JTML, Vol. 3, 33-47

ADAPTING TEXT AND GRAPHICS TO FACILITATE MUSIC LEARNING WITH HYPERMEDIA

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Music instructors often deal with groups of students possessing widely varying amounts of prior domain knowledge. The delivery of course materials to such a group can be individualized to a certain extent by using adaptive hypermedia. For guidance in the adaptation process one can turn to recent research in text coherence, which suggests that highly coherent and detailed text, while appropriate for novice students, might actually be less beneficial for those with prior domain knowledge. There are also other adaptive techniques in this medium that can provide appropriate material for learners possessing different levels of prior knowledge. This article discusses selected research on text coherence and learning in music in order to establish a theoretical basis for adaptation. Then text passages and musical examples are adapted using the principles discussed. Finally, the author's *Adaptive Tutor,* an adaptive hypermedia application, illustrates how these and other adaptive techniques can be applied. The results of an informal test of this application in a university setting are presented.

Incoming college music students frequently possess varying amounts of prior knowledge. Some students are almost complete novices, while others are quite sophisticated. One method by which instructors can address these disparities is suggested by recent research on text coherence and its effect on learning. Highly coherent text is beneficial for many students, but there is evidence that this coherence actually can be a hindrance to students with prior domain knowledge. Another way to address the widely varying skill levels is provided by adaptive hypermedia, where computerized presentations of course materials are adapted to individual students. In this environment, students can be led to the next best page or access material containing appropriate levels of difficulty.

This article explores various adaptive features as they might be used to address these pedagogical issues. The role of written text in music learning is discussed by reviewing research about text coherence, comprehension, and prior knowledge. These concepts are used to adapt sample passages of written text and musical examples. The author's *Adaptive Tutor,* a Web based adaptive hypermedia application, illustrates how adaptive techniques can be implemented in a computerized learning environment. The tutor is designed for basic level music students in a university music program and allows students of varying skill levels and abilities to choose, based on a self-evaluation, materials most suited to their prior knowledge and learning preferences.

Music Learning, Written Text, and Prior Knowledge

Learning in music involves reading written text for explanations of new terms or concepts and communication of musical insights. The amount of prior knowledge a student brings to the task, though, can affect the way this text is processed, comprehended, and learned. It is important to understand this process. A coherent text is produced by a logical sequence of sentences and ideas. The information represented by these features is then encoded in memory to produce a mental representation of the passage (McNamara et al., 1996, p. 4). Readers construct these mental representations with *inferences,* which are defined by van den Broek (1994) as a "constant fluctuation of activations" (p. 557) of information not explicitly stated in the text. Researchers have identified various types of inferences, but most pertinent to this discussion is what van den Broek calls the *elaborative* inference, where the information to be activated must be supplied not from text just read, but from the reader's background knowledge. A music student, then, when reading about the function of a major triad in a second- or third-year text, would not be provided with basic information about a triad's intervallic structure or triad types. With the process just described, the student would actively engage this prior knowledge about triadic structure from long term memory to form a complete mental representation of the passage. Without adequate prior knowledge, the student would be unable to supply the necessary information for comprehension.

This perspective on learning, comprehension, and prior knowledge also is found in music learning theory. Gordon (1977, 1993), for example, divides the music learning sequence into two types of tasks: *discrimination,* or rote learning, and *inference* learning. A certain amount of discrimination learning is necessary in early stages of development, but according to Gordon, students ready for inference learning understand novel concepts by relating them to their prior knowledge about music. For this understanding to occur, students need a strong emphasis on verbal associations in the discrimination stages of learning (Walters & Taggart, 1989). Cantwell and Millard (1994) use similar terminology in their study investigating learning strategies in music. These authors define "deep" learners as those who display a "commitment to higher-level understandings of material to be learned, and who see learning as a process of integrating old and new information to a point of personalized understanding" (Cantwell & Millard 1994, p. 46).

