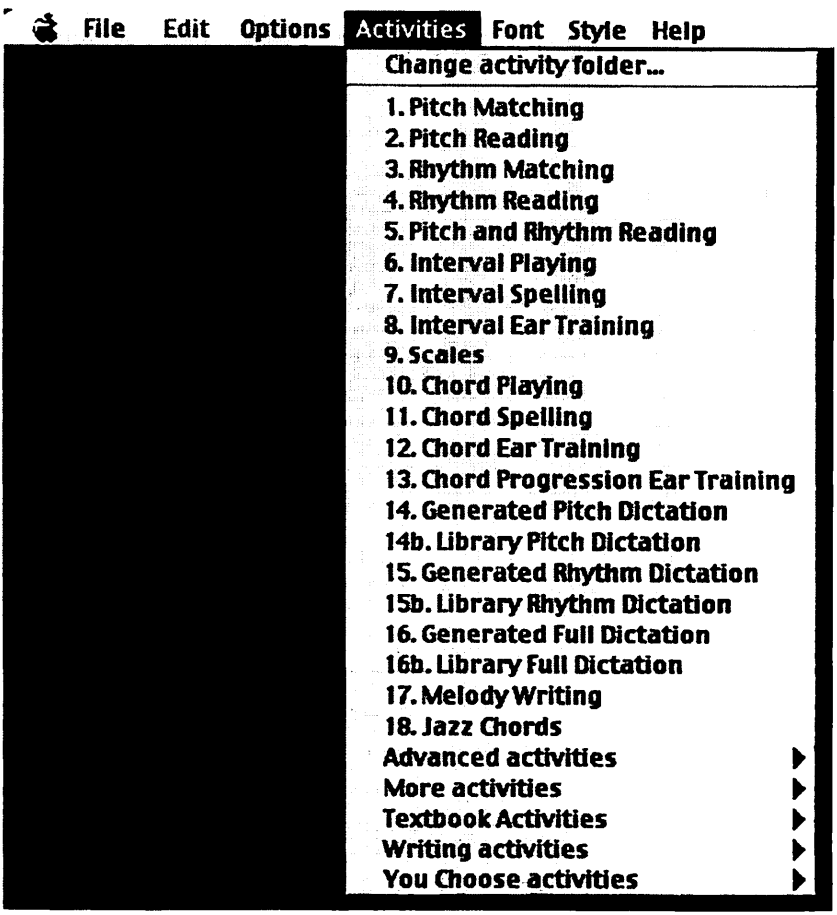
Introduced in 1987, *Practica Musica* is one of the earliest commercially-available music programs to incorporate a substantial amount of ear training. The philosophy behind the program is to combine drill-and-practice exercises in constructing the elements of music (intervals, scales, chords, etc.) and ear-training exercises, all scored by the computer. It employs a mastery learning strategy, with four levels of mastery within each activity and as many as six sublevels for each major level. The package includes a music fundamentals textbook for single users, but the company also offers renewable student files for multiple users running from a single server as a site license. A single user version of *Practica Musica* sells for $125, while the site licenses start at $600 for 50 renewable student files. Additional student files may be purchased in lots of 10 for $4 each. The current version, 4.465 as of press time, represents a substantial improvement from the previous 3.x version. Minor updates and support are available on the company web site (www.ars-nova.com) for registered users.

The program supports both internal sounds and MIDI. Students can enter answers to some exercises, such as rhythmic and melodic dictation, on a MIDI keyboard. Other exercises requiring the student to spell intervals and chords must be entered on the computer screen. An element retained from the original version is a basic analytical system that identifies the intervals and chords as one plays the MIDI keyboard. An interesting feature from earlier versions that allowed the exercises to be heard in a variety of tuning systems has been removed in the current version.

Each activity in *Practica Musica*, as shown in Figure 1, requires students to accumulate a series of points before reaching mastery. When the level is completed, the student is greeted with a round of sampled applause and allowed to continue into the next level. (The applause can be quite annoying after the first or second time.)

The program generates melodies, rhythms, and harmonic progressions and also allows for examples from the literature to be included in the libraries. In melodic dictation, the program checks pitch only, places the correct rhythm in the example, and provides

