At the beginning of the 20th century, the piano was a common instrument in the home, and many young people were educated in the art of playing and composing for it. At the dawn of the 21st century, children are much more likely to have a computer than a piano in their home, but few children are educated in the art of playing and composing for computer. With computers, as with pianos and other instruments, musicians require guidance, practice, patience, and a strong artistic sensibility to evoke the power of music from their keys. However, society-at-large and even established institutions of music education have not recognized the importance of training musicians, particularly composers, to use computers effectively in their creative endeavors.

The Walden School offers a unique program to nurture young composers in the art of composing music on a computer and of combining computer music with acoustic instruments. Students learn to use state-of-the art computers, high-quality recording equipment, and currently-available software programs that manipulate and transform sound. They also learn how to write, notate, and perform computer music. In its entirety, the program cultivates the fundamental skills we call **Computer Musicianship**.

This chapter will provide a thorough introduction to the techniques utilized at The Walden School. These techniques are appropriate for teachers who want to incorporate computer music into an existing Musicianship program or for teachers who want to develop a stand-alone, computer-music course. This approach to teaching Computer Musicianship is entirely compatible with the more traditional elements of the musicianship curriculum and students readily apply their experiences with technology to the rest of their musical life. It is clear that

young composers wholeheartedly accept electronic and computer instruments into the compositional domain.

To give a sense of the work produced by students at Walden, here are a couple of typical models. Some students record common sounds or noises (doors, birds, bells, and so on) and transform these sounds beyond recognition. With this expanded palette of sound material, they compose unique sonic environments. These range from short, directed pieces to long, thick, ambient works. Usually the composer carefully navigates the line over which audiences recognize the sound sources, sometimes letting listeners hear the original sound with its programmatic associations, other times leading listeners through abstract soundscapes. Students also record traditional, acoustic instruments and manipulate the recordings on computer to create meta-instruments with technologically enhanced sonic qualities. In concert, the original acoustic instrument is performed and accompanied by the enhanced sounds on CD.

In every case, the basis of computer music composition at The Walden School rests on a simple premise: sound material for composing is always recorded by the student; no synthesizers or note sequencers are utilized. Synthesizers, especially those centered around MIDI (Musical Instrument Digital Interface), are usually cheap imitations of real acoustic instruments. The typical synthesizer interface is a piano-like keyboard, so naturally students play and compose as if the computer is a piano—but it is not. Chords, arpeggios, and keyboard figurations, all of which fall naturally on a piano keyboard and are idiomatic to the acoustics of a piano, are not idiomatic to computer music.

The Walden School approach has its roots in *musique concrète*. This expression, coined by French composer Pierre Schaeffer in 1948, describes compositional materials and composing methodologies. For the purposes of The Walden School Computer Music Program, musique concrète may be simply defined as music comprised of recordings of physical sound. This definition implies a crucial distinction between physical sound versus synthetic sound; or sound produced in the physical world (vibrating bodies in air, liquid, or solid) versus sound synthesized by an algorithm (computer software, synthesizers, or wave generators). Sound synthesis is a rich branch in the field of computer music but the mathematical and theoretical complexities required for meaningful synthesis generation is beyond the scope of this chapter. The hardware components of The Walden School Computer Music Program include a microphone and recording medium for collecting sound from the physical world, a computer with software for manipulating and mixing the recorded sounds, and a playback medium and speakers for performing the finished composition.

In more detail, The Walden School currently utilizes two portable recording systems (stereo microphone and DAT recorder), eight Macintosh G4 workstations (Digidesign Pro Tools Free software), and a concert playback system (Mackie mixer and Genelec speakers). That's the picture in 2002; of course, one of the difficulties in writing about computer music is that the hardware and software become outdated so quickly. This chapter will not focus on particular hardware or software. No matter which operating system a teacher has available (Macintosh, Microsoft, Unix, and so on), there are scores of freeware and inexpensive shareware programs

that can accomplish the tasks necessary for the work described in this chapter. If specialized technology questions do arise, there is a supplementary help page on The Walden School web site (www.waldenschool.org). It is also important to recognize that expensive, high-end equipment is not necessary. Of course it would be nice for each student composer to have access to a Steinway grand piano, but such an instrument is certainly not necessary for learning musicianship and composition. By the same token, a fully furnished recording studio is not necessary for learning computer musicianship.

Ultimately, the particular hardware and software utilized at The Walden School Computer Music Program is not what makes the program unique. It is the teaching approach and its emphasis on experimentation and composition that have produced such wonderful results. The underlying ideology maintains that computers are as powerful and versatile as any other musical instrument. The computer is not tied to any single style. Just as there is idiomatic writing for the piano there is idiomatic writing for the computer. Just as there is a necessary level of technical understanding to compose for the piano there is a necessary level of technical understanding to compose for the computer. Just as every young music student should practice listening skills every young music student should practice computer musicianship. It is imperative that music educators begin teaching young students how to use computers as musical instruments. Computers are widespread, but young people are without a guiding voice. Now is the time for a magnificent leap towards engaging more children in musical composition. This is the gap The Walden School Computer Music Program is bridging.

The work in this chapter is divided into three levels: elementary, intermediate, and advanced. Each level maintains the three-part teaching sequence familiar from the rest of the Musicianship Course: discovery, drill, and creative work. The discovery and creative-work sections are approached in a manner similar to the corresponding sections in previous chapters. The drill sections contain listening exercises, technical exercises, and technical terms with definitions. The listening exercises have a unique place in this chapter because few young musicians have much exposure to computer music literature. The listening exercises are based on works readily available on CD. At the end of the chapter is a section with information about CD recordings and other resources for teachers interested in expanding the breadth and depth of their knowledge.

Computer Musicianship Elementary Level

At the elementary level, there is a simple discovery exercise that reinforces The Walden School definition of music as "sound organized in time". Students also learn that an acoustic space can be treated as an instrument for computer music composition. The underlying principle is that sound more often than not involves a resonating body within a resonant space. For example, the human voice has a resonating body (a unique combination of throat, mouth, sinus cavity, and so on) to amplify the sound of the vocal cords. Because the physical structure of everyone's head is unique, everyone's voice has a unique timbre. But there is also the resonant space in which people use their voices. The unique combination of all the physical properties of a room and its contents creates a unique combination of sound wave reflections. Just as the head

shapes the sound of the voice, the room shapes the sound too (imagine talking in a large concert hall versus talking in a small closet; the voice itself is the same but the resulting sound is very different).

The ability to record sound is arguably the most important discovery in music history. Prior to recording technology, musicians were limited to sounds generated in real time in one acoustic environment. Recording technology adds tremendous versatility, allowing composers to manipulate, massage, and polish their sound material out of real time. And just as important, composers can incorporate multiple acoustic environments sequentially and simultaneously. Hence, the focus for the elementary-level drill is to teach students the process of recording sound, transferring it to computer, and playing it back. The drill section includes six computer music compositions for listening and classroom discussion. There is also a list of computer music terms with definitions.

Finally, the creative work for the elementary level leads students through a compositional process. After creating a score, they record, transfer, manipulate, and perform a computer music piece. Fundamental audio manipulations are utilized (cut, reverse, gain, and mixing) with the aim of presenting a relationship between recognizable source sounds and manipulated abstract sounds.

Elementary Level Discovery

The following exercise reinforces the notion of music as sound organized in time. To conduct this exercise, after first making sure each student is prepared to take notes, instruct the students to simply close their eyes and pay attention. Decide a duration for this exercise and use a watch or clock to wait that amount of time. One minute is a good duration but it could be as short as thirty seconds or as long as eight minutes. When the time period has passed, tell the students to open their eyes. Ask them first to write down how long they think they had their eyes closed, then a list of all the sounds they heard, and finally The Walden School definition of music.

