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The Aesthetics of Interactive Computer Music

This article describes the aesthetics of interactive computer music and contrasts these with aesthetic assumptions of other genres of computer music. Interactive computer music is a sub-genre of what might be called *performance-oriented computer music*—that is, any computer music that includes a strong performance component. This broader category requires at least one live performer joined with computer-generated or electronically produced or modified music. The genre thus incorporates both the traditional tape-plus-instrument medium (Mario Davidovsky's series of *Synchronisms* [e.g., Davidovsky 1988] are paradigmatic) and more recent interactive computer music—whether precomposed, improvised, randomly generated, or a mixture of these. I will narrow the focus of this article to just those works that are interactive: works wherein the performer in some way controls the electronics or the electronics affect the performer's sounds.

The conceptual implications of this genre are rarely discussed. Even in works that purport to treat of the aesthetics of computer music in a general fashion, such as Keane (1986) and many essays in Heifetz (1989), the issues addressed fall short of those that are implied in addressing interactive computer music. Rather than merely creating a typology or presenting the more problematic aspects of its ontology, my aim will be to show what aesthetic qualities this music has that distinguish it from other genres of electronic and electroacoustic music as well as from other forms of music generally. Since aesthetic issues are intimately intertwined with value judgements, I also make some claims about the relative value of various approaches to computer-extended performance and their possibilities.

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After a brief discussion of some definitional and ontological issues (simply to set the boundaries of discussion), I turn to the main points of the article. These are considered under two broad, complementary headings: (1) the human performer's contribution to computer music, and (2) the computer's contribution to human performance.

Within these broad sections, there is a background theme involving the nature and relationship of the human element to the machine element. In a great deal of music since the advent of electronic sound production, the electronic elements have been used to imply the non-human; this is one reason electronic music has been so often used in science fiction films. This is something I refer to as the "aesthetic of the machine." The electronically generated sounds glory in effects that machines can easily perform and humans cannot, such as the rapid pitch signatures of the droids' speech in *Star Wars*.

But one might also think in this context of the Futurism of Edgard Varèse, whose *Poème Électronique* was a precursor of much electroacoustic music to come. One could say that in it he depicts the world of machines, factories, mass production, alienation, and so on. All of these elements are indicative of the 20th century's ambivalent relationship to the technology of machines—on the one hand looking to technology to bring humanity out of menial labor, while on the other fearing the enormous potential for the technology to control human life and value. The machine did not make the life of the factory worker better, at least not at first. Rather, the worker had to learn to adapt to the pace and consistency of the machine, with sometimes rather unpleasant effects. Part of my contention here is that this view of technology is now no longer relevant. Technology is beginning to empower individuals.

While it would be deceptive to hold too strongly to a human/inhuman, human/machine—or even

more generally, a subjective/objective—dichotomy in computer music (just as deceptive here as elsewhere in the modern world), nonetheless there is another more subtle aspect of these dichotomies that comes into play frequently, and I would say more insidiously: the humanist/formalist dichotomy. The degree to which musical formalism—most often associated with notions of objectivity and scientism in art—has reigned almost uncontested in the electronic arts is itself of some concern, or ought to be, to many contemporary practitioners. Arising out of these issues is a brief discussion of the aesthetics of formalism and humanism. These two “isms” are very prominent today, with contentious debates reaching all the way to popular press outlets such as the *New York Times*. For this article, however, the issues are framed in the context of computer music.

The present article attempts to give an overview of all of these issues, though not an unbiased one. Objectivity in art being one of the values herein contested, it hardly seems appropriate to make pretense to objectivity in the presentation of that contest. It is through individual subjective responses to art that it will live or die. Nevertheless, there are times when objective criteria are certainly useful. One could turn to Scruton's formulation: “In one sense aesthetic judgment is subjective—for it consists in the attempt to articulate an individual experience. But in another sense it is objective, for it aims to justify that experience, through presenting reasons that are addressed impartially to all beings with aesthetic understanding” (Scruton 1997, p. 376). Indeed, I intend to go even further than Scruton: not only must we attempt to justify that experience, but we must attempt to justify more specifically why—and how—that particular experience should be valued.

What Is Interactive Computer Music?

Does the act of diffusing a tape or CD in concert make a piece into interactive computer music? Is a piece for tape and live performer necessarily interactive? Is there a level or kind of interaction that leads to a qualitatively different musical experi-

ence? These are some of the ontological issues one is faced with when considering the nature of interactive computer music. This article is not about these issues per se. However, in order to deal adequately with the aesthetics of interactive computer music, one must first have at least some working notions of how the words “aesthetics,” “interaction,” “computer,” and—last and therefore most easily though least justifiably neglected—“music,” might reasonably be defined. To do justice to any one of these concepts is patently beyond the scope of this, or probably any other, article. However, I hope it will be possible to approach the subject using some rough (but not inaccurate) approximations that will at the very least provide a basis from which we can discuss the concepts resulting from their concatenation as a whole.

