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AUTHOR: Johnson, Timothy, A.
 TITLE: The Computer Presentation of Musical Research: A Case Study
 KEYWORDS: HyperCard, CD-ROM, John Adams, computer-assisted instruction

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ABSTRACT: The traditional format for the presentation of musical research, the journal article, makes referencing musical passages less direct than ideally desired. CD-ROM technology provides a means for the presentation of written comments and analytical sketches simultaneously with a recorded performance of the corresponding music. This article describes a computer project that uses CD-ROM technology to bridge the gap between analytical or theoretical comments and the sound of musical passages. The main goals of the article are to encourage the development of and provide guidance for similar projects.

ACCOMPANYING FILES: [johnson.hqx](#) (a downloadable copy of the program)
 [The program, for Macintosh computers, is available at the FTP site boethius.music.ucsb.edu in the directory `pub/mto/software`. Editor]

[1] The traditional format for the formal presentation of musical research, the journal article, makes referencing musical passages less direct than ideally desired. Although much theoretical and analytical work primarily focuses on the musical sounds themselves, scholarly views and explanations usually are accompanied only by cryptic references to these sounds in the form of written musical examples and references to scores by measure numbers. The lack of ready access to the sounds under discussion often makes the theoretical and analytical concepts presented difficult, if not impossible, to grasp fully. Despite the high level of ability among musical scholars in producing imagined aural recreations of such passages or in remembering past performances, many readers do not have the ability to conceive the sounds implied by unfamiliar musical examples precisely or will not take the time and trouble to obtain a score and recording of the works being discussed. And even those with exceptional score-reading abilities or memories likely would benefit from hearing a performance of the passages discussed. After all, sounding music--not music sounding in our heads--is what led most of us to devote our lives to

its study (even if music sounding in our heads is what keeps us devoted).

[2] CD-ROM technology provides a means for the presentation of written comments and analytical sketches simultaneously with a recorded performance of the corresponding musical passages. The compact disks may be accessed with precision, accurate to a 75th of a second. Using a programming software package such as HyperCard, an author may create links to immediately bring the reader/listener from analytical texts or graphics directly to the relevant passage on a compact disk. Thus, the musical sounds are readily available, eliminating the problems associated with providing only written references to the music.

[3] In this article I will describe in detail a computer project that uses CD-ROM technology to bridge the gap between analytical or theoretical comments and the sound of musical passages.(1) First I will introduce some of the basic aspects of the musical theories presented in the program [section 4] and present some of the principal advantages of the use of this technology for the presentation of musical research [sections 5-6]. A detailed description of the computer program follows [sections 7-15]. Next I discuss the development effort required and relate some of the problems encountered in bringing the project to completion [sections 16-20]. Finally, an exploration of some pedagogical implications of the technology closes the article [sections 21-24]. The main goals of this article are to encourage the development of similar projects by outlining the motivation for and benefits of using this technology and to provide guidance to those who choose to undertake such projects through example and by identifying some potential pitfalls. Although a number of more polished commercial CD-ROM products dealing with similar analytical issues have appeared, the project described in this article represents a more informal model of the use of this technology, in which someone with little experience may develop a useful (though certainly less thorough) program.(2) In addition to providing a detailed description of the computer project in this article, the computer program itself may be downloaded (see list of accompanying files above) for exploration by readers of this journal who have access to a Macintosh computer, preferably with a CD-ROM and the suitable compact disks.(3) Although CD-ROM is an essential component of the project and the primary concerns discussed in this article, the computer program may be examined without access to a CD-ROM, though unfortunately no music will be played.

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1. An earlier version of this case study was supported by the Mount Holyoke College Technology Seminar, sponsored by a grant from the Pew Charitable Trusts.