Recent research suggests that this inference and encoding process can be affected not only by the student's prior knowledge but also by certain qualities of the text itself. In general, highly coherent text is thought to enhance learning for most students. When readers possess an adequate knowledge base, this kind of text is less than ideal. A study by McNamara et al. (1996) concludes that when a knowledgeable learner reads a less coherent text, "more links [are established] between the incoming information and information in the personal knowledge base." These links are the result of the elaborative inferences the reader makes to complement any unclear passages in the text, which increase active processing and "deeper understanding." Conversely, when a knowledgeable learner reads a highly coherent text, the authors contend that the reader can default to a "passive mode" where the learner processes the text superficially and thus avoids deep learning (McNamara et al., 1996, p. 5). Van Dijk (1977) discusses another perspective that can affect text coherence–the *completeness* of a text. If in the context of a highly detailed description some information is presented with little or no detail, the passage lacking detail is *undercomplete* relative to the surrounding text. Similarly, a highly detailed passage is *overcomplete* if it is surrounded with text that lacks the same level of detail. This concept can be extended to describe an entire text. A knowledgeable reader might consider a highly detailed text overcomplete, which could result in the passive mode of processing that McNamara et al. (1996) describe.

A student's comprehension and learning, then, might be affected not only by the amount of prior knowledge, but also by characteristics of the written text itself. Since this situation is at the heart of the pedagogical dilemma under discussion here, it will be profitable to investigate why this occurs. According to van Dijk and Kintsch (1983), readers form two mental structures, a *textbase* and a *situation model.* The authors define the textbase as "the semantic representation of the input discourse in episodic memory," which allows a superficial understanding and is useful for tasks such as recall or summarizing. They argue, though, that deeper understanding of text requires the situation model, a more personalized representation of content. The authors define it as the "cognitive representation of the events, actions, persons, and in general the situation, a text is about." In the situation model, information in the text combines with prior knowledge and is organized according to the reader's understanding, which makes it useful for complex tasks. To van Dijk and Kintsch the inference learning of Gordon's (1977, 1993) model occurs in the situation model, as does the "deep" learning to which Cantwell and Millard (1994) refer. These authors use slightly different terminology than van Dijk and Kintsch, but they contend that the comprehension of text or musical scores requires "a knowledge base of sufficient abstraction to provide a framework for interpreting complex data" (Cantwell & Millard 1994, p. 45). And it is in the situation model where McNamara et al. (1996) suggest that levels of text coherence can encourage more links to prior knowledge and thus an increase in active processing and learning.

These findings suggest a way to address the needs of music students possessing varying amounts of prior domain knowledge. They will be best served by text that is adapted to display the linguistic clues and level of completeness that allow the most meaningful learning for them. An appropriate topic with which to investigate these design issues is voice leading, one of the most challenging skills for lower level music students to master. Each note in a chord is "led" to a note in the next chord, and students must use their musical knowledge to determine what that note will be. It is with this complex task that learners apply their knowledge of basic music fundamentals to composing music. Voice leading is also valuable as a way to strengthen problem solving skills.

An inexperienced music student reading a passage about voice leading has no situation model of this topic, and thus he can not link new information to facts stored in long term memory. As the student reads, his textbase in episodic memory organizes the information as the author has structured it. He also begins to construct a situation model reflecting his own understanding of the topic. Learners such as this one derive the most benefit from highly coherent and detailed text, since they are "limited in their constructive processes" and are thus unable to make elaborative inferences from prior domain knowledge (McNamara et al., 1996, p. 4). The situation is different, though, with a student possessing prior domain knowledge. When this student reads a similar lesson about voice leading, the student already possesses a situation model containing relevant information. If the student reads a detailed text containing many linguistic and organizational clues, the student could slip into a "passive processing mode" (McNamara et al., 1996, 5). If this student reads a text in which only the most pertinent information is included, the student is able to access her prior knowledge for elaboration. This process results in links with information in long term memory, more active processing, and more effective learning.

The research cited above deals exclusively with written text, but most learning in music occurs with musical examples as complements to the written text. There is evidence to suggest that these principles of text comprehension and coherence can be applied to musical examples. Cantwell and Millard (1994) compared learning strategies in music and written text. According to these authors, "learning music has many similarities to learning textual material. Both activities are complex . . . [and] in both media, successful learning implicates much higher-order processing" (Cantwell & Millard 1994, p. 45). Hahn (1987) concurs with this assessment. She writes that "innate cognitive systems of organization" allow humans "to internalize, through experience, the rules of their language or music" (Hahn 1987, p. 42). Neurological evidence also suggests the similarities of music and language processing. Koelsch et al. (2002), in a study using MRI brain imaging, concluded that there is a "considerable overlap" of the areas in the brain used for language and music processing.