Music

The nature of music has, particularly in the century of John Cage, multiculturalism, and other varieties of aesthetic choice, become more problematic. Nonetheless, I think it is possible to reduce the problems somewhat. Just as I have considered aesthetics in only its broadest manifestations, similarly, music can be roughly considered to be sounds made with aesthetic intent, or even sounds listened to with aesthetic interest. The former gives more weight to the role of the creator, while the latter formulation tends to privilege the listener. Though there may yet be controversial cases, none of them will affect the arguments that follow.

Thus skirting the more problematic issues of what the words “aesthetic” and “music” actually refer to, I would like to dispose of easier tasks and present what I take to be the domain of interaction and the computer.

Aesthetics

First, to be clear, we are not going to be dealing with an aesthetic of music theory, because such a theory, as a theory, is more readily related to a scientific

theory than to an aesthetic object. If one aesthetic criterion of a scientific theory is to use the fewest assumptions consistent with as many facts as possible while yet achieving the most comprehensive explanatory scope, it is not clear that there is any similar criterion for minimizing assumptions that is obviously applicable to music. Music as aesthetic object, or rather music that is the object of an aesthetic interest, may have very little in the way of "facts" and almost nothing in the way of explanatory scope. At best, we might hope for a laying out of conditions under which such an object might be taken to have musical value, with the caveat that this notion of "musical value" may extend along dimensions social, historical, and personal in ways that are hardly quantifiable.

Second, while the study of what kind of object a musical object is (i.e., its ontological status) is a major focus of current work in musical aesthetics (see Levinson 1990 or Scruton 1997 for recent examples), I will neglect that topic in order to bring to the fore an aesthetic topos that has for the most part lately been either ignored or at least short-changed: aesthetic valuation. Admittedly, this is an almost heretical undertaking in this age of moral, social, and—most apropos here—cultural relativism. That it has often been ignored can probably be traced in the main to the shift, at least in the Anglo-American milieu, toward a positivist philosophy. On the other hand, the aesthetic theories of Adorno (a principle proponent of the non-positivist stance) have held sway over Continental aesthetics. In his book on aesthetic theory, Adorno wrote:

The diremption of understanding and value is a scientific institution; without values nothing is understood aesthetically, and vice versa. In art, more than in any other sphere, it is right to speak of value. Like a mime, every work says: "I'm good, no?"; to which what responds is a comportment that knows to value. (Adorno 1997, p. 263).

And yet, the political and social dimension of Continental aesthetic thought, while a reasonable outcome of that particular world view, has remained rooted in a time and place some 50 or more years distant from our present. At the very

least, this calls for a re-evaluation of the political and social specifics of these philosophies, that is, a re-evaluation within the context of our current political, social, and cultural environment.

Owing to this extreme dependence of music, or any art, on highly variable social and cultural contexts, it becomes impossible to define generally that which is and is not categorized as art. In this article, therefore, I will minimize the need for defending any particular ontological position by adducing exemplifications where necessary of those types of interactive (and, for contrast, non-interactive) computer music I take to be representative. Though this leaves open a lot of potential ontological problems, I believe the examples I cite will be largely acceptable to most readers, partly because they will be simply representative of types of musical activity, and because no strong conclusions depend on any specific details. This strategy I hope will leave me much more room to argue my case with regard to aesthetic valuation, relegating any residual disagreements in the ontological domain to a secondary status, without severely limiting the relevance of my main points.

This still leaves something to be said about the definition of "aesthetics." So I will simply say that an aesthetic is the artistic valorization or system of valorization that inheres in a work or experience. Aesthetics is the study of such systems or, as a simple plural form, a set of such systems. Older definitions of aesthetics as either the study of sensual perception or the study of the "beautiful" are, in the former, too broad, and in the latter, too tied to a particular 18th-century valorization. This definition, of course, is not very specific. For one thing, leaving the word "artistic" in the definition leads to a certain circularity—but I think it will do for the circumstances addressed in what follows.

Interaction

Interaction has two aspects: either the performer's actions affect the computer's output, or the computer's actions affect the performer's output. These can occur at fairly simple levels or at more complex levels, and they can be combined in various ways. The first implies the presence of a hu-

man being controlling, to at least some degree, the performance of the electronic component of a musical work as it is being performed. This can be either broadly interpreted to include any kind of control even such as that evinced in a purely tape music piece (despite the now anachronistic terminology) when the sound is diffused live, or even trivially as when someone pushes the "play" button on a CD player. The interaction, however, surely becomes a more significant aspect of the work the more the performer can actually effect changes not only in spatialization but in tempo, dynamics, timbre, rhythm, pitch—in short, in every and any of the usual or unusual musical dimensions.

