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Symposium on Computer Music Composition

Edited by Curtis Roads, with Marc Battier, Clarence Barlow, John Bischoff, Herbert Brün, Joel Chadabe, Conrad Cummings, Giuseppe Englert, David Jaffe, Stephan Kaske, Otto Laske, Jean-Claude Risset, David Rosenboom, Kaija Saariaho, and Horacio Vaggione

Introduction

From the very first research in music composition with computers carried out by Lejaren Hiller and his associates in the mid-1950s, the computer has offered enormous potential to the composer. Computers are among the most malleable tools ever developed by human beings, and in the three decades since that early research, many hundreds of composers have adapted computers to their own musical needs.

Articles in *Computer Music Journal* and other publications[1] point to the broad application of computers in musical tasks, especially to sound synthesis, live performance, and *algorithmic* or *procedural* composition.

This symposium is the product of a questionnaire sent in 1982, 1983, and 1984 to over 30 composers experienced in the computer medium. The questionnaire contained 21 questions. Composers were asked to respond to at least five of them. The composers were also invited to submit scores and other graphics that describe their work. These fourteen composers responded to the challenge:

Clarence Barlow (Cologne, West Germany)
Marc Battier (Paris, France)
John Bischoff (Oakland, California USA)
Herbert Brün (Urbana, Illinois USA)
Joel Chadabe (Albany, New York USA)
Conrad Cummings (Oberlin, Ohio USA)
Giuseppe Englert (Paris, France)
David Jaffe (Stanford, California USA)
Stephan Kaske (Munich, West Germany)
Otto Laske (Boston, Massachusetts USA)
Jean-Claude Risset (Marseille, France)
David Rosenboom (Oakland, California USA)
Kaija Saariaho (Paris, France)
Horacio Vaggione (Paris, France)

At the time of their responses, the composers ranged in age from 22 (Kaske) to 66 (Brün). They live in the USA, France, and Germany, although their countries of origin include Italy, India, Argentina, and Poland, as well.

The views represented here cover a wide spectrum of opinions and attitudes, edited lightly for publication. Because of the way the responses were gathered (by written questionnaire), it is important to consider each reply by itself, that is, not as a response to the previous composer's reply. No composer saw the responses of the other composers. The order of responses was determined by the editor.

What was the most important part of your musical training?

David Jaffe: The most important parts of my traditional education were the practical experience of playing violin and mandolin in both classical and improvisational contexts, conducting, and composing and hearing my music. The music of eastern Europe, particularly Jewish music, which I learned from my father, has had an important influence on my style, as have my many years as a bluegrass musician.

As for my theoretical background, one experience stands out above the rest. At Bennington College, I had the opportunity of witnessing and participating in the spatial and orchestrational experiments set up by Henry Brant. The spatial and orchestrational planning that has gone into my recent computer music pieces can be traced back to this training.

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1. See Curtis Roads, ed., 1985, *Composers and the Computer*, published by William Kaufmann, Inc. (Los Altos, California) for articles on nine prominent composers.

Herbert Brün: Listening to music in concerts and on records in the company of friends.
Jean-Claude Risset: I consider my piano studies as the most crucial part of my traditional music training. This may look paradoxical for a composer, especially one who seldom uses real-time computer facilities. I shall explain why.

The first reason is personal. I had a remarkable piano teacher, Robert Trimaille, who demanded and obtained very much from his piano students. Without the intense musical experience and the secure feeling of professionalism I received through his training, I am not sure I would have dared to venture into the profession of music. Also, working on the piano repertory was a thorough and active introduction to a large body of music. To be revived in performance, works have to be studied both in their details and their overall form. A great deal of musicianship is demanded of the teacher here. Robert Trimaille and Huguette Goullon were admirable guides to me.

Having to realize the pieces in sound—with ten fingers—implies deep learning (in both head and body) about phrasing, contrast, and the use of registers. One has to steer the sound, to understand the correlates of musicality in performance, to realize illusions such as playing legato on a piano. Such knowhow is invaluable training for the realization of pieces through computer synthesis, where all these aspects must be handled by the composer.

But I must also mention that studying composition was very enlightening, especially orchestration with André Jolivet, who had a deep feeling for the idiosyncracies of the instruments. Studying harmony and counterpoint is very useful to gain a thorough understanding of western tonal music, while offering the opportunity to try one's hand in a domain with explicit rules and criteria. Of course, these criteria correspond to styles of the past, and it is debatable whether the study of harmony and counterpoint is a must for the composer of today. It does seem worth studying at least one established musical language or system.

What was the least important part of your traditional musical training?

Herbert Brün: The universally accepted, academically perpetuated, consumer-oriented routine of accepting the *consequences* of composition as if they were the *properties* of the composed music. I had, alas, to suffer it, but I did not ever believe in it.

What was your most important educational experience?

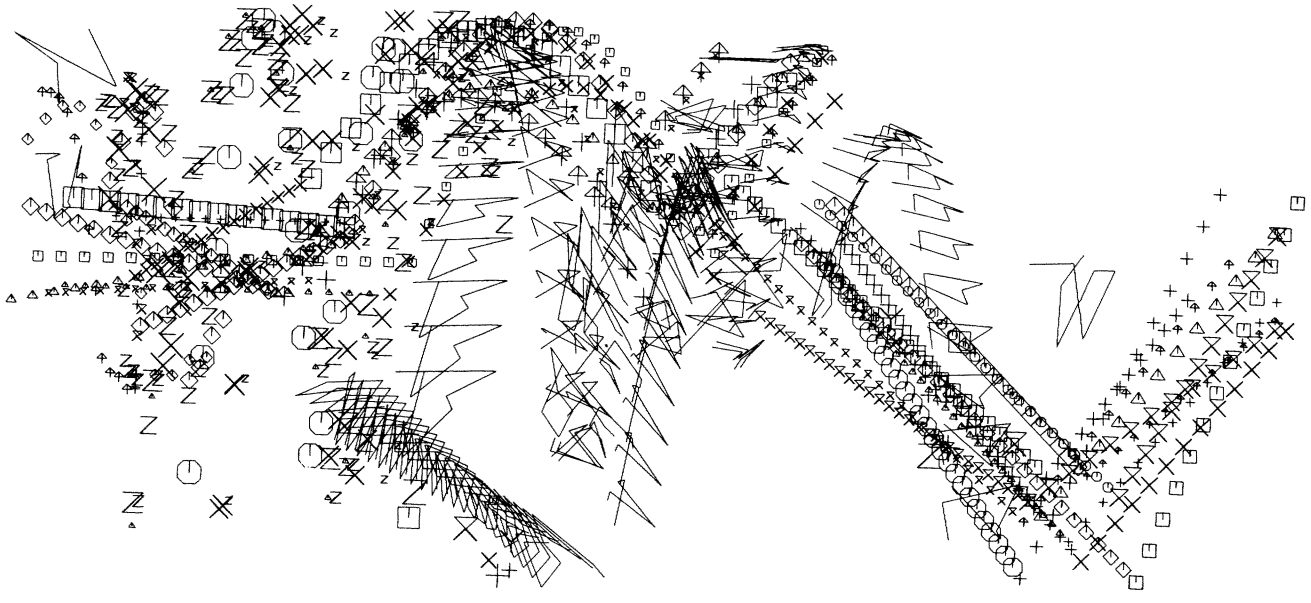
Marc Battier: My most important educational experience was the first computer music class in the music department at the University of Paris VIII, Vincennes. The class, taught by Patrick Greussay, was mostly directed toward artificial intelligence techniques in music, using languages such as Lisp.

Before you worked with computers, what was your main compositional medium?

Marc Battier: I had the chance to study computer music early in my student days, back in 1969. Before that, however, I had intensive experience in the practice of traditional tape music, mostly *musique concrète*. Aside from working with computers, I have continued this electroacoustic activity. These days, I consider the two media as integrated with one another.
Herbert Brün: Instruments in chamber ensembles.
David Jaffe: Before working with computers I wrote for a wide variety of instrumental ensembles. I continue to write instrumental music along with my computer music. I prefer writing for large groups. However, since performance commitments from large ensembles are difficult to procure, much of my music has of necessity been for chamber ensembles. I find that the two media—computer music and instrumental/vocal music—complement each other. Instrumental music continually reminds one of the depth and richness of expression that is possible with real instruments played by skilled performers. Computer music allows expression of compositional ideas that would be difficult to realize with performers.