Figure 1. Activities Menu from *Practica Musica*



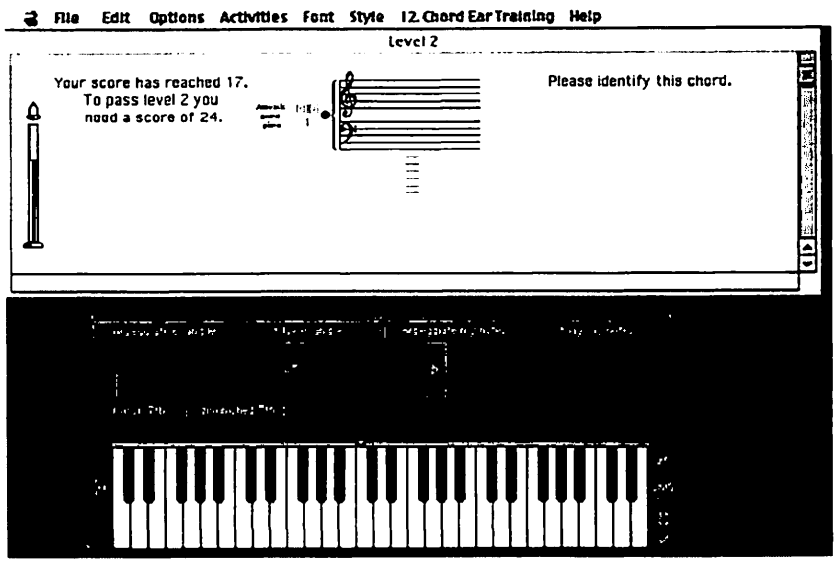
limited feedback. The generated harmonic dictation examples are adequate in general, but they do not always make complete musical sense, especially in the shorter exercises. The longer the excerpt, the better the progression. In the rhythmic dictation activities, the program only checks for proper performance placement of the downbeats and durations within the example. In this case, the assessment and reporting algorithms are more sophisticated, but the feedback is still relatively simple, identifying such things as a late onset of a note, a note not held long enough, and so forth. Nevertheless, the rhythmic performance element is probably the strongest asset of this program.

One frustration involves the default penalties for wrong answers. Figure 2 shows the chord identification screen with the student working on level 2, where a score of 24 points is required to pass this section. The default setting for a wrong answer is to reduce the points by half for each error. This can be particularly frustrating for a student with 23 points and happens to "mis-click" an answer, reducing the points to 12. Fortunately, in this version of the program the instructor controls are much improved over the past versions and the point deductions, if any, for incorrect responses can be adjusted.

The instructor has remarkable flexibility when designing or modifying activities. He or she can create new activities, decide what materials to include at each level or sublevel, identify the type of question, the form of the input from the student, create and import new libraries of music to use as examples, and much more. The instructor can also define how an exercise is to be scored within a limited range of parameters, which allows for some input into the way the computer interprets the score. The program does not provide for more complex assessments. For example, when scoring melodies, the program cannot recognize contours or transpositions and incorporate those elements into the overall score. Finally, such flexibility has to be balanced with the time it takes to design, develop, and implement new exercises. While designing new exercises is not difficult, it is time consuming.

The current version allows students to practice at any level, a substantial improvement over earlier versions that required students to progress through each level before even attempting something

Figure 2. *Practica Musica* Level 2 of Chord Ear Training



more advanced. *Practica Musica* reports the activity of each student by highlighting sections mastered and also indicating "time on task" for each activity. Individual students can keep track of their records and send the file to the instructor. In the site license version, all files are stored in a central location.

Practica Musica serves a general audience, therefore many of the activities do not reach the depth and breadth of examples of some of the other programs being reviewed here. If you need reinforcement of music fundamentals while developing aural skills then *Practica Musica* may be an adequate choice, however the price is prohibitive for most students.

MacGAMUT 2000

MacGAMUT 2000 features the most sophisticated assessment mechanisms of the programs under review. While it does not have the polished look of the other packages, it more than makes up for that with content, design, and flexibility. The philosophy behind the program is similar to that of *Practica Musica* in that it includes a combi-

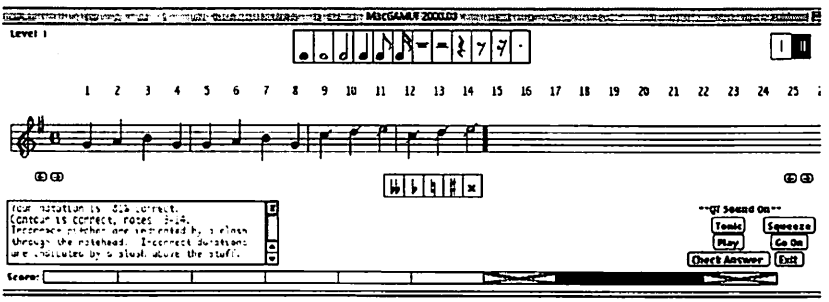
nation of drill-and-practice exercises in constructing the elements of music (intervals, scales, chords, etc.) and ear-training exercises all scored by the computer. It also employs a mastery learning model, although with much more detail and depth. *MacGAMUT* incorporates 18 levels of intervals, 10 levels of scales, 14 levels of chords, 18 levels of melodic dictation, and 20 levels of harmonic dictation in the basic configuration alone. Each student purchases a student disk (currently $35 each), registers with the web site (www.*MacGAMUT*.com), and receives a student file via e-mail. The student file is the key to *MacGAMUT* since the program will not run without it. Support and minor upgrades are available at the company web site for registered users.

