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The Development of HARK!, a Computerized Assessment Tool in Music Cognition

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Even though psychological studies in music have a long history, little attention has been paid to the study of the perception of complete compositions. Rather, there has been considerable research to study the perception of music with small isolated stimuli-single tones or small melodies (e.g., Cuddy, 1981; Deutsch, 1975; Deutsch, 1980). Perhaps because of influences from the field of psychoacoustics, many studies have favored the use of brief musical stimuli for the easy manipulation of sound variables (Aiello, 1994).

While interest in the perception of small musical fragments continues to be of interest and importance, researchers in music cognition have begun to study the perception of more complete musical pieces (Clarke & Krumhansl, 1990; Deliege & El Ahmadi, 1990; Deliege, Melen, Stammers, & Cross, 1996; Karno, 1992; Pollard-Gott, 1983). The use of artificial sequences as stimuli has left untouched a range of issues relating to listeners' understanding of extended structures (Clarke & Krumhansl, 1990). In addition, the aesthetic properties of the music are often not considered (Aiello, 1994).

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The use of short musical stimuli is not naturalistic in terms as to how people actually listen to music in real life (Sloboda, 1985). When individuals listen to music in concert halls or on recordings, they face a whole range of cognitive demands that are not addressed in the kinds of experiments mentioned above. For example, even in excerpts of just a few minutes in length, working memory limits may be exceeded, reducing a listener's ability to recognize certain musical structures of some length (Berz, 1995). Attention might be another factor that would greatly affect a listener's ability to detect structure. Motivation may be a significant contributing factor as well; subjects may simply not be motivated to listen attentively after a certain length of time, thereby not detecting the appearance of a new musical event.

Research where subjects are required to listen to long extant examples does raise a number of experimental concerns-most notably data collection. How can a researcher gather information while a subject is listening to lengthy examples? One cannot really detect what the listener is actually hearing and therefore perceiving. Commonly, subjects are asked to reflect on what was heard, providing written accounts, descriptions, and/or recollections (Aiello, Tanaka, & Winborne, 1990). Yet can a subject be realistically expected to remember listening experience and reactions after a given length of time? Computers might be able to be used as a data collection tool, gathering information in methods that would provide memory cues.

Computerized assessment would hold some advantages over pencil-and-paper methods. First, data collection and analysis can take place simultaneously with the computer performing many calculations automatically- certainly a worthy and practical advantage. Second, data can be collected without interpretive bias; typed responses appear exactly as subjects entered them, complete with mis-spellings and the like. The ability to link music directly with the assessment instrument would certainly be an advantage. Of course, computerized assessment might well carry some negative attributes, most notably perhaps the cost of hardware. The development of specific software might be considerably more time consuming than using traditional methods.

External devices (foot pedals, switches) linked to computers have been used as signaling devices to help indicate when certain events were heard by listeners; the devices can be used separately or in conjunction with computerized technology. There has been some important research in using computers as assessment devices in music cognition, which helps to establish validity for the basic approach; much of this work has been directed at producing stimuli and/or collecting responses (Cohen, 1989; Dowling, 1989; Grieshaber, 1993/1994; Peters, 1992), usually with stimuli of limited duration.

HyperCard, first released in 1987, is an object-oriented computer programming environment developed by Apple for the Macintosh computer. It is a commercial software implementation of hypermedia-a system of linking multimedia information non-linearly with philosophical roots dating back to the mid-1940s (Berz & Bowman, 1994). It offers fast and efficient information-managing capabilities, a sophisticated, easy-to-use programming environment, and flexibility for designing the user interface (Geisler-Brenstein & Brenstein, 1989). Through use of its scripting language, HyperTalk, authors can develop and/or adapt applications to suit specific needs. HyperCard is quite popular in the educational community because of these characteristics and because of its relatively low cost. When first released, it was bundled at no additional cost with new Macintosh computers.

As a specific means of computerized assessement, HyperCard holds great potential for use as a data collection platform, since researchers can build applications specific to special needs with relative ease. With the mouse, the need for specialized input devices is eliminated. HyperCard would seem to be especially important for music assessment using naturalistic examples because of its ability to be linked to and to control multimedia devices, particularly CD-ROM, giving researchers the potential to control high fidelity sound. This solves the previous practical problems associated with the vast storage and processing of digitized music; previously computers had not been capable of storing and manipulating the vast amount of data required in music research. Since an almost unlimited body of musical repertoire is now available on audio-CDs, researchers and educators have an almost unlimited source of musical repertory with which to work. The vast storage potential of CD-ROM, combined with the ability to easily control the device with computers, opens new opportunities for collecting data centered around a naturalistic music presentation.

HyperCard has been employed as a research platform for a number of cognition studies outside of music (Carreras, 1993; Carter & Walsh, 1992; Martin & Wilcox, 1989; Quinn, 1991; Schuldberg & Nichols, 1990). Boltz, Kapadia, and Joyner (1991) developed a HyperCard stack (Psychmuse) designed to support research relying on musical stimuli. The stack accesses a set of digitized sounds which had been collected using a MacRecorder (an audio digitizer). It then allows experimenters to create monophonic melodies with the ability to present the stimuli in flexible formats. The authors concluded that the stack was an efficient and inexpensive tool with which to conduct psychomusicological research. Examples were relatively short due to storage limitations.

HARK!