I have mixed feelings about the combination of live performers and computer sound. I have written

Fig. 1. Herbert Brün's Mutatis Mutandis 33, *composition for interpreters, with ink graphics drawn by a plotter under control of a computer programmed by the composer.*



for such combinations, as in my piece *May All Your Children Be Acrobats*, in which eight guitars, a soprano voice, and stereo computer sound are combined. However, one factor plagues all attempts at combining computer sound with traditional instruments: the discrepancy between the projection of an unamplified instrument and of a loudspeaker is so pronounced that the two seem in completely different worlds. Many composers have handled this problem by amplifying the instruments. I consider this solution inadequate because it is, in effect, lowering the instruments to the level of the speaker. I believe Edgard Varèse may have had the right idea in his composition *Déserts*, in which he avoids ever combining the taped and live sounds.

Why have you turned to the computer?

Clarence Barlow: In 1971 I attempted to realize a five-minute stochastic piece using an adding machine and random number tables. Six months would have been necessary but for my sudden idea of employing a computer. Within a week of my first Fortran lesson, I had the piece.

John Bischoff: The power of the computer to carry out procedures and its general lack of innate musicality allow a composer to add structure from the ground up in making an instrument. Therefore, the composer has a chance to experience more clearly the operation of those structures. For example, Jim Horton in Berkeley, California has developed numerous melody-generating systems that he and others have listened to extensively over the past five years. One can almost hear melodic spinning wheels turning in these programs. They do not just simulate a broadly recognizable musicality (a sequencer does this instantly), but rather they try to build an original musical entity from the bottom up. This is unique to music by computers.

Otto Laske: I turned to the computer because of an inner necessity in my compositional thinking, expecting to find new planning resources. There was also an outer necessity of having my ideas realized. Actually I turned to computers before I had access to one, on account of the kind of precompositional work I was doing. I was always highly dissatisfied with "writing music from left to right," a procedure that seemed to restrict my intuition to lower-level processes since it was predominantly bottom-up. In short, the computer permitted me to explore high-level planning as well as bottom-up (event-driven) elaboration of musical structure. Unfortunately, the majority of programmed tools in existence today are

not sophisticated enough to support a fully interactive way of working on all compositional levels.

Joel Chadabe: Long ago I wrote instrumental and vocal music, mostly chamber music. Then I worked with analog electronic system. In about 1975 I started working with computers because my interests at that time, as now, lie in performance with electronic systems. Computers have the significant advantage of exact repeatability from performance to performance, and the setup time, because they do not require patching or tuning, is short.

The main reason I like to work with computers when composing is that I can compose while in the presence of sound, and, in my case, in the presence of the functioning system. Since my compositions are functioning systems that operate with performer interaction, I begin with a crude model of the finished system, something like a first draft of its operations as well as the sounds it makes, and then I refine it until it's ready. If I had to work with a non-real-time computer system, I am not sure I would want to use it. My primary motivation in composing is to be able to experiment with sound and musical process, and the quick response of a real-time system is a prerequisite to successful and enjoyable experimentation.

Herbert Brün: I had been waiting for it. I turned composer of music only after I barely surfaced from the helpless depression of a haunted victim in 1942. All my music attempts to reflect, by analogy, social configurations and relations that I prefer to those I see. Soon, however, I discovered that my analogies kept referring to a "not yet reality" that could only be reached if it were true that *people have to change* so that "our society as is" could function better. While not denying the potential of that vision, I dislike it, because it would support fascism and totalitarianism. It is thus under the rigorous dialectics of a pregnant contradiction that I continue writing for instruments. At last the computer enables me to begin experimenting with compositions that by analogy point to social processes where it is *the structure that changes* in order to preserve the variety of human temperament by guaranteeing the possibility of every human being's contentedness.

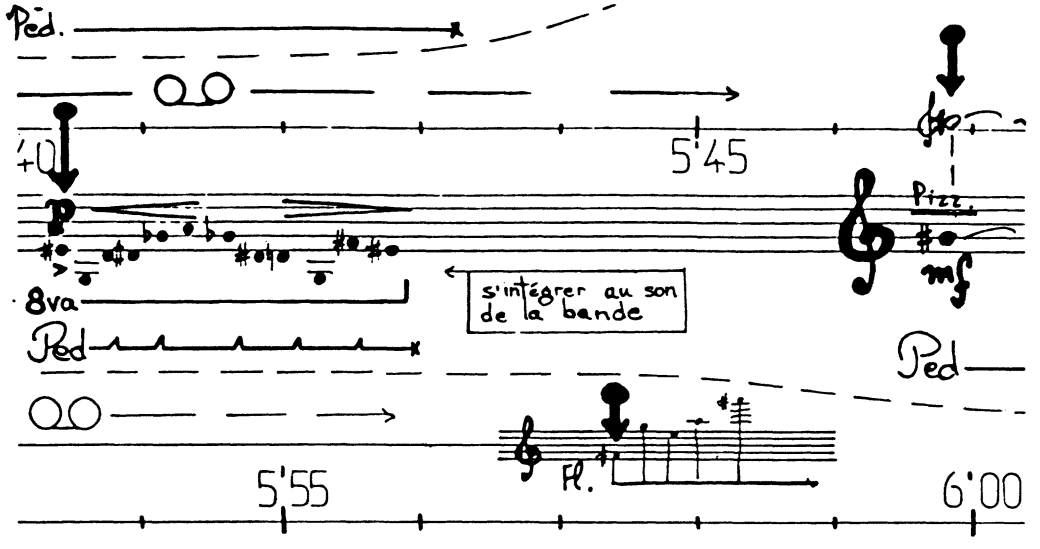
Kaija Saariaho: I had gradually started to work in my compositions with independent processes associated with different musical parameters. I became increasingly interested in the nature of "process" as well as timbre as a musical parameter. In computers I saw a means of entering inside sound concretely in order to control timbre, and finding a vocabulary for describing the different factors that comprise musical color. It was also a means of continuing my research on musical processes in an especially suitable environment.

Stephan Kaske: The reason I thought it would be necessary to use computers in my music was my despair about a composition for chamber ensemble. It became impossible to survey all the structural lines or developments of the composition. I needed a helping hand that could keep the structural organization under my control. I realized that a computer program could do the job for me, so I wrote a very inefficient Pascal program on an Apple II computer. Then I wanted to improve my computer music programming knowledge, so I attended a course at M.I.T. My compositional problem was not solved there either, but with digital sound synthesis I was seduced to think about an aspect of music that I had tended to underestimate until then: timbre. Unfortunately, the composition for chamber ensemble was never completed.

Jean-Claude Risset: I always had a certain vivid interest in timbre. I was intrigued by the potential of certain timbres to best express certain musical virtualities. I enjoyed composing for traditional instruments—and still do—but I was disappointed by [analog] electronic music. I felt it opened a wide sonic field, but it did not seem to me to offer enough control to composers, who had to, to some extent, rely on ready-made objects or processes.

I was fortunate to work with Max Mathews on developing the musical use of the computer in 1964–65 and 1967–69. Although it was not easy to explore the possibilities of computer synthesis of sound, this exploration was rewarding because everything could be capitalized upon and replicated. The computer provided refined control over sound. It also helped in the application of compositional processes to sound structure. This was the answer to my more or less conscious urge to compose the

Fig. 2. Excerpt from Jean-Claude Risset's Dialogues *(1975) for instruments and computer-generated tape.*



sounds and give a functional role to timbre. To state it more explicitly, these are the projects I wanted to tackle with the computer:

- Experiment with the design of my own constraints, instead of having to come to terms with instrumental or electronic constraints
- Assemble a personal palette of lively sounds, endowed with some characteristic of identity, but also very ductile—thus susceptible to intimate transformations that preserve certain characteristics and alter others (e.g., the inharmonic tones in my piece *Inharmonique*)
- Create a flexible sonic world that could diverge from the instrumental world but also merge with it in subtle ways (I tried this in my pieces *Dialogues*, *Mirages*, *Profils*, *Passages*, and *L'Autre Face*)
- Suggest an illusory world, as John Chowning demonstrated so convincingly, by playing directly, so to speak, on perceptual mechanisms, thus unveiling perceptual "primitives" (cf. the decomposition of pitch and rhythm in my pieces *The Little Boy*, *Mutations*, and *Moments Newtoniens*)