The other extreme of this is the case where the performer controls every characteristic of the electronic sounds produced. This might come about by means of a controller that transduces the performer's gestures into parameters for synthesis or processing. Since this occurs by means of some mapping of gesture to parameter, there are different degrees of control offered by different kinds of mapping. On the one hand, there can be a mapping that relates the performer's gestures to a predetermined "score" and simply steps through that score, as in a score-following scheme. On the other hand, the mapping can occur at a more fundamental level, inducing a correspondence between gestures and pitch, dynamics, timbres, etc. In this second approach, the performer follows not even a semblance of a preconceived score, but participates in a "free improvisation" of the sort that became so popular in the late 1960s. Largely to have a clear focus for the argument, I will keep to the domain of interaction wherein a live performer can effect changes at least at the level of the timing of electronic musical events. Even this shades imperceptibly toward the less interactive side. (For example, should changing the reverberation time be considered a change in the timing of musical events?) Nonetheless, it will be easier to follow if this limitation is kept in mind.

The second aspect of interaction is that the electronics may affect the output of the performer. This is a little simpler to grasp and is very commonly used. For example, the computer can be programmed to add pitch shifting or reverberation or echoes or any number of other effects to what-

ever the performer produces. Again, this can either be accomplished in a relatively fixed manner, such as playing with a reverberation unit with fixed settings. Or it can be achieved in a more flexible manner wherein the computer changes the processing over time depending either on the performer's gestures or on a pre-determined score.

It is also possible for the computer to do something that requires the performer to respond to it. While the simplest form of this might be that the performer is required to wait for the computer effect—such as reverberation—to die away, a more complex interaction might include the computer generating notes or rhythms or anything else that the performer must then react to in an improvisational sense. George Lewis, in *Voyager* (1993), provides a good example of this. Here, the computer "improvises," and the performer responds by improvising. This might even include the possibility of the computer generating a graphic score to which the performer must then respond.

Note that in both of the above categories of interaction—electronics affected by the performer or performer affected by the electronics—can be mixed, and the boundaries can become blurred. In any case, the categories should be sufficiently broad to encompass all that currently fits under the heading of "interactive."

Computer

Use of the word "computer" is fairly straightforward. However, as everything from phones to refrigerators becomes more and more an active participant in the riotous digital revolution, it becomes less and less an issue whether something uses an actual dedicated computer or whether it simply has embedded computer technology in its very design. Hence, I do not discriminate whether we are talking about using an SGI, a Macintosh, or a Palm Computer, nor even whether the computing device is digital or analog in its sound synthesis, nor even whether it is a special-purpose audio computer such as a synthesizer, or a micro-electronic device built right into a violin. Furthermore, as the technology advances, the field of

wearable computers and computer implants may become a significant factor in music. It is one thing to lug hundreds of pounds of equipment around to give a computer concert; it will be quite another to have all the hardware necessary either attached or built into one's own body. Similarly, while the low cost of computers has led to more widespread use of them in music, of potentially much greater impact will be the effect of their growing transparency. As software increases in sophistication and hardware becomes more liberally embedded, one will feel less like one is working with a computer than just simply working.

Having said this much by way of preface, perhaps it is best if I jump right to my main question. As mentioned above, this is divided in two parts. On the one hand, what does live performance bring to computer music? And on the other, what do computers bring to live performance? While in the first case, the re-emphasis on human performance relates more readily to the pre-electronic musical tradition, in the second case, the use of the computer conjoined with a human performer brings with it the possibility for certain new extensions to performance brought about by the technology itself. I will discuss the effects of live performance on technology first, returning later to discuss the aesthetic ramifications of the new performing possibilities brought about by the use of the computer. But keep in mind that the idea of re-connecting with past traditions—in some cases skipping over immediately preceding eras—is a thread that will wind its way through this article.

What the Human Performer Brings to Computer Music

While interactive computer music, as music, shares a great deal of its aesthetic issues with all music, it does present some areas of contrast with other forms of computer music that are less interactive. These differences stem directly from the inclusion of a live performer at the moment of communicating the piece to some listener. This inclusion, while it can of course be minimized (the stage can be so darkened as to prevent his or her

making any visual effect, or his or her role can be minimized to be no more than a button-pusher of one kind or another, etc.), can open the work to aesthetic values that frequently remain outside less interactive computer music. Indeed, I believe the inclusion of an active performer in one way or another re-introduces into computer music elements that had been almost entirely removed from computer and electronic music of the recent past. The first group of these aesthetic elements is brought about by the re-emphasis on human performance and human cognition that comes from working with a live performer. It is a re-emphasis in the context of music as a whole, where the performance element has played a large role since the beginning of musical time. However, it is a new emphasis for computer music, which has tended toward abstraction and objectivity, often with disappointing results.