2. Some excellent commercial CD-ROM software products include: Daniel Jacobson and Timothy Koozin, *The Norton CD-ROM Masterworks*, Vol. 1 (New York: W. W. Norton and Company, forthcoming in 1995); Daniel Jacobson and Timothy Koozin, *CD-ROM Listening Guides for The Enjoyment of Music, 7th ed. by Joseph Machlis and Kristine Forney* (New York: W. W. Norton and Company, 1995); William Renwick and David Walker, *CD-BRAHMS* (Hamilton, Ontario: McMaster University, 1994); Robert Winter, *Anton Dvorak, Symphony No. 9 in E minor: From the New World* (Irvington, N.Y.: Voyager, 1994); Robert Winter, *Igor Stravinsky, The Rite of Spring* (Santa Monica, Calif.: Voyager, 1992); and Robert Winter, *Ludwig van Beethoven, Symphony No. 9* (Santa Monica, Calif.: Voyager, 1989).

3. The following compact disks may be used with this program: John Adams, *The Chairman Dances*, San Francisco Symphony, Edo de Waart, cond. (Elektra/Nonesuch 9 79144-2); Adams, *Grand Pianola Music*, and

Steve Reich, *Eight Lines* and *Vermont Counterpoint*, Solisti New York, Ransom Wilson, cond. (EMI CDC-7 47331 2); Adams, *Harmonielehre*, San Francisco Symphony, Edo de Waart, cond. (Elektra/Nonesuch 79115-2); Adams, *Harmonium*, San Francisco Symphony Orchestra and Chorus, Edo de Waart, cond. (ECM 1277); Adams, *Nixon in China*, Orchestra of St. Luke's, Edo de Waart, cond. (Elektra/Nonesuch 9 79177-2); *American Piano Music of Our Time*, Ursula Oppens, piano (Music & Arts CD 604).

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[4] This computer program, prepared using HyperCard for the Macintosh, presents analytical and theoretical comments linked to musical sketches and compact disk recordings of passages from John Adams's music. The theory presented in the program identifies the seven chord successions used in passages that repeatedly alternate between two chords. The seven chord successions correspond to two more general procedures, called operations. These operations, taken singly or in combination, stipulate relationships between two chords based on either the circle of thirds, alternating between major and minor thirds, or on notes moving by half step. The computer program describes and displays each of the seven typical successions, and links these theoretical explanations to analytical sketches and recordings of the corresponding musical passages from a variety of Adams's pieces. In addition, a more extensive example from the first scene of the opera, *Nixon in China*, suggests that these successions connect different passages by providing recognizable chord root and quality relationships.

[5] The interactive format of this program allows users to explore the ideas presented at their own pace and in their own way--spending more time to examine certain areas or to hear additional musical examples while skipping over areas of less interest. This format seems particularly appropriate for the presentation of theoretical or analytical material, since many ideas require explanation from a variety of approaches and in reference to multiple examples, while other ideas may be immediately grasped with little explanation or demonstration. Furthermore, the exploration of the theoretical and analytical ideas may be focused according to each user's own interests and background.

[6] In addition to providing direct links to precise musical passages on compact disks and allowing individualized interactive access, the HyperCard platform also facilitates the production of animated sequences that can illustrate complicated theoretical concepts with ease and with little textual commentary. Thus, instead of describing how a collection of notes may be manipulated to produce a related collection, the manipulation procedure may be shown as a step-by-step process unfolding upon the screen. Even familiar concepts such as inversional symmetry may be shown clearly and succinctly by gradually inverting a collection of notes to yield the same collection through an animated process. Another advantage of CD-ROM technology is the capability of highlighting specific locations in an analytical sketch at the same time as the corresponding music plays. Consequently, the correlation between specific analytical symbols and the parallel location in the music are immediately apparent without reference to location cues such as measure number or section. Because of this coordination, even an uninitiated student of music theory cannot fail to grasp the relationship between elements of the analytical sketches and the relevant musical passages.

[7] The following detailed description of the key features of the computer program (sections 7-15) will provide an account of the program to readers without access to a Macintosh and will offer commentary on the essential aspects of the program. In addition to

their descriptive purpose, these remarks are intended to serve as a guide for the development of similar projects by identifying potential problems and suggesting possible solutions. Those who have the facilities to examine the program may wish to read this section while observing the relevant screens in the program, skimming over the descriptive material in this part of the essay and focusing on the commentary.