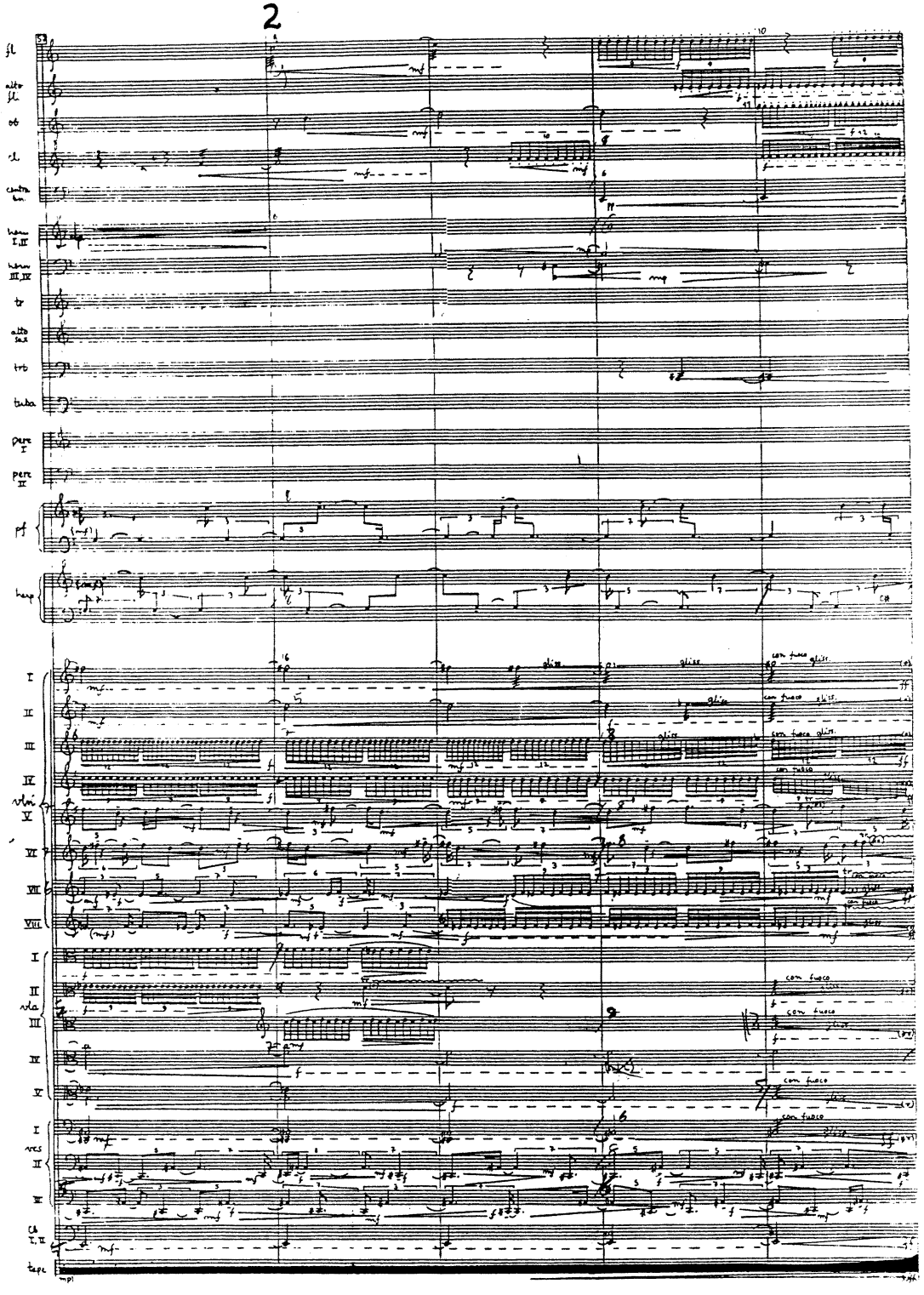
David Jaffe: I would not say I "turned" to the computer since I continue to write instrumental music. However, it can be said that I "turned away" from analog electronic music. I had done work with analog electronics (an old Moog synthesizer) and had been frustrated by the lack of precise control over both the individual sounds and the progression of sounds.

I was first introduced to computer music by Joel Chadabe. Computers provide the potential to make any sound. Thus, they must be able to produce that subset of those sounds that can be called "vital" and "expressive." Realizing this potential is another matter entirely. Generally speaking, it is quite difficult to synthesize electronic sounds that rival the sounds of nature in complexity and interest. The more I work with computers, the more I have come to appreciate the richness of acoustic instrument sounds as well as the subtlety of phrasing and tone production imparted to those sounds by gifted players.

Is composing computer music significantly different from composing traditional vocal or instrumental music?

Kaija Saariaho: Generally speaking, the computer is a tool for working out ideas, like a pencil. In any

Fig. 3. Page 10 from Kaija Saariaho's Verblendungen *(1984) for 35 instruments and tape.*



case, the conditions under which people have to work with computers differ from the demands of composers with traditional instruments. For example, the use of time is completely different when you are composing intensively with paper and pencil, when you are dependent on your own motor facilities, than when you are using a slow timeshared computer system, in which the computer rules your time. Under these conditions, composers can very easily lose contact with their original inspiration in the jungle of algorithms and bugs.

On the other hand, computers widen the working field and open up possibilities for contact with musical material that can be more concrete and inspiring than ever. Compare work with timbre using computers and using an orchestra. With computers, composers can enter into the sound. Colors can be built from the inside of a sound, and one can test mixings and change things very freely. When writing experimental instrumentations for symphony orchestra, the composer is very happy if the first performance just interprets the original idea. The time span between the moment of composition and the performance (final listening) is at best several months. It is also much more difficult to maintain a searching mind within the confines of the orchestra as an institution and traditional music circles in general than it is in computer music studios, where a curious and open attitude is a basic requirement.

My work with computers includes much more planning than my work with instrumental music. The search for material takes a much longer time, since I try to understand the possibilities that the computer offers and find musical ideas that are idiomatic to this medium. My awareness of different musical parameters has grown as well, since aspects of performance and interpretation must be included in the work, if living music is desired. Here I have noticed that the final mixing process replaces the interpretation of instrumentalists. Hence, I should have the same objective as they, namely an analytical yet sensitive approach to my material.

Conrad Cummings: It doesn't sound different. The environment where composition goes on is different but there is also a difference between working in your notebook on a camping trip and pounding it out on a piano back in your studio. Do we gain anything by thinking of it as different? We only impoverish our sense of connectness to the rest of music making.

Giuseppe Englert: The specific exegencies of the computer to the composer/programmer are: (1) in the case of loudspeaker music—the knowledge of acoustical phenomena and their mechanism that has to be created and (2) in the case of instrumental/vocal music [composed using a computer]—the knowledge of what has to be *formalized* with respect to *interpretation* by the performer.

What have the practitioners of computer music learned from the practitioners of past electroacoustic (electronic, musique concrète) music?