The program supports both internal sound and MIDI, however the Macintosh version was not completely USB compatible as of press time. Interestingly, the program functions quite well without MIDI due to the unique circumstances under which it developed. Through an administrative decision, the music lab where students were testing the earliest version of the program had Macintosh computers, but no MIDI keyboards. Of necessity, the programmers developed an interface that works remarkably well without the keyboard.

Each level of exercises has a regular and practice setting. When attempting to demonstrate mastery of a particular level, the student must complete 8 of 10 exercises correctly (the number may be adjusted by the instructor). When assessing the melodic and harmonic dictation, the program incorporates quite sophisticated analysis algorithms to determine "greater errors" from "lesser errors" as an overall score is determined for the exercise. Figure 3 shows a melodic dictation example where the computer identifies the correct contour even though the pitches are incorrect, a error students commonly make. *Practica Musica* simply counts the pitches wrong with no further feedback, whereas *MacGAMUT* identifies the type of error and shares the information with the student. The program still counts the pitches as incorrect, but the larger-scale patterning that *MacGAMUT* can identify reaches a step beyond the other programs.

MacGAMUT does not have a separate rhythmic dictation section. Rather, rhythm and pitch are evaluated simultaneously when

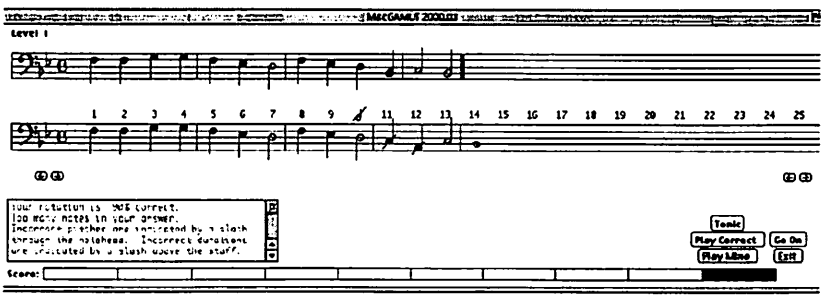
Figure 3. *MacGAMUT* Melodic Dictation Example



the melodic dictation exercise is scored. Figure 4 shows an example of a melodic dictation exercise containing a rhythmic error and a couple of pitch errors. The program scored this particular melody at 90%, presumably accounting for the "lesser error" of a missed duration and added notes than missed pitch and duration. By not separating rhythm from melody, this program more accurately represents how we perceive music, but more importantly requires an integration of concepts not required in the other programs.

Figure 5 shows an example of a student answer, the correct answer, the incorrect elements, and the overall score of a harmonic dictation exercise. The screen includes a feedback box on the left-hand side of the screen that indicates the error(s), buttons on the right-hand side that allow students to hear their example and the original to make comparisons, and a tracking bar on the bottom of

Figure 4. *MacGAMUT* Melodic Dictation Example

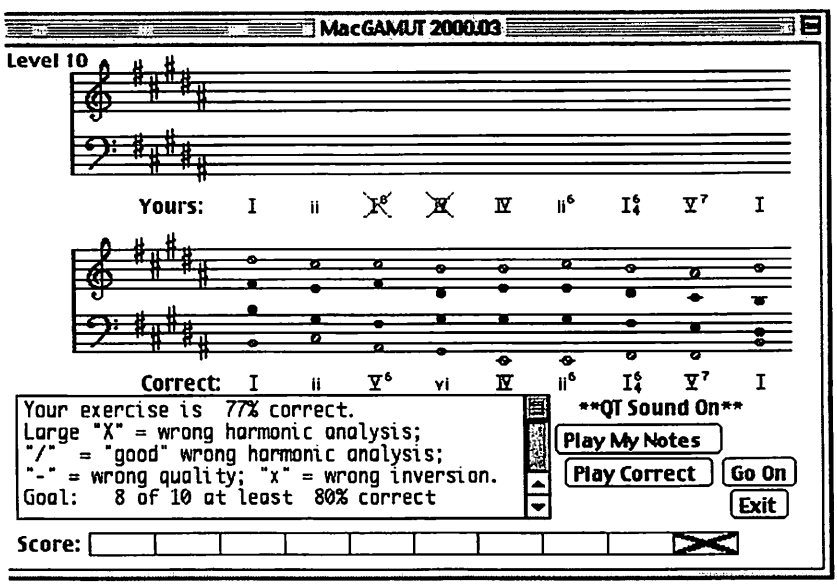


the screen tracks the number of correct answers out of the last 10. As the student moves to the next exercise, the red X in the tracking bar box on the right-hand side of the screen will move one place to the left. When 8 of 10 boxes turn green, representing correct answers, the level has been mastered.