Lead the students through a short discussion about time. Let the students brainstorm and encourage them to go beyond attempts at scientific definition. In particular, try to lead them into an understanding that one person's impression of time is usually different from another person's. Discuss the various forces that influence these differences; aside from Einstein's theory of relativity, the time of day might change a person's experience of time, as might moods (what if one person is happy and another person is sad?), level of attention (what if one person is daydreaming and another person is studying?), and location (what about swimming in a quiet lake or standing beside a freeway with high speed traffic?). Depending on the discussion level of the students, it can be provocative to lead them into a discussion about the importance of absolute time perception. What does it mean if one person while daydreaming outdoors in the sun, thinks that ten minutes lasted an hour, and another person while studying hard for an exam, thinks that ten minutes lasted only one minute? Is it important to have a precise understanding of how time passes in order to appreciate music? The students might make the leap into a

discussion about the importance of absolute pitch. Eventually, ask each student to read out loud the duration they thought the listening exercise lasted. The range of answers is often astounding. Then ask them to share what influenced their particular experience of that period of time. They should be able to draw from the previous discussion to consider why their own experience was different from other students.

Then have a short discussion about sound. Again, let the students brainstorm freely. Ask them what the concept of absolute timbre recognition might mean. Then let each student read out loud some of the sounds they heard during the listening exercise. What degree of timbre recognition is there? Did anyone mistakenly attribute a sound to the wrong source? Most importantly, did anyone mention the sound of the classroom? Since the unique, physical layout of the classroom will change all the sounds within it, everything heard in the room will have a unique coloration. Every sound has a unique timbre, but the same sound heard in two different spaces will produce two different sonic results. This is how people can guess the general size of a room even if their eyes are closed; the sound of snapping fingers in a closet is very different than the sound of snapping fingers in a concert hall.

The third component of The Walden School definition of music deals with organization. Have an open conversation about organization. Is something considered to be organized if the organizing principle is not evident? Ask the students if the listening exercise was organized. Does it matter if the duration is random or planned? Does it matter if the instrumentation is random or planned? Does it matter if the venue is random or planned?

While on the topic of venue, bring up the idea that an acoustic environment can be treated as a musical instrument. Composers of instrumental music do not often have a choice about the venue in which their music is performed. So it is understandable that the acoustic environment rarely enters into their compositional process. Explain that in preparation for this exercise, a choice had to be made about where to conduct the class. Perhaps the class could move outdoors or into a different room (gym, hallway, or cafeteria). The choice of where to run the exercise is like that of a musician with many instruments who chooses a particular instrument for a particular performance.

So finally, ask the students if what they heard was music. Did the event have the requisite components of time, sound, and organization? If they agree that it was music, what was the piece about? Meaning is not mentioned in the definition; so does music have to be about anything at all?

Elementary Level Drill

Students should be provided with the equipment and knowledge to record sound. Only a brief introduction to a microphone and recording medium is necessary. The primary objective is to allow the students to learn recording techniques through direct experience. There is no harm in students making mistakes as long as they are taught to avoid damaging the equipment and their ears. Since the recording medium can be one of many possibilities, some perhaps not yet known,

this book will not attempt to explain a particular medium; the assumption is that an inexpensive and easy to use device will be utilized (in 2002, this would likely be a minidisc recorder). Once they understand the recording process, the students can divide into groups of two or three; or if there are enough recorders, they can work individually. Regardless of the group size, it is of course important that each student have the opportunity to learn the complete recording process hands on. Privately, each group or individual can choose a particular acoustic environment they want to record. They should be encouraged to record about ten minutes of audio. Upon returning with an aural record of that space, students should be taught how to transfer the sound to computer (again, the technical specifics will vary depending on the hardware). Finally, they should be shown how to play the sounds from computer through speakers.

The class is ready to play a sonic version of hide-and-seek. One by one, each group or individual can play the sound of the chosen acoustic environment while the other students try to guess where the recording comes from. It can be surprising how attentive listening and careful observation to detail will make the source environment apparent. Of course, hints may be provided if the space is especially difficult to locate. This detective-like process is most effective when the students talk out loud and discuss their interpretations of the audio material.

After the game of sonic hide-and-seek, lead the students through discussion to the concept of an aural postcard. Just as tourists might take a visual picture of a special place, suggest that aural "pictures" may be just as evocative. Encourage students to record aural postcards for each other or for distant friends and relatives. In the end, one objective is for

students to feel comfortable with the processes of recording, transferring, and playing audio. A second objective is for the students to realize that with the ability to record comes the responsibility of choosing where to record. If a computer music composer wishes to use the sound of one hundred marbles poured from a metal bowl, a choice must be made about where to record; in a concert hall? in a closet? outdoors?

Elementary Level Listening

Since most young composers have not heard much computer music, they are unable to place their work in a larger historical context. So listening to existing works is an important part of the Computer Musicianship curriculum. Discussing these works is also vitally important because a developed and commonly understood language for talking about computer music does not yet exist. In contrast, when discussing traditional acoustic music, students will likely have a common understanding of basic terms like melody, theme, and cadence. But how can a cadence be discussed when there is no functional harmony? How can a melody be discussed when there is no discernible pitch? Does that mean computer music employs neither cadences nor melodies? Through discussion, students learn that those terms can have broader applications that do in fact relate to computer music.

Listening exercises should be structured during class with the instructor leading the discussion. The Socratic process is vital here; straightforward lectures do not provide the students enough opportunity to gain insights and to ask and answer questions. As often as

possible, encourage the students to refer to works they already know as they discuss new pieces. The following six compositions are suggested for listening with accompanying topics for discussion.

Listening recommendation #1: *Chambre d'Enfants* by Francis Dhomont. Suggested topics for discussion: How many different acoustic environments are there and what are they? When there are very different environments, for example a synthetic-sounding, indoor space and a natural-sounding, outdoor setting, how does the composer move between them and maintain cohesion? Note the use of simple cross-fades between environments. What is the relationship between melodic, instrumental material and musique-concrète material? Do these varied materials help define the musical form? Can the initial sound, which lasts through most of the piece, be considered a pedal tone; not in terms of pitch, but in terms of timbre? Lead the students to the concept of pedal timbre.

Listening recommendation #2: *Bouffée Délirante* by Ned Bouhalassa. Suggested topics for discussion: In comparison to Dhomont, how does Bouhalassa frequently transition between environments? The composer uses the term "jump-cut". The first incidence, at 1:26, is a powerful example of something only possible in computer music; the sudden and drastic shift in acoustic space. In another comparison to Dhomont, how does Bouhalassa utilize the stereo field? There are many quick shifts between left and right. How does a match lighting function in this piece? And the function of streams of air? What is the relationship between those two sounds?

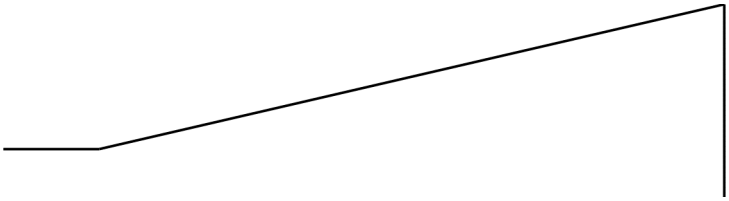
Listening recommendation #3: *12 Penny Apples* by Up, Bustle and Out. Suggested topics for discussion: What makes this computer music? Despite the common instrumentation, the students should immediately catch the extreme changes in acoustic space. The first change, at 0:12, quickly shifts from a large-sounding, reverberant space to a very small, muted space; almost like suddenly moving the entire ensemble from a concert hall to a closet. Starting at 0:26, each of the percussion instruments has individual movement in the stereo field and individual reverb changes. So not only does each instrument have its own room, it is also wildly flying around that room. With such a surreal use of space, how does the piece maintain unity? When the lead instrument suddenly moves from a small room to a large hall at 0:50 and right back to the small room, does it delineate form? Does that same gesture happen again in the piece? The surreal positioning of the percussion returns from 1:30 to the end of the piece; can this be considered a kind of spatial solo, not in the sense of virtuosic rhythms and tempi, but in the sense of virtuosic spatial movement?