[8] The title page, in addition to providing descriptive information about the program and its developer, invites the unassisted user to try the software program. The instruction, "click the mouse anywhere to begin," indicates the only knowledge necessary to get started--the recognition of a mouse and the initiative to press the button. After several informational screens and an opportunity to hear a sample from Adams's music, another introductory screen attempts to alleviate fears of computer novices through humor while clearly providing necessary information to more experienced users. The technologically aware user is instructed to click the mouse in a button to select the level of help, while the novice is advised to "click the mouse anywhere else if computers scare you!" Three levels of help are offered, ranging from no-help to virtual hand-holding, to provide flexibility for the different backgrounds of potential users.

[9] The importance of getting users started and providing sufficient help cannot be overestimated in developing interactive programs. Unless the first screen is sufficiently inviting and uncluttered, many potential users may stare blankly at the screen hoping someone else will come along and demonstrate the program. The help provided for those who venture into the hyperspace created in the program is even more essential, since furnishing too much help will bore and annoy sophisticated users (which, judging by the recent exuberant activity on the music theory list, are becoming more and more common among music theorists), and too little help will leave many users confused and unable to continue. Instructions on the use of the software that are provided should be simple and gradual, and opportunities must be provided for the user to try the maneuvers necessary to run the program, accompanied by descriptive guidance.

[10] The main menu screen serves as a home base for the user and supplies an outline of the entire program. However, unlike the table of contents in a book, clicking the mouse on any particular entry in the outline provides immediate access to that section of the program. Each button on the main menu screen provides access to different areas in the program, and all screens in the program provide a possible direct link back to the main menu. In this program, the seven typical chord successions are listed in the right column of buttons and are connected via lines to the buttons containing the corresponding operations listed in the left column. An overview button heads the list, centered at the top of the screen, and a button linked to a list of musical examples and the quit button appear centered at the bottom of the screen. The main menu functions as a familiar location from which to explore the entire program. Whenever the user becomes disoriented, a click of the mouse on any of the "return to main menu" buttons produces this recognizable screen from which a new course of exploration may be contemplated.

[11] Choosing "Overview" from the main menu reveals background information about the theory as well as essential aspects of how the main menu is constructed. Relationships between the operations and the chord successions emerge graphically while theoretical commentary on some crucial aspects of the theory appears in text boxes. The overview, in addition to providing a brief synopsis of the musical theory, aids the user in understanding the construction of the program and suggests possible areas to explore.

[12] Choosing one of the operations from the main menu provides a detailed description of that operation and its connection to the corresponding typical chord successions. Similarly, choosing any of the chord succession buttons from the main menu, in addition to showing its link to an operation, produces a graphical representation of the abstract idea and supplies a link to some musical examples that illustrate the theoretical device. For each typical succession, the user may choose to examine and hear any of the examples listed on the buttons in the center of the screen or may choose to return to the main menu or repeat the graphic portrayal of the chord succession. Choosing one of the musical examples reveals a screen that clearly displays the title and measure numbers of the selected passage and the theoretical construct under investigation at the top of the screen. The main portion of the screen is devoted to a sketch of the harmonic content of the passage. And the bottom of the screen provides an opportunity to learn about the sketch technique used in the project, displays the duration of the example, and gives the option of playing the example or exiting to the previous screen. A box highlighted in reverse video, indicating the section of the sketch being played, moves through the sketch as the recording is heard.

[13] Check marks appear next to all example buttons after the corresponding example has been examined and heard. This signal allows the user to keep track of which examples have been explored and which remain, though these place indicators do not prevent users from returning to any of the examples for further study or replays. Similar check marks on the main menu help the user to keep tabs on progress on a grander scale.