The instructor can determine the number of examples needed for mastery, the percentage of the example elements that must be correct to be counted as a pass, and a variety of other parameters through programs available on the instructor disk. Instructors can create additional melodies, harmonic progressions, scale patterns, interval exercises, and so forth. The process is extremely flexible, intuitive, and very functional.

MacGAMUT does not have real-time rhythmic dictation exercises, as does *Practica Musica*. The advantage of such exercises can be found in developing timing, arguably the most important factor in musicality, rather than rhythmic identification and understanding. Such a series of exercises would be a welcome addition to future versions of this fine program.

Figure 5. *MacGAMUT* Harmony Exercise



Computer Assisted Software Project for Aural Skills Reinforcement (CASPAR)

A new addition to the body of ear training programs is *CASPAR*, developed by Eric Lund at the University of Illinois and published by W.W. Norton in New York (www.wwnorton.com). The program is designed to coordinate with Leo Kraft's *New Approach to Sight Singing*, 2nd Edition (W.W. Norton, New York) and also to serve as a stand-alone program. The philosophy behind *CASPAR* differs dramatically from the previous two programs in that the computer does not score any of the exercises. Rather, the computer provides single line melodies and harmonic exercises in the form of SATB chorales and the student writes the dictation on manuscript paper. The program is organized into four sections of melodic and four sections of harmonic exercises with each unit consisting of eight or nine lessons. When students purchase *CASPAR* (currently $31.50), they receive a CD-ROM with 260 graded exercises. *CASPAR* supports internal sound and MIDI, with the exception of USB MIDI on the Macintosh in this version.

Figure 6 presents the melodic dictation screen for *CASPAR*. All melodies have the key signature and starting pitch given. Beginning in the lower left-hand side of the screen, the metronome can be adjusted by the student with or without a count off measure. The harmonize button will play a tonicization pattern in the key at any time. The student can select specific measures for playback, the playback controls are self-explanatory, and the tempo can be adjusted.

CASPAR provides on-board help featuring partial or substantial guidance with the task at hand through the view tabs at the top of the screen. The tonic tab will indicate every location of tonic in the melody, while the 1-3-5 and 5-7-2-4 tabs indicate the locations of the scale degrees of the tonic and dominant harmonies, respectively. The rhythm tab will show the rhythm of any or all of the measures. The contour tab highlights shapes, and the implied harmony tab reveals possible harmonizations of the scale degrees present. The hints tab reveals one or more hints depending on the complexity of the melody and finally the entire answer can be revealed with the answer tab.

Figure 6. *CASPAR* Melodic Dictation

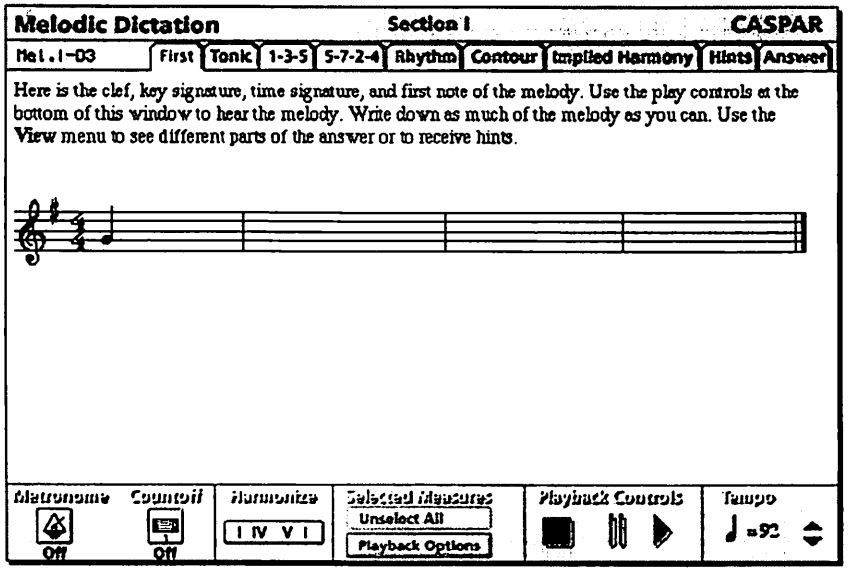


Figure 7 shows *CASPARS*'s harmonic dictation screen from a dictation exercise in the fourth section of the program. The controls at the bottom of the screen are consistent in all of the exercises, and the top of the page allows the student to listen to any or all voices in any combination by turning them on or off with the speaker icons. Since this exercise modulates, there are two rows for the analytical symbols and function identification. Figure 8 shows the answer(s) to this particular exercise.