Listening recommendation #4: *Shatter* by Marc Ainger. Suggested topics for discussion: What is the theme of this piece? Traditionally, themes are based on melody or harmony but can a theme be based on timbre? If composers usually create variations on a melodic theme, what does Ainger do to create variation on a timbre-based theme? From a different perspective, instrumental music is often written in a particular harmonic key; what is the key of this piece? Is it possible to think of this piece in the key of "shatter" where all the different sounds of shattering are like notes comprising the scale of "shatter"? Let the students discuss which analogy makes more sense to them; timbre as theme or timbre as key. How does the change in

timbre during the second half of the piece, from about 4:30, inform those analogies; does it suggest a second theme, another key, or maybe both? If the second half is like another key is it closely related to or distant from the first key? Does the gradual change over the course of the second half function as transition or resolution?

Listening recommendation #5: *Le Vertige Inconnu* by Gilles Gobeil. Suggested topics for discussion: What is the identifying gesture of this piece? When asked to draw the shape represented throughout this piece, students usually create something like Example 1.

Example 1. Common shape in *Le Vertige Inconnu* by Gilles Gobeil



The following gestures are clear examples of this shape: 0:10-1:00, 1:52-2:52, 5:50-6:50, and 7:35-8:20. Can that shape or gesture be considered the primary theme of this piece? What is unique about the moment at 0:56? How is digital silence different than analog silence; that is, if there is an orchestra performing and none of the performers makes a sound, is that silence different than the digital silence in this piece? What techniques does the composer use to build tension and release?

Listening recommendation #6: *Sanctus* from *Requiem* by Michel Chion. Suggested topics

for discussion: All of the various topics raised so far are relevant to this piece (acoustic environment, stereo field, timbre, theme, silence, synthesis versus musique-concrète sound source, and so on). But what issues confront the listener concerning emotional content? Is the composer dancing around the dividing line between humor and horror? How important is it to know the history and purpose of the requiem mass? This is a relatively short piece so repeated listening can allow the students to delve beyond the electrifying surface.

The list of recordings at the end of the chapter contains many additional works suitable for discussion. For the elementary-level student, the following pieces are also good examples: *Bruits* by Yves Daoust, *Arturo* by Elainie Lillios, *CommEnt* by Tom Lopez, *Scatter* by Jon Nelson, and *Mémoires Vives* by Robert Normandeau.

Finally, play a "drop-the-needle" style listening game. It's called a game rather than a quiz because there is no grading and the purpose is fun and motivation rather than evaluation. For this identification game, the students should first discuss the attributes of the various pieces already heard. This will remind them of the identifying features of each work. The usual procedure is to play a random selection from one of the pieces; the duration could be from 0:15 to 0:30 depending on the piece. It is important the students realize the goal is not to simply yell out the name of the composition. Rather, they should present what they think are the identifying features of the piece and through a process of elimination determine which piece was excerpted.

For example, they should ask if the excerpt had regular or irregular rhythm (beat or

pulse), had abstract or specific emotional content, had more than one acoustic environment (indoor versus outdoor and reverberant versus muffled), had synthesized or musique-concrète sound sources, whether the musique-concrète sounds were human, machine, instrumental, or natural, and how much manipulation was used (reversal, time compression/expansion, stereo movement, and so on). A challenging and fun extension of this game is to excerpt a different work by one of the same composers. Are the students able to extrapolate the composer's style to identify an unknown piece by a known composer? Of course, depending on the selection, this can be practical or downright impossible.

Elementary Level Terms

It is not standard practice in the computer musicianship course to require memorization of terms. They are provided here as a guide for teachers who may not have much experience with such terminology. It is important that teachers include these terms regularly and correctly in class. And students should be able to utilize these terms accurately during their discussions of computer music. If desired, additional technical information can be found in the books listed at the end of this chapter and on The Walden School web site.

Amplitude is the measurement of strength of an audio signal. Amplitude is objective (with scientifically measurable values) similar to volume, whereas loudness is subjective (different from person to person).

Analog audio refers to an electrical representation that varies continuously and directly to an acoustic sound wave. In analog recording, the magnetic pattern stored on audio tape (cassette or reel-to-reel, for instance) is analogous to the original sound wave.

Clipping is distortion that results when the **amplitude** of a **waveform** exceeds the limits of an audio device. During recording, clipping can occur when the volume exceeds the capacity of the microphone or of the recording device; solutions would be to move the microphone away from the sound source or in the latter case to lower the record level on the recording device. During playback, clipping can occur when the volume exceeds the capacity of the amplifier or of the speakers; solutions would be to lower the playback level on the mixer, or the amplifier, or the speaker itself if it is self-powered.

Compact disc (CD) is a medium for storing binary information such as digital sound or computer data.

Decibel (dB) is the logarithmic unit for measuring change in **amplitude**. A decibel is one tenth of a bel, named after the American scientist Alexander Graham Bell. Subjectively, 1dB is the smallest change in loudness that a person can hear; so relative to silence, a 10dB change is approximately the loudness of a whisper, and a 120dB change is approximately the threshold of physical pain. It is important to note that 0dB does not necessarily represent silence, it simply means no change in loudness.

Digital audio tape (DAT) is a small cassette for storing binary information; for example, digital sound or computer data.

Digital audio refers to an electrical representation of a sound wave coded in binary. In digital recording (**DAT** or **CD** for instance), the magnetic pattern stored on the medium represents the binary numbers converted from the sound wave.

Fading is the process of changing gain. A fade-in means slowly changing the volume from negative infinity (off or silence) to unity (full on). A fade-out is the opposite; slowly changing the volume from unity (full on) to negative infinity (off or silence).

Fader is the volume controller in an audio signal path. A common example is the vertical slider found on mixing boards for adjusting the volume level of each channel.

Frequency is the measurement of cycles per second of a **waveform**. When the frequency of a sound is in the audible range (approximately 20Hz to 20kHz), the sound has **pitch**. Frequency is objective (with scientifically measurable values), whereas pitch is subjective (different from person to person).

Gain is the change in **amplitude** of an audio signal expressed as the ratio of output to input. Thus, no change in amplitude is a gain ratio of 1:1, this is also called unity (marked with the letter 'U' or the number '0' on volume controls).

Hertz (Hz) is the measurement for **frequency**. Named for German scientist Heinrich Hertz, 1Hz equals one cycle per second.

Line level is a stronger audio signal typically produced by synthesizers and playback devices (like CD and cassette players). Compare **mic level**. Most mixing boards and recording devices allow line level or mic level input so it is important to choose the appropriate setting.

Loudness is the subjective, human perception of **amplitude**.

Mic level is a weaker audio signal typically produced by microphones. Compare **line level**. Many mixing boards and recording devices offer a choice between mic-level and line-level input, so it is important to choose the appropriate setting.

Musique concrète is an historical term, coined by French composer Pierre Schaeffer in 1948, which describes compositional materials and composing methodologies. For the purposes of The Walden School Computer Music Program, musique concrète may be simply defined as music comprised of recordings of physical sound.

Pitch is the subjective, human perception of **frequency**.

Saturation is distortion that results when an audio signal exceeds the magnetic capacity of an

analog tape.

Timbre is the color or character of a sound. It allows us to distinguish two different sources producing the same **pitch** and **loudness**, for example a violin and a flute.

Transducers convert energy from one medium to another. A microphone is a transducer that converts acoustic energy (sound pressure in the air) to electrical energy (audio signal in a wire). A speaker is a similar transducer except it converts energy in the opposite direction (from electrical energy in a wire to acoustic energy in the air).

Waveform is the graph of a sound.

Zero crossing is the point on a **waveform** where the **amplitude** is zero. A zero crossing typically occurs as the amplitude level changes from positive to negative or vice versa; these points are the best places to make edits on a sound wave.

Elementary Level Creative Work

According to the working methodologies of Pierre Schaeffer's musique concrète, the composer begins with pure sound. With this concrete sonic material, the composer develops abstract music. This process is usually contrasted to the reverse process of instrumental writing in which the composer begins with an abstract musical idea (internally or on paper) and develops

a concrète musical product (brought to aural physicality through performance). As mentioned earlier, The Walden School approach to musique concrète does not strictly follow Schaeffer's ideology. The main point of divergence concerns the value of working with notation on paper. Computer music students at The Walden School learn to create a score as the first step in composing.