A novice student reading text about voice leading comprehends an accompanying musical example in the context of the text. Along with a textbase, one could hypothesize that he also forms a "scorebase" containing the graphic information shown in the example. This learner benefits from a highly detailed musical example, one containing clear annotations, brackets or arrows, and chord labels. The enhanced detail helps the student form a situation model about how these voice leading conventions appear in written musical notation. An experienced student will benefit from a different type of example. The student's situation model already contains information about voice leading as it appears in musical notation. However, this student does not have links for the specific concept being discussed in the text. If the example is shown with only the most necessary annotations, then this experienced learner will use her prior knowledge to fit these new concepts into her existing situation model about voice leading and how it appears in musical notation. The active processing necessary to accomplish this task results in a deeper and more thorough learning experience.

Adapting Text and Musical Examples

There are two levels of text organization, local and macro, that are relevant to this discussion. The local level concerns the clarity of sentences, the connectives they include or omit, and so on. At the macro level one finds the global organizational clues in the text, such as length of paragraphs and the placement of bullets or subheadings. Figure 1 shows a passage of text describing voice leading with seventh chords. The text references the musical example shown below the passage.

Realizing a Figured Bass with 7th Chords
Here is an example of how to **realize** a figured bass. When the correct harmonies are determined for a figured bass we use the term realize, and the result is called a realization. On the left of the example is a figured bass shown alone. To the right you will see one possible realization of the bass line. You will hear a root position 7th chord as well as all three inversions. There are only three chords in this harmonization: the tonic A, the dominant E7, and the supertonic Bm7. Try to find all these chords in the example.

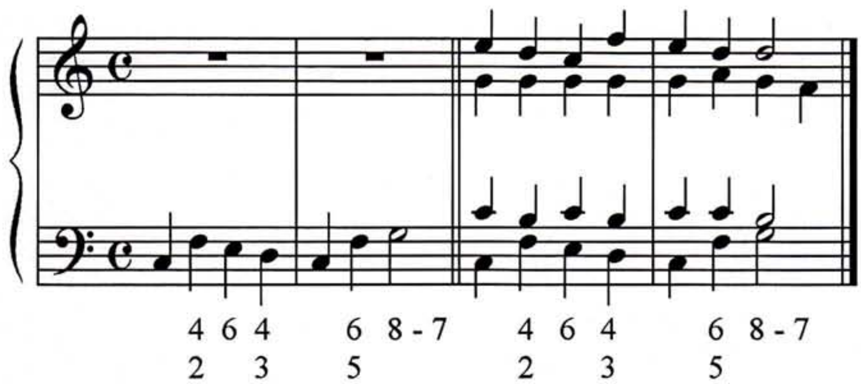

Figure 1. Passage with maximum coherence and detail.

This passage contains many clues and phrases that provide maximum clarity. The passage is preceded by a bold-faced heading that tells the reader the topic, and a new term is set in bold type and defined in the next sentence. The reader is carefully oriented to the musical example: The three chords in the example and sound file are named, the text briefly defines a figured bass, and all possible inversions of seventh chords are listed. Finally, the reader is encouraged to locate, on the example, the three chords named in the text. There are no missing references here and thus no elaborative inferences are necessary.

The process by which the text in Figure 1 is altered for minimal coherence is reductive, and many of the organizational clues one takes for granted are omitted. The subheading is a global organizational clue and is helpful for the knowledgeable reader, so it remains. The first sentence orients the novice to the musical example, but for knowledgeable readers the sentence could be shortened to "Here is a figured bass and one realization." The sentence requires an elaborative inference; the same figures and bass line are underneath both examples, but one is harmonized. Realization, then, refers to the harmonized bass line shown on the right side of the example. The last sentence of the fully coherent version not only tells the reader to expect three chords but also names them. A knowledgeable reader, though, could be expected to recognize the chords.

Realizing a Figured Bass with 7th Chords
Here is a figured bass and one realization. You will hear a root position 7th chord and all inversions. There are three chords in the example.

Figure 2. Passage with minimal coherence and detail.

It may seem there is now too little information, but for an experienced reader it is coherent and complete. The first sentence tells what the example shows, and the second informs the reader that seventh chords in all inversions are included. Students are left to engage their prior knowledge to make connections between the inversions and the figured bass numbers. The last sentence states that there are three chords and allows readers to identify them. This version does not contain clarifications. It does, however, encourage active processing by allowing the reader to elaborate upon the text and example with their prior knowledge.