CASPAR keeps a progress report for each student as shown in Figure 9. It tracks the complete time on task, the number of hearings (full and partial), and the amount of help requested based on each help item. The progress reports can be sent to instructors along with the completed exercises.

This type of program can be useful in the right circumstances with dedicated students willing to put forth the effort to honestly engage the learning process that such a program facilitates. It also moves the grading from the computer to the instructor, so the exercises can be scored using the teacher's own rubrics. However,

Figure 7. *CASPAR* Harmonic Dictation, Level 4 Exercise

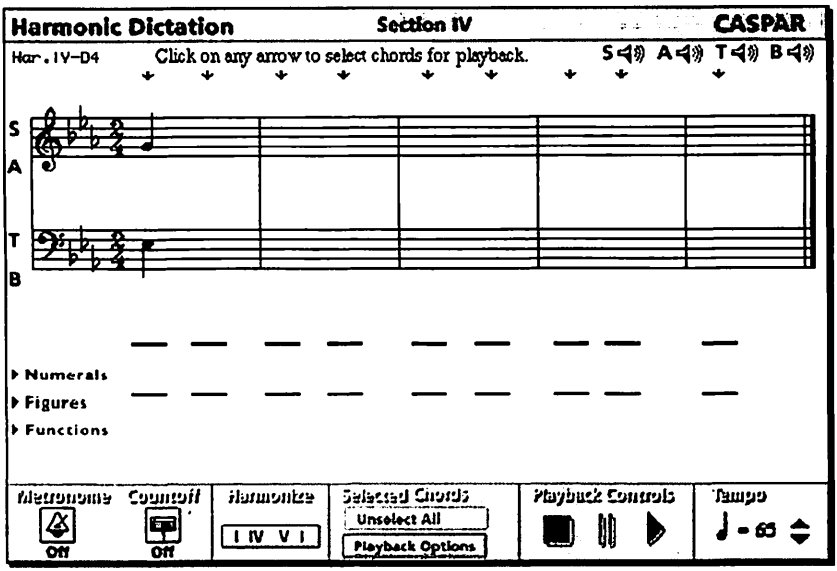


Figure 8. *CASPAR* Harmonic Dictation, Level 4, Answer

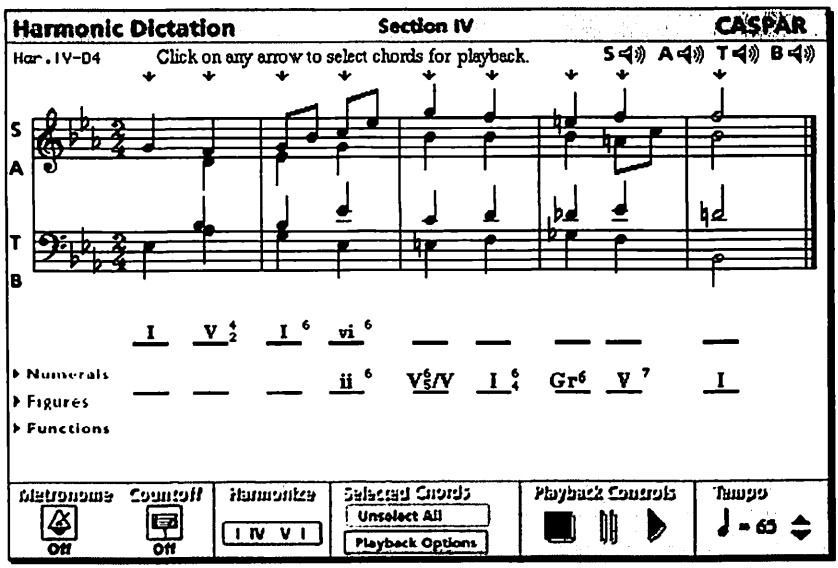


Figure 9. *CASPAR* Progress Report

Click or press any key to advance pages or return to CASPAR

CASPAR Progress Report — Doron

Wednesday, October 3, 2001

Melody: note: where applicable, "/" separates number of clicks for partial info. from clicks for full info.

Melody	time	Playbacks--- full	partial	First	Tonic	1-3-5	5-7-4-2	Rhythm	Contour	Implied Harmony	Hints	Answer
	7:42	0	0	0	0	0	0	0/ 0	0/ 0	0/ 0	0	0/ 0
I-A1	2:44	5	0	3	3	2	2	0/ 0	0/ 0	0/ 0	1	4/ 0
I-A2	1:43	2	0	1	1	1	1	4/ 0	0/ 0	0/ 0	0	0/ 1
I-A3	0:19	1	0	1	0	0	0	0/ 0	0/ 0	0/ 0	0	0/ 0
I-B1	1:43	4	0	1	1	1	1	0/ 0	0/ 0	0/ 1	2	0/ 1
II-A1	0:18	1	0	0	0	0	0	0/ 0	0/ 0	0/ 0	0	0/ 0
II-B2	0:00	1	0	1	0	0	0	0/ 0	0/ 0	0/ 0	0	0/ 0
III-F4	0:00	1	0	0	0	0	0	0/ 0	0/ 0	0/ 0	0	0/ 0
I-D3	2:21	2	0	1	2	2	2	1/ 0	10/ 0	1/ 1	1	0/ 1
Totals	16:50	17	0	8	7	6	6	5/ 0	10/ 0	1/ 2	4	4/ 3