This re-emphasis on human performance yields several important effects. I will consider three of these. The first gives rise to possibilities that could be actualized if desired; the next two are virtually unavoidable in any performance involving human beings due to human nature itself. After this, I will contrast these effects with a few words about what non-interactive computer music gains—and what it loses—by removing the performer.

Gestural Nuance

The first element that results from the human performer's participation in an interactive work is the incorporation of gestural nuance such as *rubato*, subtleties of phrasing and articulation, and dynamics. In the non-interactive work, such nuances require great pains to produce. Though it is difficult in a tape piece (and even in a traditional piece for performers) to completely distinguish the compositional and performative domains, it is more difficult to incorporate "performative" inflection into tape music, and therefore, for practical reasons, it becomes less likely to occur. As a result, much non-interactive work avoids the kinds of situations where this kind of nuance is called for: rarely is non-interactive music com-

posed of lines and phrases that require subtle nuance in timing, phrasing, etc. Indeed, in much non-interactive music, the emphasis has been shifted either toward gestures of extreme contrast (as in Davidovsky synchronisms) or toward broad gestures of rich timbral development (as in most *musique concrète*). It is not that subtleties of this sort are impossible in non-interactive music—indeed, there are many examples—it is simply that, because they are difficult to produce, there is a definite tendency to avoid them.

Physical and Cognitive Constraints

The second element can be seen as one of the constraints placed upon a work that incorporates human performance: that it be "performable." While this may be obvious on the face of it (the complexities of Ferneyhough being only an apparent, not a real, exception) what is perhaps less obvious are the aesthetic implications of this constraint. Beyond the merely physical factor of playability, such as the physical impossibility of playing the low cello C on a standard violin, the constraint on "performability" imposes cognitive limits as well. The performance gestures, and to some extent even the sounding gestures, must be cognizable: the performer must be able to get their mind around them in some way. This limitation, in turn, imposes some constraints on the compositional possibilities. The composer without physical limitations of performance can more easily convince himself or herself that they have created something real and comprehensible, whereas what they have may be an unhearable ideal. It is relatively easy to create algorithms that generate sounds whose qualities as music are inscrutable, beyond the cognitive or perceptive abilities of listeners. And with computer programs, it is not only possible but becomes a rather frequent occurrence. It is obviously also possible to do this in the acoustic realm, even within the performer's abilities—many people think Milton Babbitt's music is this way. However, because of the performance tradition, it is more likely that composers will keep reexamining these constraints.

I am not suggesting that it is possible to "imagine the unimaginable." Rather, there is a shift of domain that is important: I can imagine the program, but not the results of the program. A simple case is a program that samples a hard disk according to some algorithm, interpreting the result it as a stream of audio samples. Sometimes the result will be noise, and sometimes it may be preexistent audio samples. These constraints have both positive and negative features, but I believe ultimately constraining music to what is cognitively graspable, without confining it to what is already cognitively grasped, brings about a more realistic compositional attitude which in turn leads to more successful works.

Interpretation

The third broadly considered element that is brought about by the insertion of a human performer into the performance of a work of computer music has to do with the inherent variability a human performer brings to the performance. This variability, when brought about consciously by the performer, is often referred to as "interpretation." It is a relatively complicated notion and has two aspects. One is more local, i.e., largely within a particular performance of a particular piece. The other is more global, impacting issues of concern to many pieces in many cultural situations.

First, more locally, performance variability results in a kind of performance we are familiar enough with from the past: since the details are not all entirely fixed, to one degree or another human interaction results in a work that is variable. In this case, each "performance" is a unique representation of the work, each performance can change details and change emphasis, and, for better or worse, each performance becomes a version of the work and not the work itself. Again, we must bear in mind the continua of possibilities between very fixed (a piece for headphones without any further mixing or spatialization other than what the composer, or sound engineer, put on the recording medium) and very unfixed (a piece for human improvisation with a computer "partner," for ex-

ample, such as the previously mentioned *Voyager* series of works/performances by George Lewis.)

The second aspect of this draws out the implications more globally. Since the human performance is a variable one, by its nature, that variability can become the focus of aesthetic issues, even simple ontological issues. Because the performance changes from time to time and from performer to performer, the notion of "the work" becomes more and more clouded. The work, even from an objective rather than an immanent point of view, becomes something open-ended. Each performance becomes an "interpretation" of the possibilities inherent in whatever was "composed." However, each of these concepts is highly problematic. This "interpretation" can have significant consequences for the meaning—and therefore value—of a work in a cultural context. Since the work is not fixed, it is open to new interpretations, and therefore the possibility at least exists for the growth of the work over time or across cultural boundaries. The work can thus maintain a longer life and have a broader impact culturally, because it is able to change to meet changing aesthetic values. As Gadamer notes,