[14] The master list of musical examples, comprised of working buttons, provides alternative access to each of the examples in the program. Thus, users may choose to approach the theoretical and analytical information through the operations or chord-succession types listed on the main menu, as described above, or they may explore the examples according to individual piece titles and measure numbers. The check marks indicating progress appear on this screen even if the example was entered from the chord-succession screens. A Discography/Bibliography, presented using the analogy of index cards, gives the usual information a familiar feel despite the unfamiliar technological mechanism. A user may move through the entries in the bibliography by using the arrow buttons at the bottom of the screen or by "thumbing" through the index cards by pointing to the top right corner of the cards and clicking with the mouse.

[15] Whereas most of the examples in this program are brief excerpts from a number of different pieces, a more comprehensive view of the first scene of *Nixon in China* appears as a separate example. Instead of a graphical representation of the various passages, this extended example simply lists the many typical chord successions and their associated chords that appear in repeated alternation in the scene. The entire scene may be played while tracking the various typical successions as shown by a highlighted box, or individual passages may be played by clicking on the various selections in the list. This example serves as a summary, where the typical chord successions may be considered in a broader context.

[16] This profile of the computer program and its essential theoretical components identifies the key features of the project. Although many aspects described above are unique to this project, the general concepts are applicable to other future projects. Offering an inviting initial screen, providing appropriate help, linking all areas of the program to a central screen, and indicating progress through the program are all essential components of successful interactive computer programs. In addition, providing effective metaphors for

familiar concepts, such as the bibliographic index cards described above, helps the user to become acclimated to the program more quickly.

[17] The development of this project required a rather substantial initial investment of time and effort. Developing additional projects, however, would take far less time since familiarity with the software and with design strategies would accelerate the process considerably. This project took approximately two and a half months of full-time work to complete--beginning with *no* knowledge of HyperCard or CD-ROM technology, almost no Macintosh experience, but considerable experience working with IBM-compatible computers. Included in this time period was a four-day music-technology workshop at the University of North Dakota.(4) After the workshop, continual reference to a valuable resource by Daniel Goodman,(5) and considerable trial and error guided the advancement of this project. In the final stages the Academic Computing Staff at Mount Holyoke College provided invaluable assistance.(6)

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4. Although there are a number of fine workshops on HyperCard and CD-ROM, I chose this one for the opportunity to work with Tim Koozin and Dan Jacobson, a music theorist and a musicologist who both have had substantial experience in developing applications similar to this program.

5. The Complete HyperCard 2.2 Handbook, 4th ed. (New York: Random House Electronic Publishing, 1993).

6. I especially would like to thank Jurgen Botz, Vijay Kumar, and Kevin Prime.

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[18] The development of this project required a Macintosh Computer with a CD-ROM drive, headphones or speakers with an amplifier, a full authoring version of HyperCard, a CD sound-driver, Voyager Audio Stack, and compact disks of the music under investigation.(7) The project initially cost approximately \$1170 (\$750, music-technology workshop including travel; \$50, books; \$120, compact disk recordings; \$75, CD-Caddies; \$150, Voyager Audio Stack software; \$25, audio wiring), not including computer and CD-ROM hardware.(8) Completing additional projects, however, would require only the cost of the compact disk recordings.

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7. Similar projects may be produced using an IBM-compatible computer and a comparable software product to HyperCard such as Toolbook. For Macintosh computers a *full* version of HyperCard must be procured since, although Macintoshes are customarily shipped with HyperCard, a full authoring version is not always supplied. A CD sound-driver is software that allows CD-ROM to be used for sound production rather than just data storage, the Voyager CD AudioStack is a software program for the Macintosh that facilitates access to compact disks, and the compact disks used for this application are standard commercial CD recordings.

8. The development of this project was supported by a faculty research grant from Mount Holyoke College.

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[19] This program was initially presented as a "poster" at the Annual Meeting of the Society for Music Theory, Kansas City, 1992. A major obstacle in presenting this project at a national conference was transporting computer equipment to the site. Although a laptop would

have been ideal for this application, test runs on a Powerbook revealed a "bug" in Powerbooks making their use problematic and causing substantial levels of stress for the developer (the computer would "freeze" during relatively lengthy animated processes since the keyboard was not in use). Other problems involved the disparate speeds at which the animated sequences ran on different computers, negating the effects of working out precise timing for certain animated processes. This timing problem has become more of a factor as computers constantly increase in speed; therefore, the program has been revised to rely on clock time rather than the computer's internal processor speed. Fortunately, none of the problems encountered were insurmountable, and the presentation took place without incident.