Harmony:

Harmony	time	Playbacks--- full	partial	Visits	Roman #	Figure	Function	Sop.	Alto	Tenor	Bass
I-A1	0:20	2	1	1	0/ 1	0/ 1	0/ 1	0/ 0	0/ 0	0/ 0	0/ 0
IV-D4	2:29	2	0	2	0/ 1	0/ 2	0/ 2	11/ 0	0/ 0	12/ 0	0/ 0
IV-E2	0:19	1	0	1	0/ 1	0/ 1	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0
IV-B4	2:01	1	0	1	0/ 1	0/ 1	0/ 3	0/ 0	0/ 0	0/ 0	0/ 0
Totals	5:09	6	1	5	0/ 4	0/ 4	0/ 6	11/ 0	0/ 0	12/ 0	0/ 0

Total Session Time: 21:59

CASPAR has some shortcomings. First, it does not provide any exercises to serve as quizzes where the material is not presented to the student. Second, it does not lighten the burden of grading exercises. Finally, the limited number of examples could be a problem for students who need additional work. The 260 examples average to just over four melodic and four harmonic dictation exercises each week over a two-year, 15-week/semester sequence. While that may be an appropriate number for some students, others may need many more exercises based on strength of their musical background.

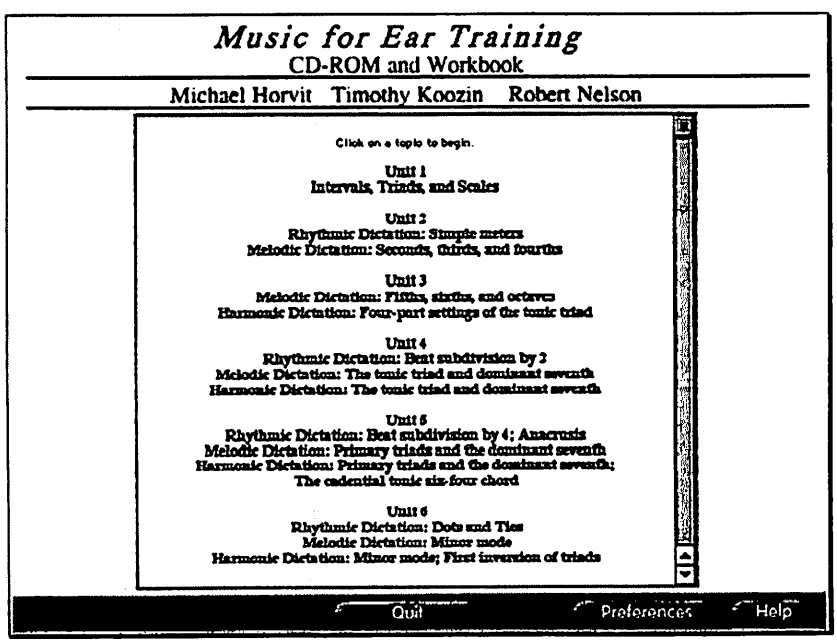
Music for Ear Training

Another new addition to the body of ear training programs is *Music for Ear Training*, designed by Tim Koozin at the University of Houston and published by Wadsworth (www.wadsworth.com). The program coordinates with Benjamin, Horvitt, and Nelson's *Music*

for Sight Singing, 3rd Edition (Wadsworth) and serves as a stand-alone workbook with software. The philosophy behind *Music for Ear Training* is similar to *CASPAR*. The computer provides melodic, harmonic, rhythmic, and transcription exercises. The CD-ROM is packaged with a spiral bound workbook with perforated pages. The workbook contains printed blank staves that coordinate with the exercises on the CD-ROM. The book and CD-ROM set currently costs $42.26 and can be purchased directly from the Wadsworth web site. Figure 10 shows the first page of the main menu indicating the first six of seventeen units. Many units are divided into harmonic, melodic, and rhythmic dictation exercises, while Units 10, 14, and 17 are dedicated to transcriptions from music literature. *Music for Ear Training* uses several good internal sounds and supports all MIDI devices.