Here the aesthetics of genius has done important preparatory work in showing that the experience of the work of art always fundamentally surpasses any subjective horizon of interpretation, whether that of the artist or the recipient. The *mens auctoris* (authorial mind) is not admissible as a yardstick for the meaning of art. Even the idea of a work-in-itself, divorced from its constantly renewed reality of being experienced, always has something abstract about it. (Gadamer 1988 p. xix)

It is this notion of a work's surpassing "any subjective horizon of interpretation" that is important. And, fundamentally different from the written arts (and the static visual arts), the musical arts do this best through performance. Perhaps this is largely due to the importance of the element of temporal control. But the extent that a work can be interpreted is a matter of degree. It is important to consider the difference between a recording—largely fixed in its presentation—and a poem, seemingly

fixed in its presentation. The relative significance of the variable elements is different in each case. How you read the poem to yourself is not fixed: different words can be emphasized to stress different construals. The reader has great latitude for stopping and pondering, re-reading, re-considering—in effect, performing the poem. Similarly, in painting, how one views the painting can shift, because one can give different weight to the different visual elements through how one directs one's gaze and thoughts in time. In music, by contrast, the listener is much more at the mercy of the performer, and necessarily so because the time element is itself a crucial aspect of the art.

In any case, perhaps this interpretive flexibility is one of the reasons for the longevity of the classical/romantic repertoire. This repertoire has focused so much on performer "interpretation" that it has managed to be reinterpreted with new significance through over 250 years of cultural change. Though to be sure, one must have adequate "raw material" with which the interpreter can work. On the other hand, it seems to me that the current classical music scene shows us that even Beethovenian material—probably as "adequate" as any—cannot continue to be renewable if circumstances militate against it: as interpretability becomes less variable and more homogeneous (due largely to commercial recording standardization but also to globalization and concomitant mass marketing of star performers), the audience begins to stagnate, and the culture decays into a museum culture. (I will have more to say on this in relation to electroacoustic computer music later.) The essential point here is that the introduction of performance variability into the aesthetic frame of the work at least holds the potential for the work to evolve in response to cultural changes. It seems to me that this ability to evolve through re-interpretation makes such work, to the extent it can realize this potential, culturally more valuable—not less.

These two aspects of interpretation come about directly as a result of the introduction of a human performer. There is another element that may enter into the aesthetic consequences of interactive computer music that is less a direct consequence and

more of a consanguinity of—for lack of a better term—aesthetic intent. This is perhaps a good point to back up a bit and look at what has happened in the world of non-interactive computer music.

Modernism and Humanism

The rise to prominence of modernism in the beginning of the 20th century was partly characterized by artists' embracing the notion of themselves as demigods able to fashion new artistic worlds out of their own imaginations. This of course can now be seen, in part, as merely a 20th-century extrapolation of the 19th-century cult of genius. This led, ultimately, to an extreme obsession with "making it new," as Ezra Pounds sloganized, and became so embedded in the aesthetics of the second half of the 20th century that Dahlhaus, already in the 1960s, felt compelled to remind his readers that "it ain't necessarily so." We might want to keep in mind his caveat on this issue:

...[T]he esthetics to which the criterion of originality belongs is a historical phenomenon itself; it arose in the eighteenth century and its duration can not be predicted. (Dahlhaus 1982)

This newness fetish led in turn not only to a greater and greater divorce from any possible communality whether of means or ends—a problem still with us in the 21st century—but also, owing to a refusal to rely on well known techniques of the past, to an almost desperate need to systematize. If one refuses to rely on one's encultured or instinctual command of a tradition, one must invent a new tradition. Once it is invented, how can it be validated? If one does not rely on what one knows has worked in the past, then how does one know—unless one really is a genius of course—if one is right? The answer of course was, "Prove it!" Composers attempted to prove the correctness of their music's method by a variety of scientific and pseudo-scientific theories, pronouncements, and manifestos. This attitude is evinced, for example, in the following statement of Roland Barthes, from *Critique et Vérité*:

The science of literature will hence have as its object, not explaining why a particular meaning must be accepted. . . but why it is acceptable. . . by virtue of the linguistic rules of the symbol. . . . In the same manner, one aims at describing the acceptability of works, not their sense. (Barthes 1987)

Acceptability, in this context of verbal meaning, simply displaces the responsibility of determining a work's meaning from the readers to the theorists and their validating linguistic rules. In the musical world, there was a similar retreat from personal meaning toward systematization. Adorno described the situation: "More was constantly pulled into the vortex of the newly taboo; everywhere artists rejoiced less over the newly won realm of freedom than they immediately sought once again after ostensible yet scarcely adequate order" (Adorno 1997, p. 1).