Musical examples can also be annotated by employing these principles. In a minimally coherent version, the examples might feature only the necessary annotations, which allow the reader to relate it in their own way to the prose. In a fully coherent version, the musical examples can be labeled and annotated. Figure 3 shows a passage with coherence that complements the musical example.

Chord Resolution Models
Each root progression has chord resolution models to determine voice leading between adjacent chords. In the following examples, both keyboard style and SATB style (Soprano, Alto, Tenor, Bass) are illustrated.

Ascending and Descending Progressions by Fourth: Major and minor chords used in root progressions of a perfect fourth always share one common tone (shown on the example with arrows). In both ascending and descending fourth progressions it is possible to keep the common tone in the same melody line, or voice. This type of voice leading is called the common tone resolution model, which is shown here with both descending and ascending root progressions. In this example, the common tone is G, and it remains in the same voice in each model.

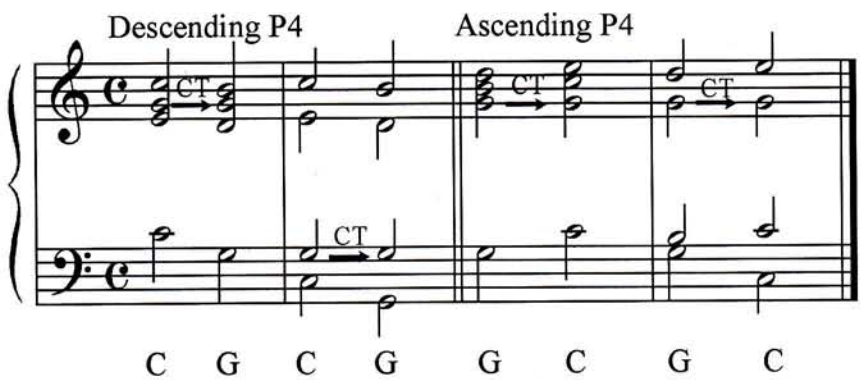

Figure 3. Musical example with full detail.

The reader learns immediately that the models determine voice leading between adjacent chords. The reference to SATB is explained in the text, as is the reference to *voice* (defined as a melody line), and the resolution model is identified as a type of voice leading. The second paragraph begins with a subheading that matches the annotations on the example and implies that this type is the first in a list of types. The text that follows orients the student to the musical example. On the example are annotations showing the interval of the root progression, the names of the chords creating that progression, and labeled arrows identifying the path of the common tone in each resolution. Finally, the common tone in the example is also identified by name in the written text. No elaborative inferences are necessary, since the reader is carefully led through the passage and its correlation to the example.

Figure 4 shows the text and musical example from the same voice leading lesson, now in a version designed for a student with adequate prior knowledge.

Chord Resolution Models

Each root progression has models of voice leading. Major and minor chords in perfect fourth progressions always share one common tone. In both ascending and descending fourth progressions it is possible to keep this tone in the same voice. This is the common tone resolution model.

Figure 4. Musical example with minimal detail.

Sentences one and two mention root progressions, but the first mentions voice leading while the second does not; the knowledgeable reader will infer that the two sentences are related. The last sentence mentions the common tone resolution model, but the reader needs to make the connection with voice leading. The musical example has only the arrows showing the path of the common tone, which leaves the reader to determine what the chords are, if they are in fact related by a perfect fourth, and so on.

Adaptive Techniques for Hypermedia

To address the issues discussed here, one can deliver text and other course materials with adaptive hypertext or hypermedia. These applications adapt the content to individual users. The user enters information or a self-assessment of their expertise, which provides the application with information to guide the adaptation process. Generally these programs provide either *adaptive navigation support* or *adaptive presentation.* The first technique enhances the program's hyperlinks by hiding or ordering the links, or guiding the user to the most appropriate link; adaptive presentation actually alters the content presented to the user. Two common evaluative models are the *overlay model* and the *stereotype model.* With the first model, the specific domain is represented and compared with the user's information. The stereotype model is less complicated and uses the information entered by the user to place them into a stereotypical group, such as Beginning or Advanced (Brusilovsky 1996, 1997). Adaptive or Web based systems generally feature one of two designs. They are the "tutor-centered" type, a design often found in intelligent tutoring systems, and the "student-centered" type, which allows more flexibility to the user (Magoulas et al. 2003, p. 514).