Because a standard notation for computer music does not exist, students are free to experiment with notation techniques. Scores may be comprised of text, symbols, pictures, or graphs based on time-lines; even physical objects like rocks can be arranged to represent form and structure. The point is to encourage young composers to think about their music ahead of time and, more importantly, out-of-time. That is the significant advantage to working with notation on paper. At a glance, the composer can see the overall shape and development within a work without listening to the entire piece in real time. It is even possible for instrumental composers to scan traditional notation and hear the music in their head faster than real time. This practice of hearing a musical work inside one's head is just as important to composers of computer music as it is to instrumental composers. But it is difficult to keep everything inside one's head, hence the value of notation. This is not to say that students should deny themselves the one incredible advantage of composing computer music; they should certainly listen to their works in real time, an opportunity instrumental composers do not have while working on paper. Also, students should not be pressured to stick to a score; if a student finds during the compositional process that the sonic materials suggest a direction different from the original score, they should leave the paper behind. Improvisation holds a vital position in the

compositional process even for computer music and will be explored further in the advanced level.

Based on the discussion topics presented with the listening repertoire, a good objective for this first piece is for the student to explore the relationship between straight source material (with its associations to real world objects) and heavily manipulated material (with its abstract sound world). After creating a score with information about source material, each student can use the recording, transferring, and mixing skills learned in the drill section to begin composing a piece. Fundamental software editing features can help the student create a palette of sounds to draw from. At this point, students should be comfortable reversing a sound, compressing or expanding the duration of a sound, changing the gain of a sound, changing the frequency of a sound, cutting sounds into pieces, and mixing sounds together. These features can provide the tools needed to create a wide range of sounds, some maintaining their worldly associations and others floating into abstraction.

Ideally the final step for this creative work is to present the compositions in performance. Despite their reputation, concerts of computer music can be active and exciting events complete with surprises. As tempting as it may be to simply put two speakers on stage and play a CD, so much more can be achieved with four speakers or even just two speakers and active volume and panning control. The performance practice of recorded-audio playback is called “diffusion”. This term (originally French) implies that the prerecorded music is actively performed through speakers. It has been said that tape music is a studio art, that the finished product emerges from

the artist's studio already completed. But at The Walden School, when a tape or CD leaves the studio, it must still be brought to life through diffusion in concert.

Students should have time on stage to practice the diffusion of their music just as acoustic instrumentalists have rehearsal time on stage. The score of the composition is the perfect diffusion map for the composer. Students should carefully decide which moments in the piece should be adjusted louder or softer, or moved left or right in the stereo field, for the best result in a particular performance space.

Computer Musicianship Intermediate Level

At the intermediate level, there are fun discovery exercises that demonstrate recording techniques and explore the relationship between linguistic meaning and music. Simultaneously, students can improve their command of the recording process.

The intermediate drills allow the students to practice particular recording techniques. They also learn more sophisticated audio processing: echo, delay, chorus, reverb, filters, equalization, and so on. Of course the types of processing depend on the particular software and hardware available to the classroom studio. There are six more computer music compositions for listening and discussing as well as additional computer music terms with definitions.

The creative work for the intermediate level presents the task of using a single sound

source as the basis for an entire musical composition. By using the recording and processing techniques learned during the drill section, a wide range of material can be extrapolated from one sound object. Again, preparing a notated score and presenting the music in concert is highly recommended.

Intermediate Level Discovery

In this discovery section, the primary goal is to demonstrate recording techniques; a secondary goal is to explore the relationship between linguistic meaning and music. Undoubtedly there are many ways of accomplishing these objectives, so the examples listed below may simply provide a point of departure. Throughout, the teacher operates the recording equipment and employs the class as an instrument to be recorded. Always adjust the recording level so the signal is as loud as possible without clipping.

The general idea is to create a list of parameters and explore the opposite ends of each parameter. For these exercises, the parameters are: microphone placement, acoustic space, vocal production, and words. The opposite ends for the microphone-placement parameter are "very close" versus "very far". For acoustic space, the extremes might be a small, muffled room (perhaps a coat room or large closet) versus a large, reverberant hall (perhaps a gymnasium or concert hall); alternatively, they might be indoors versus outdoors. For the voice parameter, the extremes can be whispering versus yelling. For words, the opposition might be text that evokes sunny weather (sunshine, blue sky, green grass) versus text that evokes stormy weather (loud

thunder, heavy rain, dark cloud). In the following, the terms “sunny” and “stormy” represent the opposing collections of words; but of course it would be more fun to let the students pick their own contrasting categories.

For starters, gather the class in a small, muffled acoustic space and record the students quietly whispering the sunny words. Encourage them to inflect their voices; maybe let these words be drawn out and lazy with lots of silence between them. Be sure to have the students whisper as quietly as possible and as close as possible to the microphone. For contrast, let the students change to the stormy words; still whispering quietly, they might simply add a little inflection by making the words shorter and more tightly spaced. Then, in the same acoustic space and with the same words, ask the students to yell as loudly as possible and with great agitation; be sure to adjust the recording level so clipping does not occur.

Continue the discovery exercise. Move into a large, reverberant hall and again record the students whispering the sunny words right next to the mic. This of course will sound very different, as the acoustic space has changed. As before, change to the stormy words. Then move the students as far as possible from the recording equipment. Ask the students to yell the stormy words; adjust the recording level to maintain a strong signal.

To achieve another degree of complexity, change the parameters while recording. For example, begin with the students yelling the stormy words far from the microphone; then slowly carry the mic towards the students as they lower their voices, adding sunny words and dropping

stormy words. By the time the microphone reaches the students, they should be whispering as quietly as possible and only using the sunny words.

Then go outdoors and repeat the process outlined above. Again, it will sound very different in the new acoustic space. A playful variation for this outdoor setting is to begin with the students yelling sunny words far from the microphone. On cue, have the students run as fast as possible to the microphone; yelling sunny words along the way. Just as they get to the microphone, they should suddenly begin whispering stormy words as quietly as possible right next to the mic. Of course there is the added element of out-of-breath gasping and panting. To avoid clipping, it might be necessary to make adjustments on the fly.

Complete the discovery exercise by playing the recordings in class. It is always an ear-opening experience to hear this material afterwards. Lead a discussion with the students about the various qualities. What stands out when only one parameter changes; for example, sunny words versus stormy words in the muffled room, or whispering sunny words in the muffled room versus whispering sunny words outdoors? How effective is it hearing one parameter in apparent opposition to the other parameters; hearing stormy words whispered in the muffled room? How does it sound different to move the microphone versus moving the "instrument" — for example, carrying the mic to the students in the reverberant hall versus having the students run towards the mic outdoors? When one parameter changes in the opposite direction to all the others, can students think of the result as "counterpoint"? Finally, what is the relationship between acoustic space and linguistic meaning? How do stormy words inform the sound of a closet? How does the

sound of a closet inflect the meaning of stormy words? When recording text, not only should the environmental space be considered for its acoustical properties, but also for its correlation with the words.

Intermediate Level Drill

The first stage of the intermediate drill is to split the students into groups of two or three and let them devise their own version of the discovery exercise described above. They should pick an object they want to record; it could be a rock, a musical instrument, a metal bowl, anything. Then they can write their own list of parameters to investigate. The list they explored in the discovery exercise will get them started.

After each group has finished recording, the second stage is to show them more processing options available on the computer. In addition to the functions learned during the elementary level, new tools should include: echo, delay, chorus, reverb, filters, and equalization. There may certainly be others depending on the particular software and hardware available to the classroom studio. In this stage, the students should work individually.

For the students, the aim is to create a large range of variation from the single sound source they have chosen. The two stages in this drill section demonstrate two basic ways of expanding this range: the first is to record the sound source in as many different ways as possible, and the second is to utilize as many different processing tools as possible on the

recorded material.