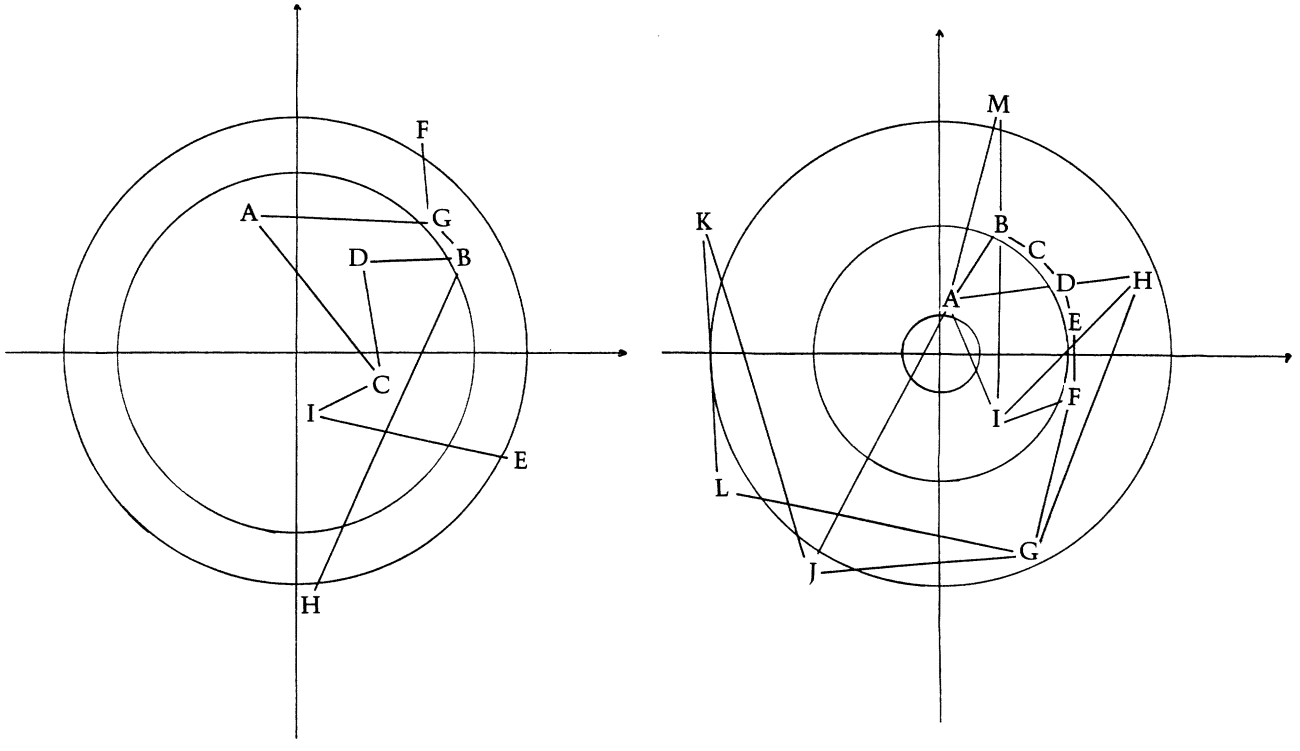
Jean-Claude Risset: Not enough. I am thinking in particular of the knowhow of *musique concrète* concerning sound classification and transformation, textures, contrast, and sound distribution via loudspeakers.

Herbert Brün: Here I speak for myself only: (a) a waveform is a sometime thing, (b) durations of sound phenomena are of supreme importance, (c) any steady state is a risk, and (d) parallel motions of different parameters or components or attributes may easily turn musical events back into acoustical events.

John Bischoff: We have learned at least three things: (a) that musical sounds can be found in the unforeseen operating margins of a system; (b) that the imperfections of an electronic instrument may musically parallel the involuntary noises of an acoustic instrument, and therefore will add to the music rather than detract from it; and (c) that a fruitful approach to a new technology is to search for the qualities inherent in the technology itself. These qualities will emerge and gain meaning apart from any likeness to past musical conventions.

Horacio Vaggione: Electroacoustic music (including concrète and electronic music) has opened up a vast area of sound discoveries by means of direct manipulation of tape. These discoveries were inaccessible and even unsuspected in the framework of tradi-

Fig. 4. "These figures show the position of each sound (symbolized by a letter) in a timbral space defined by two coordinates: a vertical axis for spectral energy and a horizontal axis for onset attack. A system of circular coordinates has been superimposed to order the transitions that take place between the timbres." From Fractal *(1983) by Horacio Vaggione.*

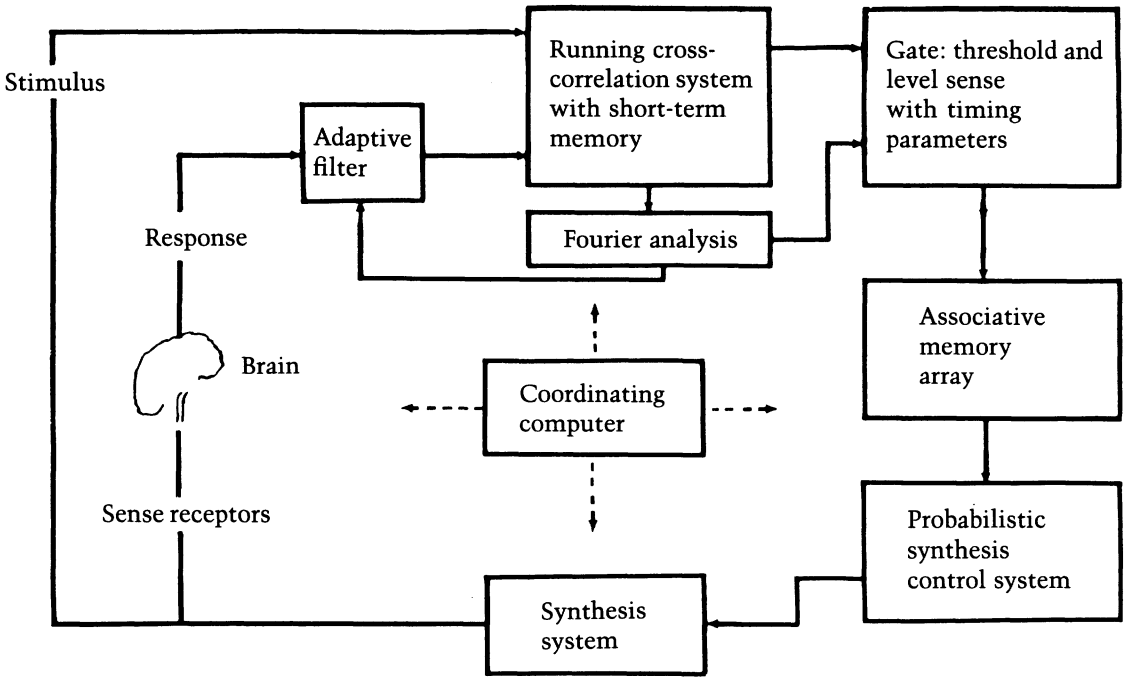


tional instrumental music. The analog voltage-controlled techniques of the 1960s enlarged the possibilities of classic electronic studios by permitting the definition of time-variant functions and by multiplying the means of access to analog modules. Toward the end of the 1950s, however, Max Mathews began to develop digital sound synthesis. With the exponential growth of computer technology, one was able to go further and further into the possibilities of composing sounds on the micro level. Today, practically all sound manipulations relevant to electroacoustics are possible with digital means. It is even possible to transform concrète sounds through analog-to-digital conversion and to do this more thoroughly (through spectral analysis) than any analog technique could do. This being the case, the most serious electroacoustic studios are now in the process of acquiring digital technology. One should not speak of a "break" between electroacoustic and computer music, but of continual growth of a generalized "loudspeaker art" in which various techniques are bridged so as to make the current technological environment of composition extremely flexible.

As examples of current development in this area, one could cite "intelligent audio editors" as well as the advent of digital modules that will quickly replace purely analog generating and sound-processing devices in studios and on stage. However, what urgently remains to be done to improve the effectiveness of the composing environment is to attack the problem of the loudspeaker itself. Loudspeakers remain far behind in their ability to produce audibly the timbral subtleties elaborated by other elements in the audio processing chain.

Marc Battier: Since electroacoustic music was mostly good at processing sounds and has developed many techniques for this purpose, computer music has incorporated these tools. What electroacoustic music gains is a flexibility unheard of before, the ability to create sound-processing systems impossible to build with analog means. I am currently

Fig. 5. Block diagram of the system used to realize On Being Invisible *by David Rosenboom.*



working with banks of filters, up to 40 bandpass filters and banks of transposition devices (like Harmonizers[2]) of several dozens of units, not to mention banks of several hundred oscillators (not only playing stored waveforms but also processing natural sound). This accumulation of resources brings new ideas into the practice of electroacoustic music.

How has your method of working changed since you began using computers?

Herbert Brün: My method of working with instruments has not changed. There I continue to be the structure who stipulates the system whose changes of state I compose. I have, however, added a method of working with computers. Here I compose the structure which generates the system whose changes of state it composes.

2. A Harmonizer is a commercially available device that can perform time-rate changing—shifting the frequency of a signal up or down without changing its duration.—Ed.

Clarence Barlow: I am able to allow myself to envisage more elaborate algorithmic compositional structures than formerly (provided the musical context demands these).

Is any scientific branch (e.g., acoustics, psychoacoustics) relevant to your current compositional concerns?