The "newly taboo" of course reflects the attitude that once something has been accomplished, it becomes taboo to do it again, thereby leading to another round of system-building, again requiring validation. Thus, this search for an ostensible order ("ostensible" in that it was not so much an attempt to understand as it was to demonstrate) became the grail of 20th-century art music, and nowhere was it more obvious nor more baldly pursued than in the field of electronic and, later, computer music. This search is of course still with us; it still is the dominant paradigm for composers as the 21st century begins. It is not the only paradigm, however, as we will see in a moment. Before that, I would like to make one more point about the repercussions of an "objectivizing," pseudo-scientific aesthetic ground.

What Pure Algorithmic Tape Music Gains and What It Loses

The ultimate objectivist "performance" would of course be one in which there was no subject, no human performer, nor even any composer, conveying anything: "pure" music. Perhaps the closest thing we have to this is algorithmically generated tape music. While not the most widely practiced

genre of computer music, it represents an important ideological extreme. In its most literal form, it refers to music that is strictly and entirely generated from an algorithm. The "composer" enters into the production only in selecting the algorithm and initiating the computation. And though that extreme is often moderated in practice by the insertion of an "interactive" compositional approach, as discussed by Vaggione (2001), it still colors the nature and kinds of musical materials and results that one can achieve.

A counterpart to the extreme precision and elaborate formalisms that this genre enables is the tendency for it to become further and further removed from anything anyone else actually wants to endure in concert. It has a tendency to become narrow experiment—experiment that does not advance the state of knowledge, for art does not advance in that sense. Once again, any formalism that can generate a piece without further human intervention is too simplistic a system to stand alone as art.

A slightly less drastic approach is represented by tape music in general. Here it is only the performer, in the traditional sense, that is removed from the production. Of course, one may argue that in this case the composer is the performer, that he or she not only creates the material nature of the piece—the notes, rhythms, textures, timbres, forms, and so forth—but also creates the actual sonic projection of those materials, shaping and interpreting them into the final audible result. Though this genre has a much better success rate than pure algorithmic work, in this case too something important is lost. And that loss seems to me not adequately made up for by the gains in new materials, new timbres, and new modes of listening that are made possible by the electroacoustic technology.

So what is it that is lost in tape music? While both of these approaches ("pure" algorithmic and more flexibly conceived tape music) enable a certain precision and control—both in a given performance and forever on a recording—this very fixity can be seen as a drawback. The very possibility of precision, first of all, can lead to an over-emphasis on precision, a mistaking of precision as an end

rather than as a means to an end as it ought to be. This leads to aesthetic lapses such as complexity without import, a preciousness of detail without a sound substantial result. Second, the fixity of the sounds can lead to a loss of dynamic life. And this is more drastic than the similar case of the recording of Beethoven's Ninth that one listens to over and over. In the latter case, there is always at least the possibility of hearing a different performance, live or recorded, that will shed new light on an old standby recording, enabling one to rehear it and experience it anew. In the case of the electroacoustic work, unless the composer decides to re-enter that world and revise or in some other way re-create it—a surprisingly less frequent occurrence than one finds in, for example, the re-orchestration of acoustic music—the work is fixed in so many of its attributes that it is not possible to provide a significant new interpretation. One could therefore come to consider electroacoustic music as the ultimate "museumification" of musical art.

Although the lack of "human" qualities in a performance of electroacoustic tape music in many cases leads to a concretization of music—a lack of growth and change—it is not necessarily destructive of it as a work of art. Rather, it is simply out of touch with what is needed to rejuvenate art—out of touch with what Adorno described as the quality of being *stimmig*, that is, being coherently harmonious with the needs of the times in which they are created and exist. Even if one accepts the values implicit in this concept of *stimmigkeit*, one need not accept the particular conclusions Adorno drew from it. What Adorno thought was *stimmig* in his time may not be what is *stimmig* in our present time: in fact, it probably is not. However, even if at one time, perhaps the 1950s and 1960s, it was *stimmig* to objectify and formalize, given the then current state of post-war Europe for example, yet I believe that time is now past. It is time to abandon that particular aesthetic goal and find a new one. This is not of course only an aesthetic valuation; it is also a political valuation in that it is directed toward making a change in the way people think about, produce, and experience music.

Similarly, along a slightly different aesthetic front, but also one strongly associated with

Adorno, we no longer need to forcefully sequester the high arts from the popular. Indeed, we need now to "de-museumize"—in a certain sense, to popularize—all of the arts which have in their increasing institutionalization become increasingly isolated from broad constituencies. This does not of course imply a capitulation to the banal and trite mass production values of much popular music. Exactly the opposite! It means to bring the true artistic experiences of richness, uniqueness, and intellectual depth and expression into closer contact with the social realities of our present cultural context. It is important to inject the artist—the composer—back into the current cultural scene rather than reinforcing the current institutionalized isolation. To reject this course will probably only lead to the complete death of art music as we have known it and to the complete hegemony of only the more banal elements of popular culture devoid of any connection to—and therefore any possible benefit from—the enormous accomplishments of the past.