When they have compiled their own varied collection of material, have them play examples for the entire class. Because the students within each group have identical source material from recording, it should be interesting to hear the different processing results they have found individually. This playing and listening process could be implemented as a game. Assuming students from different groups don't know what each other recorded, these can be presented as puzzles to be solved. Ask each student to begin playing the most processed version of the sound, the one that seems most unrelated to the original. As they play examples that get closer to the original, see how long it takes the class to guess the source.

Intermediate Level Listening

Listening recommendation #1: *5 Kleine Stücke Über die Klienen Laute eines Kleinen Menschen* by Thomas Neuhaus. Suggested topics for discussion: Play the piece without mentioning the title and see what comments students have. Then tell them the title and explain that all the sounds originate from recordings of the composer's son. Play the piece again. Is it important to know the title and read the program notes to appreciate this piece? Can this piece be considered a kind of theme and variations?

Listening recommendation #2: *Hard Cash* by Katharine Norman. Suggested topics for discussion: What are the two principal types of sound material? (coins and voices) Does the

composer treat them differently? (the coin sounds are heavily processed and manipulated whereas the outside recordings of people talking are left mostly intact) What might the composer be suggesting with the different treatment? (artificial versus natural) Concerning the use of voice, is the focus simply the timbre of the voice or the meaning of the words being spoken? Was the treatment of voice in the Neuhaus piece closer to the treatment of voice or of coins in the Norman piece? What is the relationship of the meaning of the words to the sound sources? What is the relationship of the meaning of the words to the differing treatment of the sound sources? If time allows, additional listening clarifies answers and raises new questions.

Listening recommendation #3: *Superstrings* by Adrian Moore. Suggested topics for discussion: What is the source material for this piece? (piano and harpsichord strings) If there is a scale of sound material, and one end of the scale represents the natural, unmodified sound of an object, what is represented by the other end? If the other end of the scale represents a thorough transformation of the source material to the point that the result appears to be the natural, unmodified sound of a completely different object, what might go on the other end of the scale in this piece? (rain? thunder? birds? voice?) If Thomas Neuhaus treats voice as source timbre to be modified, and Katharine Norman leaves voice untreated so meaning can be drawn from the words, how does Adrian Moore treat piano strings? Much of the piece contains modified string sounds, but there are sections with traditional sounding piano music (for example, 2:26-3:20 and 10:45-end). Can those sections be compared to the unmodified voices in *Hard Cash*? If so, is there a second level of meaning in the "piano music" just like there is a second level of meaning in the spoken words?

Listening recommendation #4: *Alias* by Åke Parmerud. Suggested topics for discussion: This piece is significant because every topic and issue raised thus far is at work in it, *Alias* makes rich use of acoustic space, timbral gesture and theme, traditional instruments (modified and unmodified), human voice (modified and unmodified, sung and spoken), and so on. Here are just a few moments to point out. In part 1: "slain" at 2:59, the original guitar sound at 6:30. And in part 2: the original Gesualdo song at 1:26 and 2:38, unmodified voice and guitar at 6:45. Read the text to the John Dowland love song and play the piece again.

Listening recommendation #5: *Mortuos Plango, Vivos Voco* by Jonathan Harvey. Suggested topics for discussion: Like Katharine Norman's piece, this one has two sound sources, one human and one metallic. Is Harvey's treatment of those elements similar to the treatment Norman used? How does this piece compare to *Alias*? There are many stunning moments when bell sounds morph into vocal sounds and vice versa.

Listening recommendation #6: *Les Objets Obscurs* by Åke Parmerud. Suggested topics for discussion: The focus of the intermediate level of listening exercises has been music based on just one or two sound sources. This typically means the composer generates a range of material in which the source is sometimes recognizable and other times hidden. A fun extension of this idea is to create a puzzle where the audience tries to determine the source material. For the initial listening of this piece, tell the class that it is a kind of puzzle about hidden objects. Ask the students to write their answers to the riddles as the piece progresses. Read the English translation

of the French text as the piece plays. As always, repeated listening is ideal.

The list of recordings at the end of the chapter contains many additional works suitable for discussion. For the intermediate-level student, the following pieces are also good examples: *Origami Animae* by Rachel McInturff is based on paper sounds, *Between the Dog and the Wolf* by Richard Nance is based on bicycle sounds, *SATX* by William Rice is based on train sounds, *Les Pas Interieurs* by André Ruschkowski is based on footstep sounds, *Wind Chimes* by Denis Smalley is of course based on wind chimes, *Hop Ken* by Carl Stone is based on an excerpt of Moussorgsky's *Pictures at an Exhibition*, and several works are based on vocal sounds (*in mosaic* by Joseph Anderson, *The Raven's Kiss* by Howard Fredrics, *Einstimmig* by Anna Ikramova, and *Scritto* by David Jones).

For the "drop-the-needle" listening game, the students should again discuss the attributes of pieces already heard to remind themselves of the identifying features. Play a random selection from one of the pieces; the duration could be from 0:15 to 0:30 depending on the piece. The students should present the identifying features of the piece and through a process of elimination determine which piece was excerpted. To keep the students on their toes, include an excerpt from an elementary-level piece.

At the elementary level, it was suggested the students ask if the excerpt had regular or irregular rhythm (beat or pulse), had abstract or specific emotional content, had more than one acoustic environment (indoor versus outdoor and reverberant versus muffled), and had

synthesized or musique-concrète sound sources; they were also asked to consider whether the musique concrète sounds were human, machine, instrumental, or natural, and how much manipulation was used (reverse, time compression/expansion, stereo movement, and so on). The intermediate level exercises raise additional identifying features: abstract versus narrative, literal versus figurative, emotional versus intellectual, whether the texture is thick or thin, whether gestures are short or long, and the use of imagery.

Intermediate Level Terms

Again, it is not standard practice in the computer musicianship course to require memorization of terms. They are provided here as a guide for teachers who may not have much experience with such terminology. It is important that teachers include these terms regularly and correctly in class. And students should be able to utilize these terms accurately during their discussions of computer music. If desired, additional technical information can be found in the books listed at the end of this chapter and on The Walden School web site.

Chorus is similar to **reverberation** in that it is the combined effect of multiple echoes of varying delay times. However, with the chorus effect, there are fewer echoes and each echo is detuned slightly thus it can make one instrument sound like a chorus of the same instrument.

Echo is the reflection of a sound, typically at a lower **amplitude** and delayed enough to be distinguishable from the original sound.

Equalization (EQ) is used to change the **amplitude** of a portion of the **frequency** spectrum. Bass, mid, and treble controls on a home stereo are simple equalizers.

Effects are hardware devices or software algorithms used to modify an audio input. Examples include **echo**, **chorus**, and **reverberation**.

Filtering selectively attenuates a range of frequencies in a waveform. A high-pass filter removes the frequencies below a determined cut-off frequency, thus allowing the higher frequencies to pass through. A low-pass filter removes the frequencies above a determined cut-off frequency, thus allowing the lower frequencies to pass through. A band-pass filter combines a high-pass filter and a low-pass filter, allowing the band of frequencies in the middle to pass through.

Pan controllers vary the amount of audio signal to two or more locations. When working in stereo, it allows routing of a signal between the left and right channel.

Reverberation is the combined effect of multiple **echoes** of varying delay times all short enough as to be indistinguishable from each other. Every room or acoustic space has a unique combination of objects and surfaces which reflect sound.

Intermediate Level Creative Work

For their next composition, the students can begin from scratch or they can use the sounds from either the discovery exercise or the drill exercise. Regardless, they should notate some sort of score ahead of time. Again, it is not essential that the score be followed closely. The point is to have a clear idea of shape and direction in mind before they begin. Encourage students to use their imagination during this step; colored pencils, markers and even paper cut-outs are useful.

To spell out one of many compositional possibilities, the sounds from the discovery exercise can suggest a sequence of events. The music could begin with highly manipulated and processed sunny words, transition into clear sunny words, follow with sunny words slowly turning into stormy words, and finish with highly manipulated and processed stormy words. Or perhaps the student might want to follow the model of *Les Objets Obscurs* and create a kind of sonic puzzle.