Figure 11 shows the melodic dictation screen. Students can adjust the tempo in the lower left-hand portion of the screen with playback controls at the bottom center. They can hear the tonic pitch

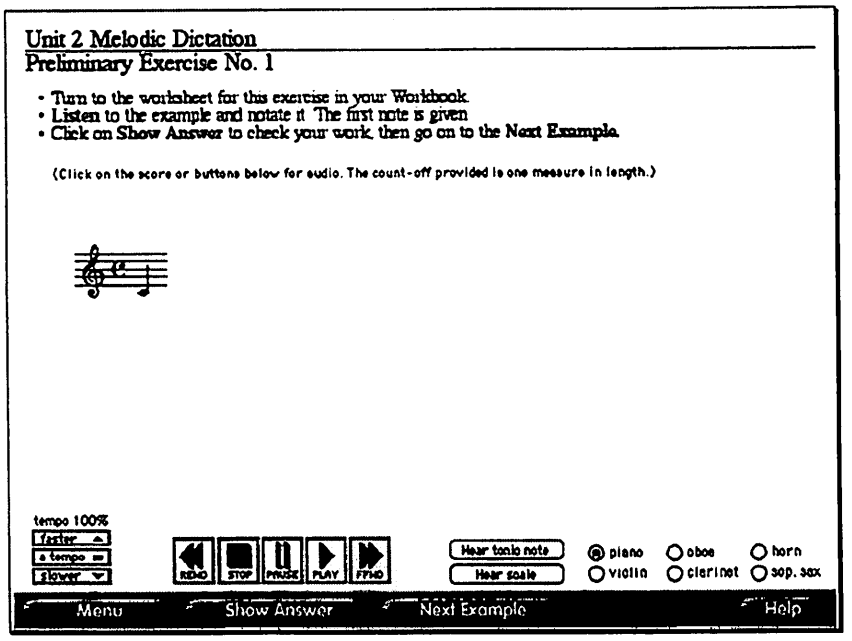
Figure 10. *Music for Ear Training* Main Menu



and a tonic scale. On the bottom right-hand portion the student can select one of the six timbres for listening. The students write the dictation in the workbook and turn it in to the instructor for grading. An Annotated Instructor's Manual with the same CD-ROM is available containing the notated examples, which is a tremendous benefit for the instructor. While grading the exercises is still time consuming, the instructor does not need to copy the dictation exercises from the computer before she can begin the grading process.

Each melodic unit includes a series of preliminary exercises and a series of melodies. For example, the first unit contains 18 sets of preliminary exercises with about 14 exercises per set, 14 sets of melody exercises with about 14 melodies per set, and 3 sets of quizzes with 5 melodies per set. The Annotated Instructor's Manual shows the first set of melodies, however the computer has an additional 19 sets for practice! In total, the program has over 1200 graded examples. The three sets of quizzes at each level, for which the computer does not give the student the answer, are printed in the An-

Figure 11. *Music for Ear Training* Melodic Dictation

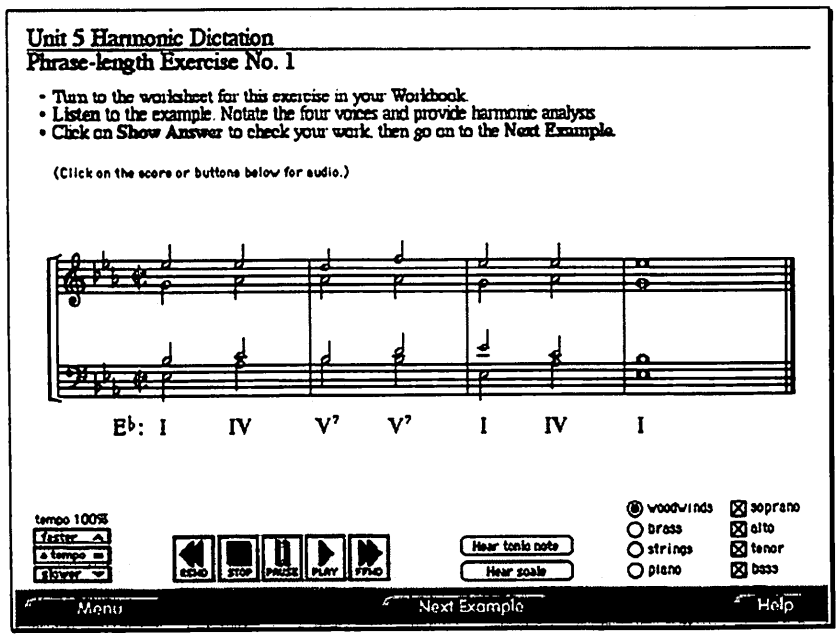


notated Instructor's Manual. The rhythmic dictation exercises in Unit 2 provide 14 sets of material and three sets of quizzes.