This should not be seen as once again valorizing "newness" as a correlate of "uniqueness." It is not newness itself for its own sake that is being sought, but rather, in this case, bringing into being something new is simply a byproduct of trying to bring about something valuable according to other criteria. As for "uniqueness," each work will be unique, but to focus on that as the primary value degrades too much the other qualities of the art.

In addition to "museumification," there is another problem related to the tendency in computer music toward an excessive formalism—excessive, that is, when it becomes a banal play with abstraction, algorithm, and parameterization without sufficient attention to the resultant sound and its possible significance. Too often an implicit assumption exists that if a formula generated it, and the formula is coherent, then the resultant music is not just coherent but somehow, and usually thereby, aesthetically valuable. The introduction of the human into the performance of computer music through interaction can be taken as one of many ways composers are beginning to distance computer music from the reigning paradigms of formalism and formalistic modes of generation

such as those referred to under the heading of algorithmic composition. Often, this aesthetic paradigm has led to works that go beyond any cognitive bounds—works built to follow a system without understanding the relevance of the result to any human hearer. I alluded to this problem above. Now it should be clear that retaining a strong link to human cognition by maintaining a strong link to human performance can help encourage composers to choose paths that will avoid this too frequent problem. Computer music that includes and must respond to the human limitations of a performer can begin to break down the excessive reliance on formal models. One could, of course, argue that the electronics also work in the other direction and permit further formalization into the domain of gestures themselves, and they could. But it is not my point that the means I advocate lead necessarily to the ends I value and to none other; it is a matter of focus, it is a matter of how much particular ends are facilitated or encouraged, or obfuscated and blocked. The consonance between human interaction and humanist values is an important driving element for the field of interactive computer music.

What the Computer Brings to Human Performance

The preceding has largely looked backwards at connections that can be made between interactive, performance-oriented computer music and older models of music that rely extensively on performer interpretation. But there is another aspect of interactive computer music that has an impact on aesthetics and has not yet been addressed. This is the capability of the computer to become an extension of the performer in a "cyber performance."

First, computers can process a live instrumental sound, as transduced simply by a microphone, and alter its sonic qualities in some way. In this case, the processing can either be fixed, such as a simple reverberator, or can itself be under the control of the same or different performer, such as Max/MSP patches that process the incoming sound in a variety of ways based on pitch, spectrum, or amplitude

tracking. This enables one to use a wide variety of electronically produced timbres while at the same time retaining control of the nuances of performance. At its best, this music can seem like a whole new instrument, yet it does not require the performer to spend many years of practice learning the instrument. The electronics extends the performer's ability based on skills the performer already has.

Second, new sensors can be added to an existing instrument to produce new correlations of physical gesture to the sonic output. For example, Tod Machover's "hyperinstruments" (Machover and Chung 1989) use mainly this model. The Hypercello tracks bow position and pressure, among other things. This works similarly to the simple processing described above; however, it allows for even greater performer control in some sense, because the physical gestures of the performer can be used independently of the sonic output to control different aspects of the sound. To the extent that these gestures or what they control are new to performers, performers must re-train themselves to establish control over the new resultant sounds. For example, if a new violin includes position tracking information (such as in Garnett and Goudeseune 1999) the violinist will have to be aware of the mapping from position to what sound aspects it controls. In such a case, the violinist might have to practice moving in certain prescribed ways to achieve particular effects. If the system is designed carefully, the new gestures, such as changing the violin's position, will not impose an undue cognitive burden on the performer and will allow him or her to retain all their usual control of detail and simply add the new control factor to that.

Third, it is possible to design and build entirely new instruments that communicate directly with a computer. This is the most radical approach and may ultimately lead to the greatest changes. In this case the mapping of the performer's gesture to sonic result can be a part of the design of the instrument or a part of the design of the software, and therefore flexible. One could consider keyboard synthesizers to be in this category, or even more idiosyncratic instruments such as Buchla's Lightning (an infrared baton) or Thunder (a variable touch surface), or Dan Trueman's BoSSA

(Bowed-Sensor-Speaker-Array)—a quasi-violin instrument (Trueman and Cook 1999). One could, under this category, also consider future instruments that might be based on computer implants or other more or less direct connections to the human nervous system. All of these more extensive modifications to the traditional performance paradigms come with potentially more substantial drawbacks: the further one gets from traditional performance models, the more a performer has to relearn or even learn from scratch. This is why I advocate instruments that only gradually extend the performance paradigm. However, it seems obvious that once a performer has decided to specialize and really learn one of these new instrument types, the ability to both extend musical ideas and to extend human performance control to otherwise unattainable gestures will be enormous and unforeseeable. In fact, the possibilities for different kinds of music are endless. Exploring and extending these possibilities has been a prominent activity for technologists in music as elsewhere. It may indeed lead to new musical ideas that may at some point develop their own aesthetics. We can guess about these, but I think it is more important to focus for now on the characteristic I believe is shared by all of them. Because cyber-instruments extend human action and thought there is a tendency to keep that action and thought within human bounds and not project a simple-minded machine aesthetic. With technology generally, there is at least a subtle predilection to think that since this is a machine, it ought to behave as a machine, to do what machines do best. But if the human performer is still actively engaged in the production, there will at least be a countervailing tendency to see the work as having meaning or significance to that human element and therefore to judge it based on that significance. In this sense, it is important that the technology be focused on extending human capability and not simply extending technology for its own sake.