In the end, a concert of finished pieces should be presented. The students should perform their own work by controlling the sound, even if it simply means fading in the beginning and fading out the end. There must be some physical interaction between the student and the resulting sound.

Computer Musicianship Advanced Level

The advanced level addresses topics of improvisation, instrument-and-tape music, and

"functional timbre" (explained in the drill section). "Tape" music lingers from the early days of electronic music when works were stored on and played from analog audio tape. Of course now, in 2002, CD is the medium of choice. But the old terminology remains. A preferable system would include the number of audio channels and the medium. For example, the following designations are more current and informative: stereo CD, or stereo DAT, or 5.1-channel DVD, or 8-channel ADAT. There is a certain amount of nostalgia for the term "tape music" but eventually it will be dropped in favor of something more descriptive. For now, a quick explanation for the students will prevent confusion when they read the term in program notes or books.

An introduction to functional timbre is provided in the drill section. Technical information at the advanced level will depend on the particular hardware and software in use. There most certainly are sophisticated and worthwhile tools to be learned. These have included such processes as binaural filtering, granular synthesis, and convolution. The teacher must determine what is available and meaningful to the students at their level of work.

The discovery section integrates improvisation, instrumental music, and computer music, providing the students with more advanced models for composition and performance. And finally, for creative work, each student must complete a composition project.

Advanced Level Discovery

The goals for this discovery section are to integrate improvisation with computer music, to integrate instrumental music with computer music, and to begin finding techniques for a functional use of timbre. The following sequence of exercises tackles these goals and integrates them in a final, comprehensive exercise.

Improvisation is a rich and vital part of music, and this as true for computer music as for any other kind. On one hand, contemporary editing and mixing software allow almost instantaneous audition, and this makes improvisation a natural part of the composition process. A composer sitting in front of the computer can try and retry manipulation processes; experimenting with settings and preferences until something interesting and unexpected arises. On the other hand, improvisation in real time is a more elusive goal for the computer musician, even though the experience of sitting with an instrument and making music spontaneously, either alone or with others, offers innumerable rewards. Of course the experience of diffusing their music provides students with a first opportunity to improvise. Now they are ready to explore additional possibilities.

There are many software packages that attempt to turn the computer into a musical instrument for live performance. Some of them are very powerful and effective. But they also require specific and detailed knowledge, often verging on the skills of a computer programmer. In The Walden School atmosphere, it is enough to utilize software that simply plays audio files. If students can amass a collection of audio files and can choose fairly easily and quickly which file to play, they are ready to improvise. Again, there are many ways to implement these

exercises; teachers can determine the particular configuration that will be most effective in their classroom.

To begin quickly, students can arrange a grouping of sound files they already know from a previous project. The main advantage in this case is that they should already know what each file sounds like based on its name. Select two students and configure the classroom so that the output of both their computers can be heard together. It is usually advantageous for a third person, maybe the teacher, to maintain control of the mixer or playback device for volume adjustment. If feasible, this same setup can work with as many computer stations as are available. Regardless of the number of performers, allow them time to play around and then organize a mini concert where they actually have to present an improvisation in front of a small audience, even if it is only the rest of the class. Be sure to lead a discussion after the concert, giving the performers a chance to hear about the audience's perspective.

The next step might be to incorporate traditional acoustic instruments. Again, a simple duo (one computer musician and one acoustic musician) works fine. Or a large ensemble with multiple computers and a variety of acoustic instruments can provide challenges and rewards worth the extra effort. The combination concert and feedback session afterwards is very important. It is during the discussions that the students really learn about which performance choices worked and which did not.

The culminating exercise involves one additional component. Instruct the computer

musicians to prepare a group of audio files for improvisational performance. Discuss with them the options for this task. How narrow or wide should the timbral palette be? That is, do they want to take just one sound source and its ensuing manipulations? Or do they want their instrument to have a wide variety of sound sources? In both cases, some of the questions they should be asking themselves include: Does the palette of sound give me the flexibility I need to be a good improvising performer? Do I have long, quiet sounds? Do I have short, loud sounds? Do I have sounds that give me a solo opportunity? Do I have sounds that allow me to accompany other musicians? Do I have sounds that can function as a cadence or stopping point? Do I have sounds that can function as a transition? Do I have sounds that develop? These last few questions should lead the students to the concept of functional timbre (to be explained more thoroughly in the drill section). For now, help the students to discover their need for such sounds and to articulate their own concept of function through sound.

Again, this exercise concludes with a performance in front of an audience, followed by discussion. The lessons learned during all this fun have far reaching rewards. Just as the fruits of acoustic improvisation can feed the diverse activities of a composer, so can the fruits of computer music improvisation.

Advanced Level Drill

In the previous levels, students have experimented with various source materials. Sometimes the music is limited to one source sound and other times the music springs from a

wide array of source sounds. In either case, the students have also experimented with various processing techniques for expanding the sonic palette. The focus for this new drill is to step beyond the creation of interesting material. Sophisticated work requires a deeper appreciation for the potential of timbre to have musical function. As initially suggested in the previous discovery section, students should brainstorm and discuss how timbre can be a functional force in music.

The tension and release qualities of harmony can propel music through harmonic progressions and convey resolution through cadences. Those functions can also be provided by timbre. A good example is the sound of a squeaky door. Take some time to find the right door and practice the following gesture. Ideally there is an initial sound from grabbing and turning the doorknob or pushing the bar that releases the door. Then there is a long, slow squeak as the door opens. Simultaneously and quite naturally, there comes an awareness of another acoustic space appearing through the doorway — a different acoustic space that was concealed by the closed door. Continue holding the door wide open for longer than usual. There is an inherent tension that begins to build. Then begin to push the door shut and finish with a bang. This final gesture can actually inspire a sigh of relief. Perform this for the class and ask them what they heard and felt.

This relatively short sequence of events is a wonderful illustration of timbral function. The sound of a door opening, and staying open, can feel like the sound of a dominant seventh chord without the tonic resolution. There is something innately disconcerting and unsettling about being in a room and hearing a door open but never shut. The combination of opening and

closing has the same quality of tension and release found in harmonic cadences.

But cadences often serve the dual function of completing one phrase and simultaneously beginning another. This is also possible with the sound of a door. For example, open a good squeaky door as described before. Then step through the doorway into the acoustical space on the other side, shutting the door behind you. Now, in addition to the cadential qualities of the opening and closing, there is the added sense of beginning something new. There is very clearly a transition from one place to another, both physical and musical.

Doors are very powerful sonic metaphors. Remaining in one acoustic space while hearing a door open and close is symbolically and musically distinct from hearing a door open, moving into a new space, and then hearing the door close.

What would it be like to hear the sound of a tree falling but never hitting the ground? To hear someone yell, "timber!" and the crackling wood but never the thud? Would that be like an unresolved cadence? What about the sound of squealing tires but no sound of a car crash? Or what if the sound of a tree falling concluded with the sound of a car crash? Would that be like a deceptive cadence? What other sonic gestures might convey musical function?

On one level, these examples all involve obvious mimetic associations. The next step is to take these sounds and process them. Let the students experiment with transforming mimetic sounds into abstract gestures. Is it possible to keep the functional qualities while shedding the

mundane associations?

Advanced Level Listening

Listening recommendation #1: *Hothouse* by Paul Koonce. Suggested topics for discussion: What are some of the sound sources for this piece? Does it help or hinder appreciation of this piece to think about the sources of the sounds? In other words, is it better simply to listen to the sounds as abstract gestures, or to make concrete, mimetic associations? How is cohesion maintained with such a vast array of material? Given sounds from babies, horns, roosters, ducks, and birds, it can be difficult to imagine a single gesture that could incorporate all those sources. Carefully listen to 2:31-3:37, beginning with the rooster sound. Follow the transformations of that one extended timbre as it winds its way through the various sources. The composer creates unity by twisting the sounds into each other, sometimes quickly and other times slowly.