Marc Battier: I find many answers in the psychoacoustics domain, as well as unexpected and exciting questions. We have both acousticians and psychoacousticians at IRCAM. The link with musicians is stronger with the latter, and several musical pieces have been written after psychoacoustic experiments have been carried out (for example, timbral studies and studies of spectral fusion). We know that the computer can play any sound, only we don't know how to describe them to the computer. Cooperation between musicians and acousticians is of the utmost importance in this activity. I am working on a piece that makes use of data from

spectral transposition and fusion studies, for tape and brass quintet.

Herbert Brün: Acoustics, cybernetics, economics, linguistics, information theory, some mathematics, and aesthetics are all relevant to my current work.

Joel Chadabe: In the recent past, system theory has been a great interest of mine, indeed a necessary interest in developing the concepts of interactive composing. At this point, artificial intelligence is of great interest to me, particularly as a route to developing more interesting musician/machine interactions.

David Rosenboom: Yes, especially psychoacoustics, information processing in the brain and nervous system, perception, cognitive modeling, mechanisms of attention and states of consciousness, physiological aspects of performance and musical proprioception, experimental aesthetics, and the application of the methods of psychobiology to aesthetic experience—these are all very important to my work.

Jean-Claude Risset: The field of psychoacoustics (relating to the physical structure of sound and its aural effect) is relevant to computer synthesis of sound in general. It affects my compositional thinking in several ways. For instance, I am interested in devising sonic structures so as to be able to bias perception to organize them in one way or another, both in the simultaneous and successive case, depending on the fine adjustment of certain parameters. For example, one might adjust the parameters to favor analytic perception—analyzing and segregating, or synthetic perception—grouping and clustering. This relates to a branch of psychoacoustics explored by Bregman, Warren, Wessel, McNabb, Chowning, and McAdams. I am also interested in the issue of categorical perception. Are established categories necessary to differentiation? If so, how can one teach (or learn) new categories? These are vital questions if one wants to develop music by structuring aspects of timbre. I also use the computer to set up illusory situations in my compositions, as I did in the endless progression of "hot-fudge sundaes" of pitch and rhythm—a branch explored by Shepard, Deutsch, Chowning, and myself. I also want to use physical models that are unexploited in sound. For example, "phasing" with oscillators playing very close frequencies is a direct transposition of multiple-ray interference in the Fabry-Perot interferometer.

Clarence Barlow: The sciences of acoustics and psychoacoustics are valuable to me for increasing the audible relevance of a composition (like a knowledge of good orchestration). I also often have to resort to algebra and other branches of mathematics in order to optimize (or indeed realize) my compositional processes. I am also interested in phonetics and linguistics.

Is any aspect of contemporary music theory relevant to your work?

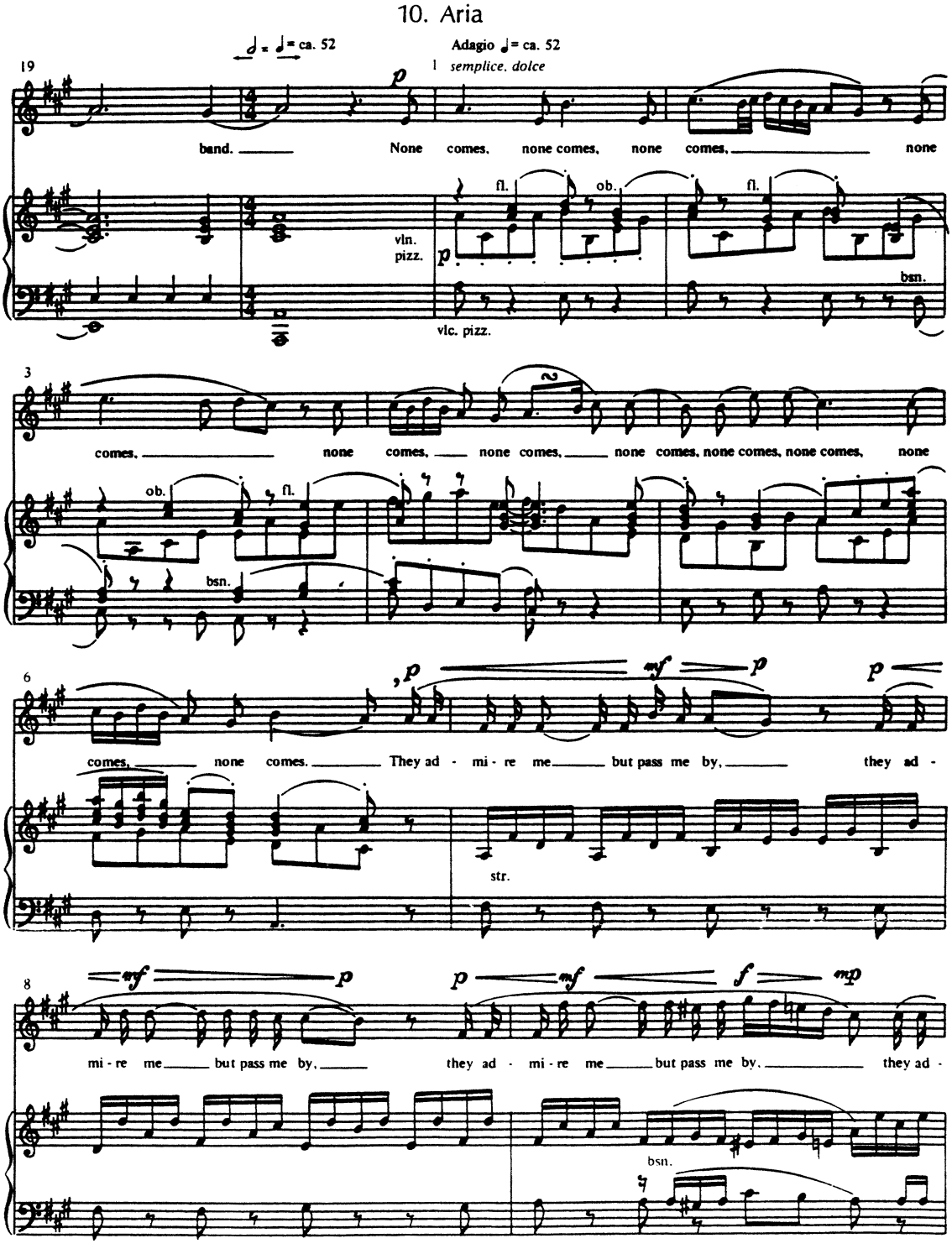
Herbert Brün: Every one.

Marc Battier: Yes. Empirical research on new techniques of playing traditional music is useful to me in sound synthesis, as well as the electroacoustic treatment of sound. The vocabulary of describing sound (enhanced by Xenakis, Boulez, and others) is important in dealing with the new possibilities in the creation and articulation of musical material.

David Rosenboom: I am especially interested in those aspects of contemporary music theory that attempt to achieve broad descriptive and analytical power when applied to the "music of the whole earth." By this I mean theories of music that are stylistically nonspecific. These tend to emphasize the scientific study of music from the point of view of perception and what might be termed aesthetic information processing. I am particularly interested in the work of theorists like James Tenney on temporal gestalt perception, David Wessel and John Grey on timbre, Diana Deutsch on musical perception, D. E. Berlyne and Paul Vitz on experimental aesthetics, Manfred Clynes on morphological contour elements in expressive action, and numerous others I cannot list here.

Otto Laske: I believe every composer is by necessity also a "music theorist," but for the composer this theorizing is highly procedural. Since traditional (including twentieth-century) music theory has been so consistently declarative, it has rarely addressed itself to problems of real music. What happens when a primarily declarative theory is

Fig. 6. Opening of Psyche's Act I, Scene 2 aria in Conrad Cummings's opera Eros and Psyche, *for vocalists, orchestra, and computer sound.*



turned into a procedure is shown by the so-called Princeton School of the 1960s.

The aspect of American music theory that is relevant to my work is strictly methodological—it is the insistence on explicitness. However, in a procedural approach to theory (as I have pursued it since 1970), *explicit* means *programmed*. And what can be programmed are procedures, not mere databases (except where they are part of a knowledge base). In brief, there are aspects of (American) music theory that are of methodological interest. Unfortunately, its protagonists are a little too afraid of their own courage and thus restrict the application of their methodology to safe topics, such as "good old" pitch classes.

How does computer music relate to the musical tradition? Is it a continuum or is it a turning point?