But I think there is something more at stake than just whether or not the technology is the goal or the performance is the goal. What is additionally at stake is the notion of music performance as a shared human endeavor. Recently I attended yet

another concert of electroacoustic music. As is typically done, before the start of each piece the hall was darkened almost to black. Audience members tended to either close their eyes or to stare at the rows of LEDs that light up the mixing console, which, as usual, had a central location in the hall. But in the silence born of a 19th century view of a music concert, the darkness born of a desire to minimize visual distraction or accentuate the lack of performer ("look, Ma, no hands"), coupled with the palpable absence of anyone presenting or communicating the music, the audience became detached, isolated, and emotionally removed from the scene. When was the last time you saw a standing ovation for an electroacoustic work? Even the best works of the genre don't usually elicit that kind of enthusiasm. Furthermore, there is, it seems to me, almost nothing like a sense of the entire audience having been through something together, as having witnessed, experienced, an important event. Personally, I would hate to lose this aspect of a shared cultural community. It may not be a specifically musical value, but nonetheless I believe it is important.

There is one final aspect of interactive computer music that is also important in its aesthetic ramifications, something that can keep it alive, and that makes it so necessary for our times. One cannot turn one's back on the most significant technological breakthrough in history without risking irrelevance to that history. One cannot avoid taking advantage of the ubiquity of this technological marvel because that very ubiquity renders all other technologies in some sense less significant. One must take computers into account, and take them to task, because it is a response to the technology of our time, to the situation of our time. To make music with the technology of our time, and specifically the computer, poses a tremendous challenge for the artist. To address this challenge, in itself, will help keep music alive and significant. To address this challenge in a way that acknowledges, directly and deeply, the human production of that music brings together into a new art form the diverse elements of performance, with its millennia of history, and the age of the computer, with its bare decades of history. Just as opera around 1600

was a response to the reawakening of interest in the philosophy and art of the ancient world, a response favorably disposed toward the growing secularization of the arts and sciences while reacting against the re-confining of expression brought about by the counter-reformation, interactive computer music takes the fullest advantage of the ideas and technologies of today and unites them with a vision of what they could be.

Contemporary music no longer needs to address the nature of the machine as something outside of us mere mortals, projecting its inhuman capabilities as an aesthetic of the machine; rather, it can now seek to integrate technology into our very selves, and to be intimately controlled by ourselves. This is a rather different model of how the human and the machine relate to each other, one that I believe will become more and more significant as the new century progresses. Rather than creating abstract pieces generated from abstract musical systems, rather than leaving the performance to the mechanical playback of a predetermined tape or CD, rather than set up a dichotomy of human versus machine between a live performer attempting to keep up with the machine knowing full well the machine can move more quickly, more loudly, and less bounded by physical or cognitive restraints than any human possibly can—rather than all these, it is now possible to use the machine, the computer or any and all electronic and physical devices, without the dichotomy, to join the mechanical power of the machine to the nuanced and "subjectivizing" control of the human performer. This, ultimately, is itself an aesthetic value for our new age. This ultimately will be the way music will need to move until the next big issues arise. Though it is impossible to say what new aesthetic values may arise in this new situation, yet I believe they will be more closely tied to human value, not less closely. As the computer can amplify human-produced gestures, so too will it be able to amplify human expression.

In summary, one could say it is no longer necessary, or even desirable, to adopt or accept the aesthetic of the machine. We can, and should, choose or invent more human, more "organic," modes of musical behavior. Rather than positing the ma-

chine as an inhuman "other,"—whether as an "other" that we deify as being more precise or more powerful, or whether it is an "other" we demonize as lacking human compassion, morals, and constraints—we can coerce the machine into being an extension of the compositional and performing self. The current youngest generation already accepts the computer as a completely natural tool—the next generation will begin using computer implants. That "next generation" brings to mind the American science-fiction show, *Star Trek: The Next Generation*, wherein a race of aliens, called Borgs, are presented as evil cyborgs bent on assimilating all life-forms into their collective mind—a classic embodiment of the machine as evil. But if we keep focused on human values as we develop our technologies, Star Trek's Borgs will not be aliens, they will be us.

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