Adaptive Tutor is a tutor-centered adaptive hypertext application for first year music students. Students first visit the entry page, shown here as Figure 5, to choose a topic and their instructional preferences.

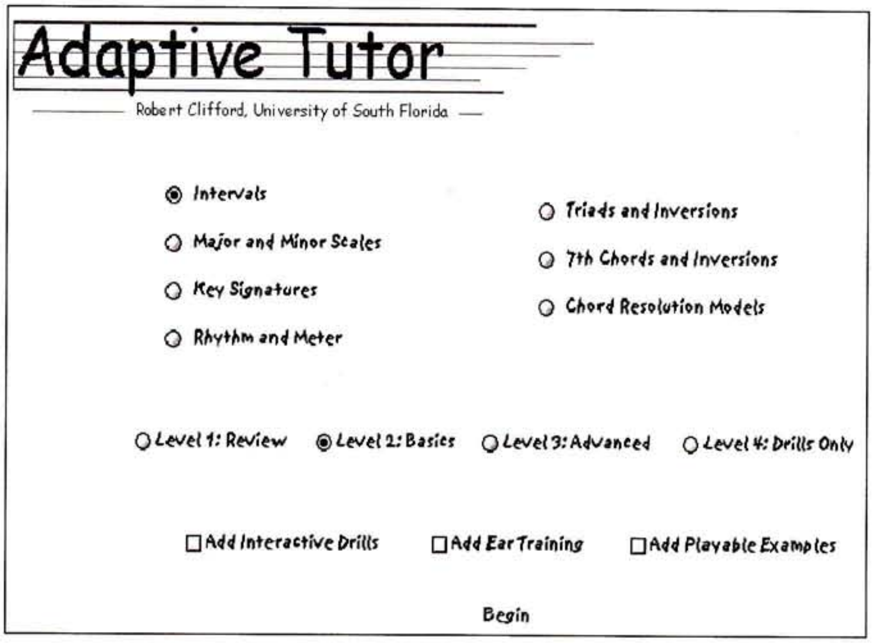

Figure 5. Entry page, Adaptive Tutor.

Information from this page determines the type of material displayed for each lesson. Three instructional levels are featured: Review (for the novice), Basic (for the intermediate student), and Advanced for those with prior knowledge. After the levels are chosen, the lesson appears in a new window. Figure 6 shows a typical lesson window in *Adaptive Tutor.*

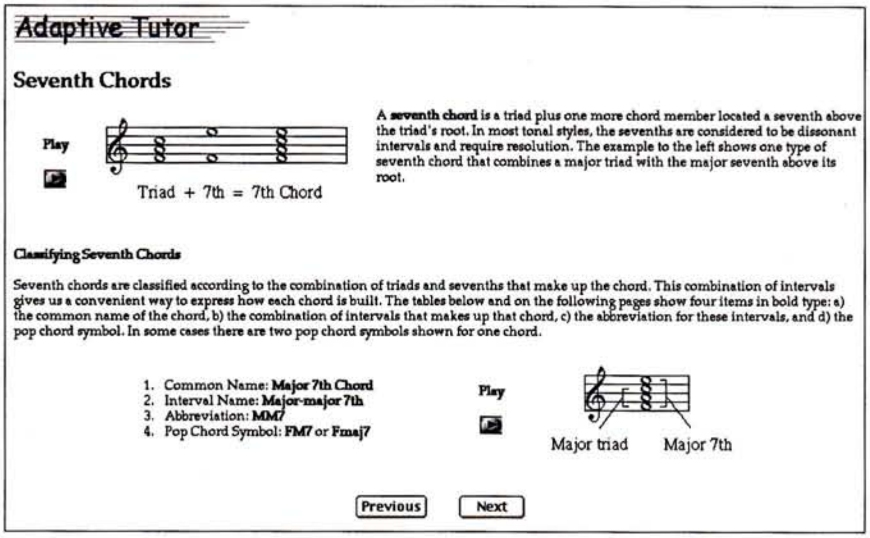

Figure 6. Lesson page.

Checkboxes on the entry page determine if the user wants to add interactive drills, ear training exercises, or playable musical examples.