Conrad Cummings: I hope the scientific mystique of Modernism is passing in music as it has already passed in architecture and the visual arts. The premise that music must be reinvented, free of its hindrance from the past, challenging its listeners to enter a new and unprecedented world—I well remember how exciting that was. Central to its implementation was the notion that art must look to science. Computer music came of age at the very end of this premise's hegemony, in the early 1960s. Like an incredible amphibian, it's been left on dry ground as Modernism crested and receded. We're all out here on the sand, finding a new life in an environment very different from the one that spawned us—and we're surviving splendidly!

Modernism has no use for the vernacular. What a surprise that Modernism's child—computer music—thumbs its nose at distinctions between high art and popular art. Digital synthesis meets *Star Wars* and reaches millions!

No, computer music itself is not a turning point. It is the late product of one era launched into and thriving in another. It's the knee joint. No better place to see Modern becoming Post-modern.

Clarence Barlow: I do not think that computer music exists as a separate aesthetic entity. If you mean digital electronic music, this is just a new subset of electronic music. (Now *that* was new!) Structural composition existed long before the advent of computers. In short, the computer enables us to do what we did before but much more efficiently, as does the printing press.

John Bischoff: Applying computer technology to music is bound to generate a new branch on the tree of musical traditions. It seems likely that computers can aid us in creating new notions of what it means to be musical. On the other hand, certain ideas absorbed from recent experimental music practices are relevant to working with computers. John Cage's insights in regard to control in music seem particularly helpful. The League of Automatic Music Composers, of which I am a member, makes music that is startlingly original yet its organizational structure is nonhierarchical and cooperative. The group is organized as a network of microcomputers running simultaneous and independent music programs. These programs continually exchange information along various paths. The rich and unforeseen music that often arises from such a situation deepens one's trust in democratic musical arrangements.

Joel Chadabe: For many composers, computer music seems to be an extension of the tradition, with the computer used as a surrogate performer. For me, however, it makes possible a technique that I call *interactive composing*, that I consider a significantly new and rewarding way of working. [See *Computer Music Journal* 8(1):22–27, 1984.]

Stephan Kaske: Computer music is both a turning point and a continuation. On the one hand it is a logical succession of a musical tradition that searched for more precise control of compositional structure and timbre, and that tried to introduce noninstrumental sounds into music. On the other hand, certain streams of contemporary musical thought lead to the automation of musical process. This will be a turning point, even if traces of automated composition can be found in music history, since the composer will have to say goodbye to the myth that creation is identical with the creator. The composer's way of thinking will presumably change dramatically.

Jean-Claude Risset: A priori, computer music does not have to relate to musical tradition. The com-

puter is seemingly neutral, although some things are easier to do than others. But tradition has great weight in music, where one deals with the fuzzy norms of collective expression. Tradition is heavily present in the *Weltanschaung* of everyone, including the composer—through the composer's training—and in the skills and habits of performers. It is present in the "history," the "mindset" of the listener, who categorizes and discriminates (or does not discriminate). The listener's mindset is especially present in the perception of pitch and timbre, where discrimination can be severely impaired by excessive reference to previously established categories.

Yet I believe that computer music (at least in some of its many trends) is indeed a turning point. It helps escape some traditional constraints, especially the constraints of mechanical systems for the production of sound. It also offers new ways of dealing with inescapable tradition. Other aspects of computer music can be regressive, as I point out in my answers to some of the other questions.

Giuseppe Englert: Computer music, to mark a turning point in musical tradition, has to satisfy two conditions: (1) the musical concept of a piece requires the use of a computer and (2) this necessity is perceivable to the listener. We have already witnessed two events that have shaken tradition: the appearance of electricity and electronics—loudspeaker music, and the introduction of new compositional categories, like indeterminacy, randomness, and probabilities. These two "revolutions" have deeply affected musical life, and have partially masked the influence of computers on musical thinking. The presence of computers is not completely accepted on the musical scene. For a long time, it had to be justified by the imitation of tradition. The "turning point" is, for most people, not really visible yet, but it will be.

David Rosenboom: I believe that the introduction of computers to the world of music has changed and will change nothing that is fundamental to music as an art form. What changes music is ideas, not tools. It is true that the computer has provided us with marvelous tools for thought development and has opened up a vast new sound palette for our exploitation. It will aid us in our growth and evolution in extremely important ways. The great Greek thinkers from the island of Samos did not have computers made of silicon. They did, no doubt, manipulate symbols by whatever means were at their disposal and the computer is, let us not forget, primarily a manipulator of symbols. It is the rest of electronic and electromechanical technology that translates these symbols into some physical manifestation.

It has been said that Galileo changed astronomy through the development of the telescope. He must, however, have had an idea of what to do with it and he basically demonstrated the truth of Copernican theory, created previously without telescopes. One is reminded again of Einstein's simple requirements, merely for pencil and paper. The Futurists expanded our musical awareness to include the realm of noise, and Cage helped us to understand silence. Neither required the development of computers. Computers have helped to expand humanity's reach. It is up to human beings alone to expand their minds.

What new musical concerns have been introduced through your work with computers?

Horacio Vaggione: I am interested in generating *timbral polyphonies*: complex events produced by many simultaneous sound sources. In my work, algorithms for sound synthesis create groups or families of sound files that are digitally mixed so as to produce complex textures, fused timbral entities, stream segregation processes, or large constellations of tiny fragments of sound materials. Each sound synthesis algorithm contains instructions for executing micrological procedures. For example, an algorithm can control the degree of fusion or of spectral parsing. It can control the speed of transformation of various sound parameters, or it can control the interpolation or exchange of values between several groups of parameters. In this way of working, the composition begins on the microspectral level. Once a network of sound sources is determined, one proceeds to define *logical models of interaction* between the sources. This is one of the most interesting aspects of computer composition:

the creation by programming of specific and highly differentiated fields of relationships. These relationships can be based on any kind of model: statistical, ergodic processes, arbitrary, psychoacoustic principles, etc.

Herbert Brün: After the "mixtures" of timbres of instruments and the "composition" of timbres in the electronic music studios, the computer now invites "transformations" of timbres. Not the concern is new, but its practical significance: in addition to changes of timbre we can now almost compose the timbre of changes and the timbre of change.

David Rosenboom: Two areas of my work with computers have opened up significant musical concerns, at least for me. The first involves the use of algorithmic compositional techniques in real time, live performance. The second involves extended musical interface with the human nervous system.

Since my earliest work with computers I have been concerned with real-time algorithmic composition. The great speed with which even early computers could execute instructions was an object of great awe and inspiration. My interest in electronic music, beginning in the 1960s, has always emphasized live performance. During my student days, access to electronic music facilities was limited to the "classical" studio. Modular, voltage-controlled synthesizers were on the horizon but were not yet widely available. I did, however, have the good fortune to come in contact with the work of Lejaren Hiller at the University of Illinois.

This led me to an expansion of the notion of performance and improvisation to include what normally would be called compositional or "pre-compositional" activities. To be able to animate compositional processes at will, as an option available instantly to the performing musician, seemed simply fantastic. To be sure, disciplined improvisation involves the animation of compositional processes in the performer's mind and even in the collective mind of the performing group. Adding this new kind of process to the possibilities already available, however, was very exciting. Moreover, with suitable inputs, these processes could be made to react to the activities of the performer, which might change from performance to performance, or to the internal workings of a performing group.

Much of my subsequent work was devoted to the realization of this goal. Though many of the early experiments were beautiful examples of artistic manifestation, we are only now reaching the point in the development of intelligent instruments that allows the realization of a significant portion of that early vision. There is still much to do, but the results are encouraging and the vision is still intact.

The second area I mentioned previously, namely, extended musical interfaces to the human nervous system, is certainly related to real-time algorithmic composition. It could really be considered a subcategory, one in which the input structures include the intelligent processing of electrical signals recorded from the brain or other parts of the nervous system.

Charles Ives said earlier in this century that someday music would be made by direct connection to the human brain. In 1927, the physiologist E. D. Adrian reported on the effects of listening to the audible manifestation of brain rhythms we came to call alpha waves. In 1965, Alvin Lucier took the next step by creating his *Music for Solo Performer* using alpha waves. Since that time, many composers, kinetic artists, sculptors, performance artists, and others have explored the world of bioelectronic signals.