[20] Another important consideration in the development of this project was the desire to discuss pieces appearing on different compact disks. Since automatic CD-ROM changers are currently rare and prohibitively expensive, users of this program must frequently change from one compact disk to another--an awkward and somewhat confusing process. Placing all pieces on a single compact disk would be ideal but would require either permission from disparate recording companies or new recordings of the pieces under discussion--both of which would be too time-consuming and expensive for non-commercial projects such as this model. The ability to utilize standard, existing compact disks is one of the most compelling features of this technology, making its wide use among music theorists imaginable and making many pedagogical applications feasible, as discussed below.

[21] The model described in this case study, though designed as a vehicle for the presentation of musical research, easily may be adapted for use with students. This project has a variety of instructional implications including interactive programs for students to explore individually (similar to the project described in this article), courseware for classroom presentations, and computer projects for students to prepare on their own.

[22] Software may be developed for students to use at their own pace that would directly link sound materials with text and graphics. The interactive nature of the software would engage the student in a rather different way than traditional assignments, since the student would have more control over her or his learning pace and sequence. Furthermore, many students, when pressed for time, often seek to streamline their studies by ignoring the audio components of assignments, choosing instead to rely solely upon the written representation. The development of this software would virtually eliminate the potential for students to listen to the assigned aural material at a different time than when they studied the corresponding graphical images and text or for students to ignore the aural material altogether. In addition, such programs would assure the instructor that students will at least have access to all of the course materials at the same time. Furthermore, the use of an interactive format allows students of widely divergent backgrounds and interests to be actively engaged in their own education. The students choose which aspects of the material to study first and in what order to proceed. When a particular aspect of the material sparks their interest, they are free to explore it in detail before returning to more general information.

[23] Creating interactive programs may be the most compelling application of the material presented in this case study; however, course material may be developed quickly by instructors that would give them immediate access to specific locations on any compact disk--providing more class time for discussion rather than just searching for the proper track and time segment. Sound examples may be further enhanced in a classroom presentation by linking the

examples to simple graphical images scanned from any source or created by the instructor using the simple drawing tools provided with HyperCard.(9) The expandable nature of HyperCard allows classroom materials to be assembled gradually from year to year, spreading the preparation time over a number of years. The coordination of graphical images with sounds further improves the quality of classroom presentations; instead of hastily drawing examples on a blackboard, a copy of the original image may be projected on a screen at precisely the right moment.

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9. The sketches in this program were prepared using the drawing tools and the Petrucci type font.
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[24] A third potential instructional application for this model is for students to design their own software programs. Instead of a term paper with written examples representing sounds pasted into the text, the students may link their ideas to the actual sounds of the music discussed. This method of presentation would give students access to sounds, graphics, text, and animation to describe their research results. This application of the technology would allow students with different abilities in expression to clearly present their ideas. Furthermore, more creative students would have an essential outlet for their creativity in courses that traditionally provide few such opportunities. In addition, in analytical assignments, students would be forced to grapple with the actual sounds they are discussing rather than taking them for granted from written representations, since at times some students complete their analytical projects without ever hearing the sounds implied by the scores provided for them, as mentioned above in connection with interactive programs. They simply apply the rules and conventions they have learned, ignoring the effect of the music in their analyses, and consequently miss the most compelling aspects of pieces by focusing instead on the mundane.

[25] In summary this article has shown some of the advantages of developing interactive computer programs with CD-ROM, has described the development of one such project, and has discussed some pedagogical implications. This technology has a number of possible uses ranging from the formal presentation of musical research to a variety of pedagogical applications. Although developing similar projects requires considerable time and effort at first, the resulting coordination between theoretical/analytical ideas and the music upon which they are based suggests that this technology has the potential to surpass many traditional methods for the presentation of musical research.

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