In *Adaptive Tutor* both presentation and content are adapted. On each page, hyperlinks are generated dynamically according to the student's choices on the entry page. With this *direct guidance,* the user is guided to what assumedly is the best next page of information (Brusilovsky 2004, p. 8). As each page loads, the hyperlink to the next page is written dynamically using the "document.write" command. The links look the same to the user, but successive pages may accommodate users of differing abilities. As Brusilovsky (2004) and Kay and Kummerfeld (1997) point out, this method is simple and commonly used, although it removes from the student any choice about which page to visit next. While this technique might be undesirable in a presentation of advanced material, its use here provides necessary guidance to lower-level music students. Figure 7 shows a flow chart of the direct guidance design of the application. The user enters at the left. Sequences of pages above the Basic level show the path an advanced user might take. Similarly, the lower path is that of a novice accessing the Review level of instruction.

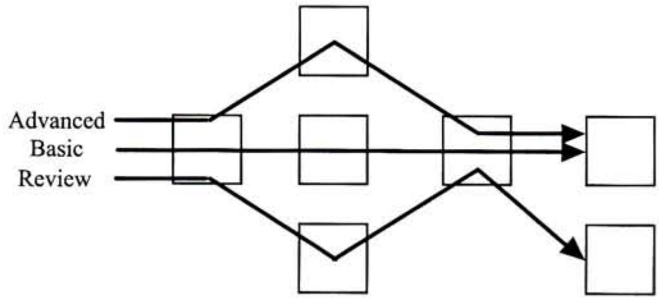

Figure 7. Flowchart, Adaptive Tutor.

This design allows users to follow a presentation of material beneficial for their level of expertise while still retaining the necessary sequence of information.

Adaptive text presentation techniques in *Adaptive Tutor* alter the coherence and detail of text and musical examples as shown above. For users accessing the Review level, the text and subheadings feature boldfaced terms and subheadings, and the musical examples have detailed annotations. The Basic level is an intermediate level similar to the Review level, but with fewer linguistic clues and annotations on the examples. At the Advanced level, one finds few explicit organizational clues. The musical examples show only the most necessary annotations. The drills and ear training exercises feature adaptation as well. For example, a drill on scales at the Review level shows a scale and then asks students to identify the sequence of whole and half steps. At the Basic level, users name the scales, a task requiring that the interval pattern is already learned. Finally, at the Advanced level the user sees a brief melody and then identifies the scale that is used. Here, users with prior knowledge about scales apply the information to the more complex task of recognizing the scale in a simple musical context. Figure 8 shows the notation for the Review and Advanced levels of a drill on triads.

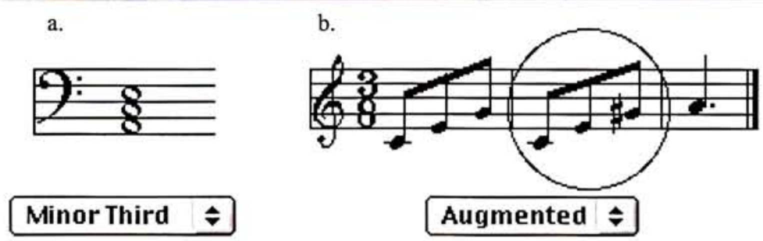

Figure 8. Review and Advanced drills on triads.

Figure 8a shows a triad and asks users to name the interval that gives the triad its name. This question focuses on basic information about intervallic structure. Figure 8b shows the example for the Advanced level. Here, users must produce the correct name for the triad when it is shown in a brief musical example, a task that forces them to access prior knowledge about key signatures, time signatures, accidentals, and so on.

A beta version of *Adaptive Tutor* was tested informally by a class of 21 music fundamentals students at the University of South Florida. This version featured the same lessons and levels of instruction, but it relied primarily on the direct guidance design, different levels of difficulty, and interactive drills as its adaptive techniques. The students in the class were both nonmajors and music majors who were denied entry into first-year theory. Information was gathered about usage of the individual lessons in two ways. First, a Web page was constructed on the site to allow student comments about what lessons they used, what levels, and any other comments they wanted to offer. Second, questionnaires were distributed to the class at the end of the semester. Of the 21 students in the class, 11 (6 males, 5 females) responded with a total of 20 questionnaires. They were to use a separate questionnaire for each lesson they accessed, but two students responded twice on one questionnaire, resulting in a total of 22 responses. The 22 responses were spread across four of the lessons: Key Signatures (Level 1), Triads (Levels 1 & 2), 7th Chords (Levels 1 & 2), Chord Resolutions (Level 1), and Unknown (Levels 2 & 3). The interactive drills were used in all lessons: Fifty percent of the respondents used the ear training drills and 86% used the interactive drills. Finally, of 21 responses (one respondent failed to respond), 14.2% found the lesson they used to be "too easy," 9.5% found it "too hard," and 76.1% found it to be "just right."