Listening recommendation #2: *Unsound Objects* by Jonty Harrison. Suggested topics for discussion: What are some of the sound sources for this piece? Are they more or less recognizable than the source sounds in *Hothouse*? Is the composer playing a game similar to the puzzle in *Les Objets Obscurs*? Is the primary sound source for the opening section revealed in one, brief, unprocessed moment at 1:55? Does that moment function as a cadence or transition between sections? How many sections does this piece comprise and what are the timbral characteristics of each? How does the composer create relationships between sections? Do the

moments of recognizable source material clarify structure? 4:45-5:00 is another example. What sound appears at 5:26 and finally resolves at 6:52? Is that passage transitional or a section by itself? Does the door sound at 6:52 function as a timbral cadence? Is a primary sound source revealed between 9:28-9:35? Are the door sounds between 9:36-9:55 similar in function to the previous occurrence of door sounds? Is there anything different about the last section of the piece? If so, does it work better as the final section because of that difference?

Listening recommendation #3: *Caution to the Winds* by James Mobberley. Suggested topics for discussion: This work is the first example of an instrument-and-tape piece. In concert, a performer plays the piano and is accompanied by the prerecorded audio on CD. What kind of material does the composer use for the prerecorded sound? Is there a relationship between that material and the sound of the acoustic instrument? Since the prerecorded sounds are all from piano there is a large degree of consistency between the tape and the instrument. In fact, the composer intentionally blurs the distinction, often times leaving the audience to wonder if a particular gesture is prerecorded or performed by the pianist. When taken as a whole, the live piano and the enhanced piano sounds on CD, create a larger-than-life meta-instrument. The result is that *Caution to the Winds* is more like a solo for meta-piano than a duet for piano and tape.

Listening recommendation #4: *Synchronisms No. 6* by Mario Davidovsky. Suggested topics for discussion: In contrast to Mobberley, what kind of material does Davidovsky use for the prerecorded sound? Since the prerecorded sounds are all synthesized, how much timbral

consistency exists between the prerecorded sound and the piano? Does this piece sound more like a single meta-piano, or a duet for piano and synthesizer, or a chamber ensemble consisting of piano and several different synthesizers?

Listening recommendation #5: *TaleSpin* by Russell Pinkston. Suggested topics for discussion: What sound material is utilized in the prerecorded part? Is it all from piano like *Caution to the Winds* or is it synthesized like *Synchronisms No. 6*? *TaleSpin* actually has a little of everything: some synthesized sounds, some processed piano sounds, and some musique-concrète material not from piano. What is the relationship between the tape part and the piano part? On one hand, it does not fit the model of the meta-piano. But on the other hand, the tape part is too rich and diverse to be regarded as a simple instrument in duet with the piano. So perhaps the tape part accompanies the piano much like an orchestra in a piano concerto.

Listening recommendation #6: *Petite Musique Sentimentale* by Yves Daoust. Suggested topics for discussion: What sound material is utilized in the prerecorded part? What material is utilized in the piano part? Does anyone recognize the excerpts from one of the *Gnossiennes* by Satie? What is the relationship between the piano part and the prerecorded sound? Can both parts be considered "found sound"? Is this a theatrical work — perhaps an operatic work where the piano has a role similar to a singer's role?

The list of recordings at the end of the chapter contains many additional works suitable for discussion. For the advanced-level student, the following tape pieces are good examples: *La*

Cloche Sans Vallées by Ludger Brümmer, *Det Nødvendige* by Rasmus Lunding, *Agon* by Horacio Vaggione, *In the Mix* by Marcus Wesselmann, and *Freak Show* by Daniel Worley.

For piano and tape works, *Into the Maelstrom* by James Mobberley, *A Little Traveling Music* by Loren Rush, and *Orpheus und Demokrit* by Kilian Schwoon are good for the meta-piano model. *Reflection* by Milton Babbitt, *Fantasy* by Arthur Kreiger, *The Blazing Macaw* by Charles Mason, and *Order and Alliance* by Larry Nelson are good for the chamber ensemble model. *Sphaera* by William Albright, *Homage—Bud Powell* by Karl Korte, *Secret Geometry* by James Primosch, *Something Else Again* by Alicyn Warren, and *Towards "The Midnight Sun"* by Joji Yuasa are good for the concerto model.

For the "drop-the-needle" listening game, the students should discuss the attributes of all the pieces already heard to remind themselves of the identifying features. Play a random selection from one of the pieces; the duration could be from 0:15 to 0:30 depending on the piece. The students should present the identifying features of the piece and through a process of elimination determine which piece was excerpted. Include excerpts from the elementary and intermediate levels. Now that they have heard a large variety of works, are they able to extrapolate a composer's style to identify an unknown piece by a known composer?

The elementary level exercises provided the student with recognizable features for identifying excerpts: regular or irregular rhythm (beat or pulse), abstract or specific emotional content, more than one acoustic environment (indoor versus outdoor and reverberant versus

muffled), synthesized or musique concrète sound sources, whether the musique concrète sounds were human, machine, instrumental, or natural, and how much manipulation was used (reverse, time compression/expansion, stereo movement, and so on). The intermediate level exercises involved additional identifying features: abstract versus narrative, literal versus figurative, emotional versus intellectual, whether the texture is thick or thin, whether gestures are short or long, and the use of imagery. The advanced level provides a few more considerations: tape piece versus instrument-and-tape piece, diversity of recorded materials (disparate sources like *Hothouse* or one source like *Caution to the Winds*), and use of timbral function (cadence or transition, for example).

Advanced Level Terms

These terms are provided as a guide for teachers who may not have much experience with such terminology. It is important that teachers include these terms regularly and correctly in class. And students should be able to utilize these terms accurately during their discussions of computer music.

Audio Interchange File Format (AIFF) is a generic computer format for audio files. Most audio software on most computer operating systems can recognize AIFF files.

Aliasing (also called foldover) is distortion that occurs during **sampling** when the **sample rate** is less than two times the input **frequency**. This is why it is important to **filter** out frequencies

more than half the sample rate. So recording at **CD** quality (44.1kHz) means that frequencies above 22.05kHz should be filtered.

Bit depth determines the sample resolution of digital audio. Commercial audio **CD** bit depth is 16.

Sample rate is the speed at which numerical measurements of an audio signal are read. Commercial **CD** sample rate is 44.1kHz or 44,100 digital samples per second.

Sample resolution is the range of values available for each numerical measurement of an audio signal. Commercial **CD** sample resolution (bit depth=16) provides a range of 65,536 values for each sample.

Sampling is the process of converting an analog signal to digital numbers.

Advanced Level Creative Work

There are many possible directions for creative work based on the topics in the advanced level. At this point, the teacher should carefully consider the needs and desires of the students and encourage appropriate projects. For some, it might mean using improvisational exercises to help develop material and ideas. For others, it might mean actually developing a piece for improvisational performance. Still others might be more suited to attempt a composition for

instrument and prerecorded sound. When appropriate, scores should be created. In performance, there should always be some physical interaction between the student and the projected sound.

Regardless of the compositional model, each student should be wrestling with the idea and application of functional timbre. They should be searching for ways to make timbre serve their musical goals. This requires patience and openness. Many natural sounds will provide powerful musical gestures all by themselves, but the student's ear has to be open in order to hear them. Or sounds may need time-consuming manipulation to yield the desired quality; in order to find it, the student has to be both patient and playful.

In the end, the teacher's role is awe-inspiring. Ideally, teachers provide love, support, hope, and respect for each student. And perhaps most difficult of all, teachers are held to a level of honesty and sincerity not expected from other role models. Never mind the changing technology, never mind the crashed computers and lost files. The biggest challenge is to create an environment of trust and respect in which everyone, student and teacher alike, learns from everyone else.

Recordings

Works designated E are discussed in the Elementary Level listening section, I in the

Intermediate Level listening section, and A in the Advanced Level listening section. The additional works are also recommended for teaching exercises and listening pleasure.