Figure 12 shows a phrase-length harmonic dictation example from Unit 5. The program features "basic progressions" and phrase-length exercises at each level. The basic progressions at this level are four or five chords and serve as building blocks for the phrase-length examples. At the earliest levels the basic progressions contain only two chords and as the phrase length progressions become more complicated, gradually additional chords are added to the preliminary exercises. Students can change the timbre for the example and play any combination of voices by selecting the corresponding boxes.

Units 10, 14, and 17 contain excerpts from music literature (see Figure 13). The examples include over 50 excerpts by composers such as J.S. Bach, Mozart, Haydn, Kuhlau, Chopin, Beethoven, Schubert, Glinka, and Grieg just to name a few. The excerpts come from a variety of genres, including solo piano works, quartets, quin-

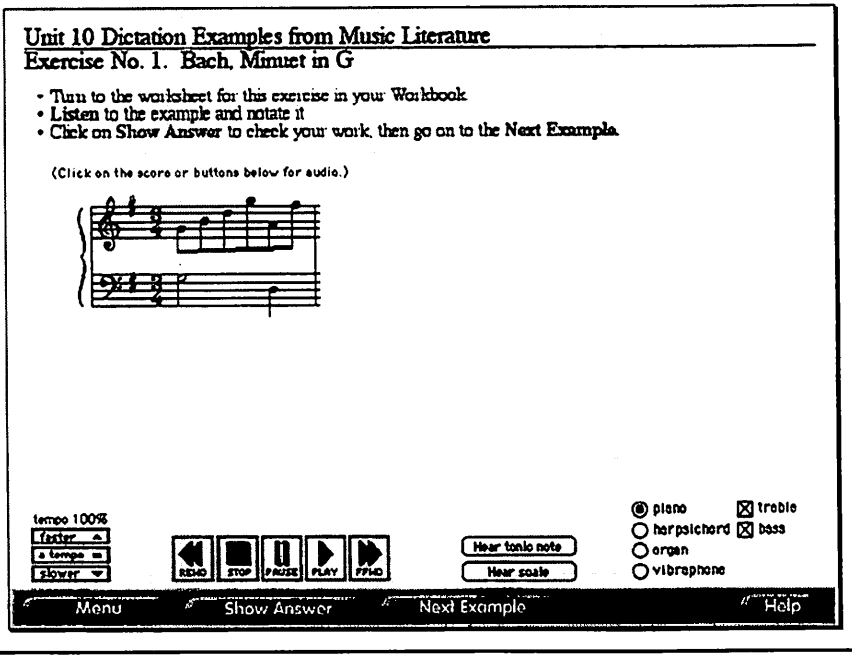
Figure 12. *Music for Ear Training* Harmonic Dictation Answer



tets, chorales, and others. The transcription exercises take students one step beyond traditional four-voice chorale-style dictation and requires them to address issues of texture, registral space, and larger-scale listening and begin to make connections from the critical listening skills to larger-scale musical contexts that appear to be missing for many of our students.

Music for Ear Training does not track student progress in the manner of the other programs. Rather, the students' work is the documentation of their progress. The combination of writing the music down with the immediacy of computer feedback provides a powerful model for dictation. By writing the music down, this program more closely emulates the dictation process that happens in class.

Figure 13. *Music for Ear Training* Dictation from Music Literature



Future

The programs reviewed here represent a tremendous leap forward from the earliest ear-training programs from the late 1970s and early 1980s. Computers today are much more powerful in terms of speed and memory, and the software development systems are friendlier and easier to learn and use. The computer has become a required tool, rather than an experimental device, throughout our society. Today, instructors can use computers to implement their pedagogical vision, rather than having that vision constrained by the limitations of the technology.

All of the programs reviewed here can be used effectively in teaching aural skills. However, the relatively limited context in which the exercises arise ultimately handicaps the instructor and the software. Without developing richer musical contexts in which to ground our students' experiences, we are doomed to continue the pattern of dissatisfaction reported by both Pratt and Hindemith.

The problem that Gardner identifies with physics also applies to music: students do not automatically transfer what they learn in aural skills classes to other aspects of their musical lives. The challenge for us as aural skills instructors is to draw on the growing brain and cognition/perception research, develop teaching materials and techniques consonant with that research, and express a vision of how to build the rich network of connections for each of our students such that they can relate critical listening skills to their other musical activities.

We live in a world of gray, yet many of our ear training programs developed during a time when computer technology limited the designers to assessing "black and white" questions. Often, the most powerful, profound, and enduring learning emerges from engaging what Michael Rogers colorfully calls the "Rich Messiness of Music."[8] The challenge for the next generation of software developers is to explore this "messiness," developing a vision of the rich network of connections necessary to bring about our stated goals by engaging the gray, and implementing tools to help us and our students grow as musicians.

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[8]Michael Rogers. 1990. The rich messiness of music: Teaching theory in music with contradiction and paradox. *College Music Symposium*, 31, p. 131-141.