HARK! is a HyperCard stack developed by the authors to assess music perception behaviors in a naturalistic setting: listening to entire musical works in context. It was designed to assess student perception of large-scale form and structure of an entire movement. The stack is a programming shell that is linked to an audio-CD and provides controlled interactive playback of a musical work. The approach is somewhat related to the hypermedia alternative assessment as described by Kumar (1994); a significant difference would be the linearness of this approach-this because of the linear character of intact music listening. Although the shell was originally developed for use by undergraduate university students, it could easily be adapted for subjects of differing ages.

When using this stack, students listen to a given work or movement and can signal the occurrence of a new structural event by clicking on buttons with the computer's mouse. After completing the listening experience, the designated excerpts are repeated and the subjects are asked to provide written (typed) explanations and/or descriptions. Additional screens are provided at the conclusion of the guided listening to gain global impressions and to solicit specific information.

Program Structure

The subject works at a Macintosh computer that allows for CD-ROM access and sound reproduction-normally using headphones in a lab setting. After seeing a title screen, the first action screen appears.

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are needed to see this picture.

The student is directed to click a button to begin the music playback, at which time a second screen appears.

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The student has three possible responses: signal a new structural event by clicking a button; abort the session and begin again; or conclude the session and move to the next stage of the program. In the next stage, the subject is directed to provide a written description/label of each specified musical event.

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Upon clicking a button, the segment that had been specified during the first part of the session is re-played; the playback stops after the given excerpt is completed. The subject is asked to respond with a written description in a field; the information is collected transparently and held in a data collection area hidden within the program. Subjects may hear the same excerpt an unlimited number of times before and during the written requirement, providing a memory cue. The subject must provide some response in order to proceed. The computer will not play the next excerpt unless some text is entered in the field; if no response is provided, a dialog box appears directing the user to provide a response. When finished, the subject clicks a done button, and the next excerpt is played. Subjects continually receive feedback as to how many total events had been signaled in the initial part of the program as well as his/her current progress. After the final event has been completed, two multiple choice questions appear. The first asks the student to choose the historical orientation of the work in question;

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the second asks the student to choose a possible composer.

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With both questions, the student selects a response by clicking a check-box; students are only allowed to make one choice. The reponses are recorded in a data collection area hidden within the program. It is possible to see if subjects selected a composer/historical period mis-match (e.g., Brahms-20th Century). After completing these two tasks, a final screen appears that requires the student to provide a written global impression of the work.

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After this is finished, the subject clicks a button that causes an exit screen to appear. These screens could easily be adapted to suit other musical works.

Stack Technical Features

The stack is really very simple in construction. It is a series of 7 cards, several with a number of appearing and disappearing buttons and fields. Buttons have relatively simple HyperTalk scripting. The subject's typed responses are collected and written to hidden text fields.

The stack uses the CD-controlling XCMDs developed by Apple Computer to drive the audio-CD; this control is the prime element of this assessment instrument. The key technological element of the stack is in the way in which the audio-CDs are controlled. The CDs are formatted according to time that provides a 3-number coordinate: minutes, seconds, and blocks; a block is 1/75th of a second. When the beginning of an event is signaled by the student clicking a button, the number trio is recorded and held as a variable by the computer. Likewise, the next click is recorded-this time as both a closing coordinate and a beginning coordinate for the next event. These pairs of three numbers are placed into a variable for later playback. For example, event 1 would hold 2 pairs of three numbers, as an example 02,10,60,03,15,21; the computer would begin the CD playback at 2nd minute, 10th second, and 60th block and play until the 3rd minute, 15th second, and 21st block, at which case the playback would stop and the student would be expected to provide the written response. After the response is completed, the next event would be played in a similar fashion, in this case the event beginning at 03,15,21 and continuing until the next click point coordinate.

Initial research and pilot testing of the stack was conducted with groups of undergraduate music majors and musical novices enrolled in an undergraduate educational psychology course. The stack was linked to an audio-CD, a recording of the last movement from Symphony No. 34 in C major, K. 338 by Mozart, recorded by the Academy of St. Martin-in-the-Fields, Neville Marriner conducting. No technical flaws were identified. Some preliminary research using this program is reported by Berz and Kelly (1998).

Discussion

Use of this shell provides a number of opportunities for the collection of music psychoacoustic data. First, because the stimuli are actual recordings on CD, the quality of sound is excellent. This helps to address the poor quality of computer-generated sound which has been somewhat problematic in some past music computerized research. Second, the computer records all subject responses, allowing for data processing behind the scenes. Third, subjects are allowed to listen in an environment that is somewhat realistic-complete musical examples that are of high quality. Fourth, subjects are provided with a chance to review the aural examples before responses are required; this reflection might help to lessen the demands on memory as well as allowing time to formulate personal responses.

Even though memory cues are provided in a realistic way (unlimited repeated listenings with the listener able to determine the number of necessary repetitions with complete freedom), it is still possible to lose the real reason that s/he made the decision. An alternative would be to ask for a response immediately after the decision was made. This, however, would interrupt the musical work and thereby defeat much of the rationale of the program: to provide possibilities, for intact, naturalistic listening. Certainly, other strategies could be provided, such as the subjects providing a verbal commentary, but again, this would require cognitive demands that would take away from the ability to listen. The mouse signal approach is only minimally intrusive.

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