"tape" music

	composer	title	date	duration	label
E	Marc Ainger	*Shatter*	1998	8:00	ICMC 2000
	Joseph Anderson	*in mosaic*	1992	10:00	SEAMUS 3
E	Ned Bouhalassa	*Bouffée Délirante*	1990	8:22	IMED 9840
	Ludger Brümmer	*La Cloche Sans Vallées*	1993	22:00	Cybele 101
E	Michel Chion	*Requiem*	1973	37:16	IMED 9312
	Yves Daoust	*Bruits*	2001	29:46	IMED 0156
E	Francis Dhomont	*Chambre d'Enfants*	1996	2:49	IMED 9634
	Howard Fredrics	*The Raven's Kiss*	1993	7:40	SEAMUS 4
E	Gilles Gobeil	*Le Vertige Inconnue*	1993	8:23	IMED 9421
A	Jonty Harrison	*Unsound Objects*	1995	12:59	IMED 9627
I	Jonathan Harvey	*Mortuos Plango, Vivos Voco*	1980	9:00	CMC 5
	Anna Ikramova	*Einstimmig*	1997	7:23	Cybele 103
	David Jones	*Scritto*	1986	7:46	CMC 4
A	Paul Koonce	*Hothouse*	1992	9:00	SEAMUS 5
	Paul Lansky	*as it grew dark*	1983	18:18	CMC 11
	Elainie Lillios	*Arturo*	1998	13:39	SEAMUS 10
	Tom Lopez	*CommEnt*	1998	10:00	*f*wmp
	Rasmus Lunding	*Det Nødvendige*	n/a	14:15	SC VI
	Rachel McInturff	*Origami Animae*	1997	5:45	SEAMUS 8
I	Adrian Moore	*Superstrings*	1999	12:30	SEAMUS 10
	Richard Nance	*Between the Dog and the Wolf*	n/a	5:50	ICMC 2000
	Jon Nelson	*Scatter*	2000	8:50	SEAMUS 10
I	Thomas Neuhaus	*5 Kleine Stücke Über die Klienen Laute eines Kleinen Menschen*	1997	6:48	Cybele 103
I	Katharine Norman	*Hard Cash*	n/a	10:40	SC V
	Robert Normandeau	*Mémoires Vives*	1989	15:54	IMED 9802
	Daniel Oppenheim	*Round the Corners of Purgatory*	1987	25:47	CMC 1
I	Åke Parmerud	*Alias*	1990	13:50	Phono Suecia
I	Åke Parmerud	*Les Objets Obscurs*	1991	14:40	Phono Suecia
	Roger Reynolds	*The Vanity of Words*	1986	20:14	CMC 4
	William Rice	*SATX*	1994	14:10	SEAMUS 7
	André Ruschkowski	*Les Pas Interieurs*	1997	11:12	SC VI
	William Schottstaedt	*Leviathan*	n/a	7:11	CMC 3
	Denis Smalley	*Wind Chimes*	1946	15:10	IMED 9209

	Randall Smith	*Elastic Rebound*	1995	15:00	IMED 9948
	Carl Stone	*Hop Ken*	1989	13:03	EAM 201
E	Up, Bustle and Out	*12 Penny Apples*	1996	2:21	Ninja Tune
	Horacio Vaggione	*Agon*	1998	8:45	ICMC 2000
	Andrew Walters	*IN>EX*	1998	7:35	SEAMUS 9
	Marcus Wesselmann	*In the Mix*	1991	13:44	Cybele 103
	Trevor Wishart	*VOX-5*	1986	6:01	CMC 4
	Daniel Worley	*Freak Show*	2000	7:22	SEAMUS 10

piano & "tape" music

	William Albright	*Sphaera*	1985	12:44	CMC 9
	Milton Babbitt	*Reflections*	1975	10:12	CRI 707
	Yves Daoust	*Impromptu*	1995	16:19	IMED 0156
A	Yves Daoust	*Petite Musique Sentimentale*	1984	10:11	IMED 9106
A	Mario Davidovsky	*Synchronisms No. 6*	1970	6:59	CRI 707
	Charles Dodge	*Any Resemblance Is Purely Coincidental*	1980	8:01	CMC 11
	Stanley Haynes	*Prisms*	1977	7:47	CMC 8
	Karl Korte	*Homage—Bud Powell*	1994	11:45	Centaur 2363
	Arthur Kreiger	*Fantasy*	1979	7:11	CRI 707
	HyeKyung Lee	*conFUsion/comBUstion*	1999	8:30	*f*wmp
	Charles Mason	*The Blazing Macaw*	1992	8:17	SEAMUS 3
A	James Mobberley	*Caution to the Winds*	1991	5:30	SEAMUS 2
	James Mobberley	*Into the Maelstrom*	1998	5:38	SEAMUS 9
	Larry Nelson	*Order and Alliance*	1991	11:00	SEAMUS 3
	Robert Normandeau	*Figures de Rhétorique*	1997	13:37	IMED 9944
A	Russell Pinkston	*TaleSpin*	2000	8:45	SEAMUS 10
	James Primosch	*Secret Geometry*	1992	12:10	CRI 707
	Loren Rush	*A Little Traveling Music*	1973	10:54	CMC 2
	Kilian Schwoon	*Orpheus und Demokrit*	1997	10:03	Cybele 103
	Denis Smalley	*Piano Nets*	1991	17:57	IMED 9209
	Rob Smith	*Essential Torque*	1995	11:00	Skitter Music
	Daniel Teruggi	*E Cosi Via*	1985	14:16	CMC 8
	Alicyn Warren	*Something Else Again*	1996	11:21	CDCM 29
	Olly Wilson	*Piano Piece*	1969	10:49	CRI 629
	Joji Yuasa	*Towards "The Midnight Sun"*	1984	19:05	CRI 707

Recording Label Web Sites

All of the labels listed below offer many recordings of electronic and computer music. In

particular, IMED (empreintes DIGITALes) has a large catalog of very interesting work.

ACF	American Composers Forum .....www.composersforum.org
CDCM	Consortium to Distribute Computer Music ..... www.centaurrecords.com
Centaur	..... www.centaurrecords.com
CMC	Computer Music Currents available from CDEMusic. www.cdemusic.org
CRI	Composers Recordings, Inc. .....www.composersrecordings.com
Cybele	available from CDEMusic ..... www.cdemusic.org
EAM	Electro-Acoustic Music ..... www.sukothai.com
EMF	Electronic Music Foundation ..... www.emf.org
*f*wmp	First Wave Music Publishing.....www.firstwavemusic.com
ICMC	International Computer Music Conference.....www.computermusic.org
IMED	empreintes DIGITALes .....www.empreintesdigitales.com
Ninja Tune	..... www.ninjatune.net
Phono Suecia	available from CDEMusic ..... www.cdemusic.org
SC	Sonic Circuits produced by ACF .....www.composersforum.org
SEAMUS	Society for Electro-Acoustic Music in the United Stateswww.seamusonline.org
Skitter Music	available from New Music Consortium ...www.newmusicconsortium.com

Books

The bibliography listed below is very short but a good place to start for more information. Most of these books have extensive bibliographies of their own if additional resources are desired.

Adams, Robert Train, *Electronic Music Composition for Beginners*, Wm. C. Brown Company Publishers, Dubuque, Iowa, first edition 1986, second edition, 1992.

Collins, Mike, *Pro Tools for Music Production: Recording, Editing, and Mixing*, Focal Press, Boston, Massachusetts, 2002.

Deutsch, Herbert A., *Synthesis: An Introduction to the History, Theory & Practice of Electronic Music*, Alfred Publishing Company, Inc., Van Nuys, California, first edition 1976, second edition 1985.

Pellman, Samuel, *An Introduction to the Creation of Electroacoustic Music*, Wadsworth Publishing Company, Belmont, California, 1994.

Schrader, Barry, *Introduction to Electro-Acoustic Music*, Prentic-Hall, Inc., Englewood Cliffs, New Jersey, 1982.

Strange, Allen, *Electronic Music: Systems, Techniques, and Controls*, Wm. C. Brown Company Publishers, Dubuque, Iowa, first edition 1972, second edition 1983.

Talbot-Smith, Michael, *Sound Engineering Explained*, Focal Press, Boston, Massachusetts, first edition 1997, second edition 2002.