The comments generally were favorable. Students responded by e-mail and with written comments and suggestions on the questionnaires. Of 49 total comments (some offered more than one comment in an e-mail or on a questionnaire), 67% were positive. Of the 49 total comments, 33% were somewhat negative or suggestions for improvements. One student wanted "more pictures" and was "bored with the subject." Another thought the wording of the text was "too formal." The multimedia features were popular among all respondents, which suggests that they are desirable to those learners with both auditory and visual preferences. None of the respondents used a lesson without also using the drills, and of the 16 negative comments, eight (50%) were requests for more drills and exercises. Students felt it clarified concepts from the lectures, which suggests that the text and the multimedia features allowed students with several styles to learn effectively. There was no posttest given in this informal evaluation, but several students commented that the application helped them master class material and gave them the confidence and knowledge base to pass tests in class.

An obvious question about an adaptive application is its accessibility to students with different learning styles. Research concerning the relevancy of the online environment to learning styles has produced mixed results.

Harris et al. (2003), for example, conducted a study using Kolb's (1984) idea of Divergers, Assimilators, Convergers, and Accommodators. The authors designed two versions of a Web based unit, one with text only and one with multimedia enhancements. They found that "individual variations in style did not appear to have any predictive value for test performance on either the text-only or the enhanced versions of the online modules or in a lecture class" (Harris et al., p. 25). Melara (1996) tested hypertext modules that were constructed in two contrasting linking models, one that was sequential and one that was nonlinear. She also referenced Kolb (1984) and found that "both structures were equally effective on accommodating learners with preferences on experimentation as well as learners with preferences on observation (Melara 1996, p. 324). Graff (2003), however, conducted a study that examined the effects of the online environment on different cognitive styles. He concludes that "it may be profitable to design web-based learning environments to match the cognitive style of the user" (Graff 2003, 416). Baldwin and Sabry (2003), in their study of learning styles and interactive design, concluded that "learners learn more effectively when information is presented in a manner that fits in with their preferred method of acquiring and processing information" (Baldwin & Sabry 2003, p. 337). Baldwin and Sabry reference a study by Felder (1993) that breaks learning styles into eight categories: Active; Reflective; Sensing; Intuitive; Visual; Verbal; Sequential; and Global. Baldwin and Sabry (1993, p. 334) provide recommendations for interactive features to address each of the styles. Of the eight learning styles identified by Felder (1993), the various adaptive techniques discussed in this article could enhance their categories of Reflective ("self-assessment questions, quizzes"), Sensing ("how concepts apply in practice through use of video, animation, sound"), Visual ("relevant visual representations"), Verbal ("written words"), and Sequential ("a linear approach through step-by-step progression").

Conclusions

Research on text coherence and prior knowledge can greatly enhance Web based learning. Much can be done to adapt lessons to different individual skill levels and learning preferences. This article has focused on instruction in music, but these principles are easily adaptable to text and graphic illustrations in other fields. The stereotype model of self-evaluation relies on a student's own assessment of abilities. This method skews the chosen level of instruction not to actual student abilities, but to their perception of their abilities. Those with little confidence might deliberately choose a level lower than is really necessary. A better method of selecting the correct level of difficulty is to use an overlay model to assess the student's level; student answers to content questions would determine the best next page. By employing this strategy, a user would automatically switch levels if their answers warranted it.

Further research, perhaps with an entire text or course, is needed to evaluate the potential of these adaptive techniques, particularly for those students with adequate prior knowledge. This could be accomplished by testing the program with a slightly more advanced group, such as incoming first-year students who have passed a placement exam. Another valid area of inquiry is further testing of the viability of learning styles in a Web based or online environment. With the current interest in learning at a distance, adaptive applications and the manipulation of course materials to suit levels of prior knowledge are strategies that will continue to increase in value.

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Author note

I am grateful to Catherine Pelzmann and Sang-Hie Lee for their valuable comments on earlier versions of this article. Many thanks to C. Victor Fung for his helpful advice.