These signals have been the subject of my research since 1968, and have, of course, revealed an enormously rich and complex coding of human activities. Perhaps my most complex work in this area is *On Being Invisible*. In it a feedback loop is created wherein the performer and the performer's nervous system become like complex circuit elements in a large system. Sometimes they play the role of initiator of actions, sometimes they play a more passive processing role in a system with a life of its own.

In a performance of *On Being Invisible* a computer begins by generating sound, either by means of a stochastically controlled music program or a stored, preprogrammed composition. Also inside the computer is a model of perception. All the computer's sonic output is analyzed according to this model of perception, which attempts to make predictions about the structural significance of the sonic events as they will be perceived by the lis-

tener. Additionally, the computer records and analyzes transient brain signal events, known as *event-related potentials* (ERPs) and coherent waves (alpha, beta, delta, theta, etc.). Recent research has indicated that peaks contained in the ERP waveform and their trends of growth and decay are significantly correlated with the salience of the stimulus to the subject, as well as to other psychological parameters. Analysis of the coherent waves provides a context for the interpretation of these events. The computer attempts to obtain confirming or nonconfirming information from these brain signals as to its own predictions of the perceived structural significance of given sonic events.

In one mode of performance, a confirmation results in an increase in the probability that the kind of sonic changes associated with the confirmation will occur again. A nonconfirmation results in a decrease in probability of such an event.

The sonic events are dealt with on several hierarchically related levels of musical structure (reminiscent of the hierarchical *Meta Hodos* systems described by James Tenney). Changes in the sound parameters (pitch, loudness, timbre, etc.) occur according to contextually sensitive weighting schemes that take into account the recent history of the parameter, its rate of change, and other factors. Since many of the relevant brain signals are significantly affected by the performer's shifts of attention, this work has been described by Larry Polansky as "an attention-dependent sonic environment."

Stephan Kaske: I have been fascinated by the control of timbre one has with digital techniques, and this has extended into my instrumental works as well. But the more I work with computers, I realize that my actual way of thinking compositionally hasn't changed much. I still spend a great deal of time figuring out musical structure without a computer, in particular the temporal organization of a piece.

Programmed music that doesn't use a huge database or knowledge base typically results in rather boring compositions, since the overall organization is very linear. That's partly because the user interface of many computer music systems forces one to punch in all those little notes and numbers—sound events—one after the other, be it with Cmusic, Music V, or Music 11. Only if there was an intelligent computer music system that enabled me to work out structural ideas interactively, would new concerns be introduced into my music.

Traditionally, computer music synthesis has been a relatively difficult task for anything beyond the simplest of effects. New digital instruments make synthesis much easier than it has been. Do you feel this will have a positive or a negative effect on the musical scene?

John Bischoff: This question brings up some common computer music assumptions: (1) computer music should be primarily concerned with timbre (an idea that stems largely from European serial music); (2) given an interest in timbre, one would necessarily turn to digital synthesis techniques. Will the greater availability of digital synthesis be positive or negative? Who can tell? Any musical feature that is made dominant and effortless by a new technological advance is the first thing one should reevaluate.

Herbert Brün: It will have a positive effect on the musical scene. The more people can do what they want to do, the more dignified becomes the critical discussion of what they did.

Jean-Claude Risset: Certainly making computer music has, in the past, been a difficult task, and it still is. However, there is always a risk in making tools "easier," that of limiting their power and making them stereotyped. It is a difficult challenge to design digital instruments that are easy to use yet which preserve the diversity of possibilities inherent in the computer. Many digital synthesizers are difficult to reconfigure, and they provide a limited palette of sonic possibilities that is hard to escape—hence, sonic clichés. Avoiding such clichés was one reason for going to the computer in the first place.

Real-time operation is hard to resist. It may entail a less thoughtful approach, and trial-and-error on real-time systems is not guaranteed to lead you where you want to go. The technical demands of real-time synthesis still impose limits on sound

richness. Some synthesizers can record a natural sound (e.g., a note from a trombone) and transpose it in pitch. While this makes it easy to generate scales from a sound, such scales sound very mechanical—a turnoff for many listeners.

Hence, the effort to make synthesis easier may lead to a musical regression—as was the case with most uses of analog synthesizers compared with the previous practice of electronic music before synthesizers were invented. It remains a tough but worthwhile challenge to make the musical potential of the computer bloom. We must improve the interactivity and real-time possibilities of computers, but we must also improve our input languages and information transmission.

Conrad Cummings: It happened with the Moog synthesizer already. Composer X: "These sounds that we worked so laboriously to generate—we can't use them anymore because they're in every video game." Modernism was inherently elitist. We knew the way of the future, and we would teach it until everyone else saw that it was right. Putting the music of Modernism in a video game is not cheapening or perverting it, it is unselfconscious guerilla warfare on the highest level. You want to show us the right way to use your sounds? Well thanks, but we'll use your sounds our own way! Ease of access and ease of use lead more people to use the tools for more varied ends. Nothing could be healthier for the continuing vitality of our musical life.

Stephan Kaske: Did the introduction of the pianoforte have a negative effect on the musical scene? Or the first sine wave generator? If the only virtue of music produced using computers was the capability of generating new timbres, then computer music would be a poor show. The introduction of inexpensive digital synthesizers like the Yamaha DX series is releasing composers from the obsession of creating new timbres. I suppose it will have a positive effect on the scene in that it will help many composers who had been seduced by the rather peripheral aspect of sound synthesis to get back to the real thing called music.

David Rosenboom: I feel this is a decidely positive development. The proliferation of accessible, powerful new tools can only increase the probability of truly great works being created. Some of the finest composers, particularly younger ones, cannot afford or do not have access to the fruits of developments in computer science. Of course, such proliferation will also result in a great deal of boring and uninteresting work being created with these instruments. So what else is new? Nothing will change in this regard. The proliferation of the piano has resulted in great music and uninteresting music, none of which can really be blamed on the piano itself.

In addition, I might point out that the creation of "great" works is not the only legitimate goal for the use of these instruments. A vast amount of musical activity by the people of our culture is undertaken for the personal edification of themselves as individuals or their social groups. The evaluation of musical works for their high cultural longevity is an irrelevant activity for these persons. Their musical activity has its own legitimacy, even if its meaning is limited to a relatively small social sphere. The people need rich and inexpensive resources for their musical activity. This is an important point and should not be overlooked by those primarily concerned with "high" art.

Giuseppe Englert: Devices that aid composers in certain tasks enable them to concentrate on other tasks that are more important to them. But such devices will impose limitations on composers or pose unforeseen problems on them. Certainly musicians involved in live electronic music performance welcome digital modules.

Digital synthesizers and signal processors have an extremely wide dynamic range with low noise, matching the capabilities of high-quality amplifiers and loudspeakers. Analog tape is the weakest link in the performance chain. Therefore, new techniques that allow musicians to dispense with analog tape will enhance the acoustical quality and add liveliness to concert performances.

Marc Battier: For a long time there have been works for tape and instruments, developing the idea of a *mixed music*, and there have also been works for electronic instruments and orchestra (not to mention pieces in which the older Ondes Martinot or Hammond organ has been used). At IRCAM we are working toward an integration of traditional instru-

ments and electronics. In order to achieve integration, we use several modes of interrelation between the two worlds. We use digital sound processors, capable of sound synthesis and natural sound treatment in real time. The real-time processors can respond to commands from a performer or conductor, and more generally to *cues* from a traditional instrument. Thus it is responsive to gestures. Its activities can also be triggered by sounds, after some sort of pitch, octave, or amplitude threshold detection. More importantly, the sound quality and capabilities of modern sound processors are such that it is not so much an instrument as it is a network of sound activities. The positive aspect on the musical scene can be viewed as a better connection between the electronics and the instrumental performers, the conductor, and the composer.

What do you think of attempts to automate or simulate compositional processes?

Otto Laske: This question concerns a much maligned and even more misunderstood topic. The issue is human musical planning. For me, computer programs for composition are planning aids, regardless of whether they "automate" or "simulate" cognitive processes. It is always the human composer who develops the meta-plan for the use of such tools.

Although an individual's compositional processes are, by nature, highly idiosyncratic, one would have to be a solipsist in the sense of Schopenhauer to deny that composers share a common cultural context, including certain scripts and procedures. (Schopenhauer, in good German fashion, recommended a beating as the only way to cure solipsism. I don't know what the musical equivalent would be.) The question is: How can we transfer human musical expertise to a computer and represent it within the machine? How can we construct musical knowledge bases incrementally? How can we get the machine to explain its musical reasoning to a human being? There is nothing peculiar about musical expertise that would force us to use different methods from those used in artificial intelligence applications today to solve these very legitimate problems.

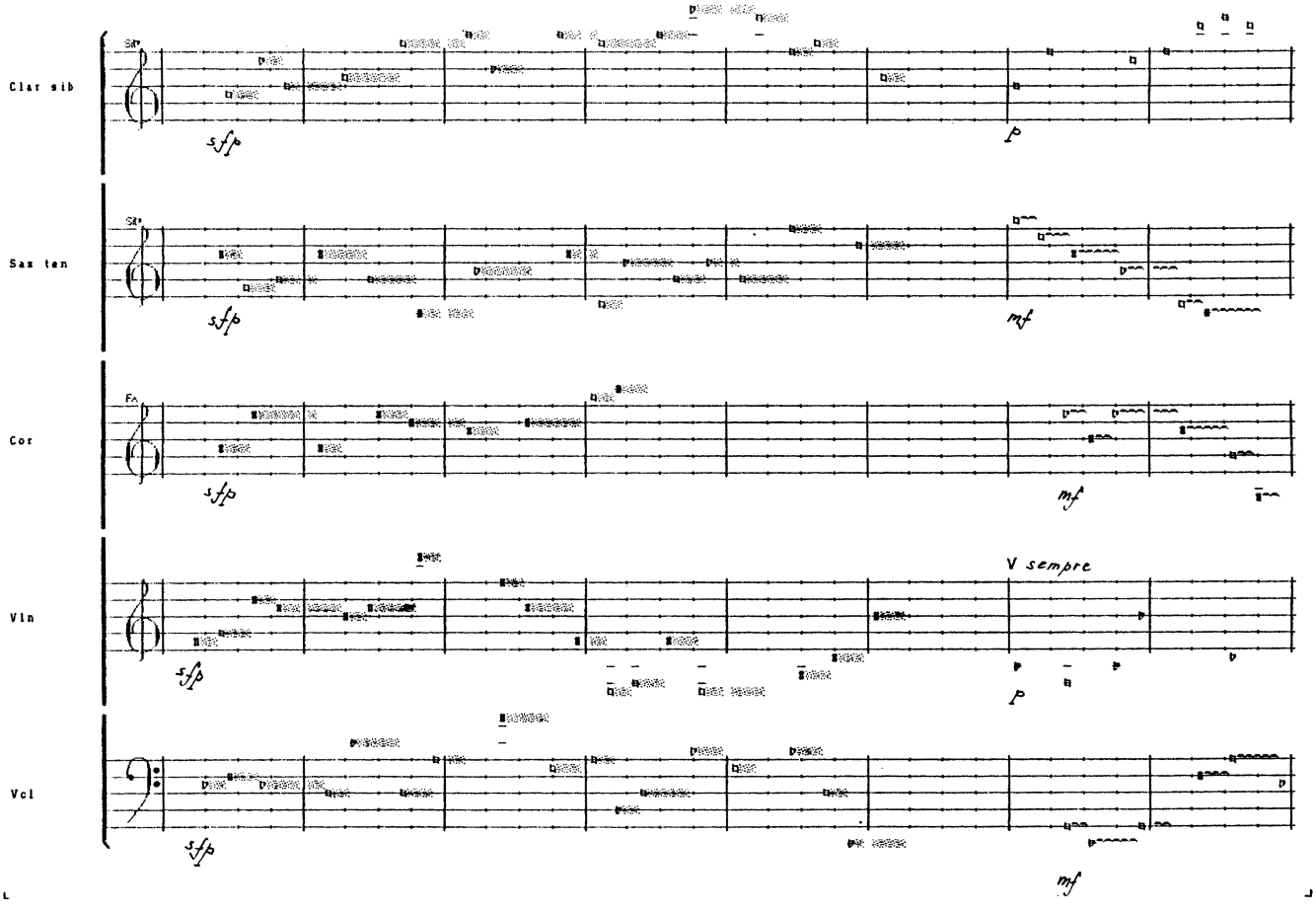
Herbert Brün: The question ought to be investigated and politically analyzed. For example, is artificial intelligence desirable if it triumphantly simulates the human moron's submissive obedience and ruthless efficiency? Furthermore, I cannot simulate compositional processes. I can, however, compose automated processes or processing automata.

Giuseppe Englert: Algorithms have been introduced by many composers at all times. There are also compositions for which all attempts to discover rules or formulas have failed. Composition rules are algorithms that can be traced in works of more than one composer in a specific historical period. More interesting are individual algorithms that a composer invents, eventually for only one piece. The research made by André Riotte on compositions of J. S. Bach, Stravinsky, and Bartok reveals astonishing facts.

For some of my works like the cantata *Au jour ultime liesse* (1963) and the string quartet *La joute des lierres* (1966) I have built strict rules and mechanisms. These are algorithmic compositions written long before I became interested in computers. My recent compositions are automated to a large extent: *Mutations Ocre-Violet* (1982) for NEDCO digital synthesizer lasts 30 minutes and requires only a few manual interventions during performance. *Babel* (1981) for orchestra and *Ecorces* (1982) for five instruments are pieces in which pitch, duration, and articulation are calculated and printed by computer, with dynamics added by hand afterward.

The myth of automation (for power) has accompanied the intellectual life of mankind a long time. Adam eating the Apple (Ho-ho! Coincidence?) Prometheus, Rabbi Loew—Golem, Faust—Homunculus, etc. The logical scheme behind the myth, simplified, is as follows: "What I know I can describe. What I can describe I can reproduce (or simulate)." This represents three stages: knowledge acquisition, description, and formalization. To fully automate a composition process we have to know all about what goes on in a composer's brain (and other interior organs) in a given cultural context. For the moment we have only partial knowledge of the problems involved, which limits present expectations in automated composition. A final remark: in all traditions or legends related to the myth of

Fig. 7. Page 1 of Ecorces *(1982) for five instruments by Giuseppe Englert.*



automation, the simulation of man by artificial means is finally condemned and punished. This could explain why some of our colleagues become irrationally angry when discussion turns to musical automation.

David Rosenboom: I am very concerned with particular kinds of applications of these processes. I believe this to be an absolutely valid and interesting pursuit and possibly, a new kind of music that can be listened to with new ears and a new type of musical attention.

David Jaffe: A good composer draws on a wealth of practical experience with musical materials and is versatile in a number of techniques. For a given piece, a composer develops whatever techniques are needed to produce the desired expression. When working with a computer, a composer who can program can depict a musical idea in terms of a program. The program can be completely deterministic or have probabilistic elements. Even if it is deterministic, it may be sufficiently complex that the exact details of the output cannot be imagined in

advance. However, this does not imply that the composer does not have a clear general conception of the result.

On the other hand, automation is not a prerequisite for quality, nor does it guarantee quality. It is neutral. It is just a technique that can be used toward artistic ends by an imaginative composer. In my computer music, I have used a variety of techniques within a single piece that span a landscape from completely automated to completely manual composition. Automation can be implemented on any level of the compositional process. Often I will specify exact pitch and rhythmic material but have automated systems controlling how these are used.

Sometimes automated systems can produce results that could not be attained with manual techniques. For example, in *Silicon Valley Breakdown*, tempo, rubato, and phrasing are automated such that groups of instruments can have wildly varying rubatos but still "understand" where they are in the music. Several schemes are used, depending on the musical context. One scheme involves ensembles of pseudo-instrumentalists, called *voices*. Each voice follows its own tempo and rubato trajectory, yet within the context of this high level of contrapuntal independence, keeps track, from moment to moment, of the resulting harmonic combinations. Based on what it "hears," each voice or ensemble of voices can alter its own or another voice's preplanned behavior. (This intervoice communication is implemented via message-passing in the Pla programming language.) In this manner, a responsive improvisational ensemble is created that nevertheless remains faithful to the precomposed plan.

Stephan Kaske: Every composer should know a little about how he or she works, since intuition is too nebulous a term for describing the compositional process. So a simulation of creative phenomena is definitely worth profound scientific investigation. But I wonder if I would be interested in automating composition to such an extent that I would be only peripherally involved in the composition process.

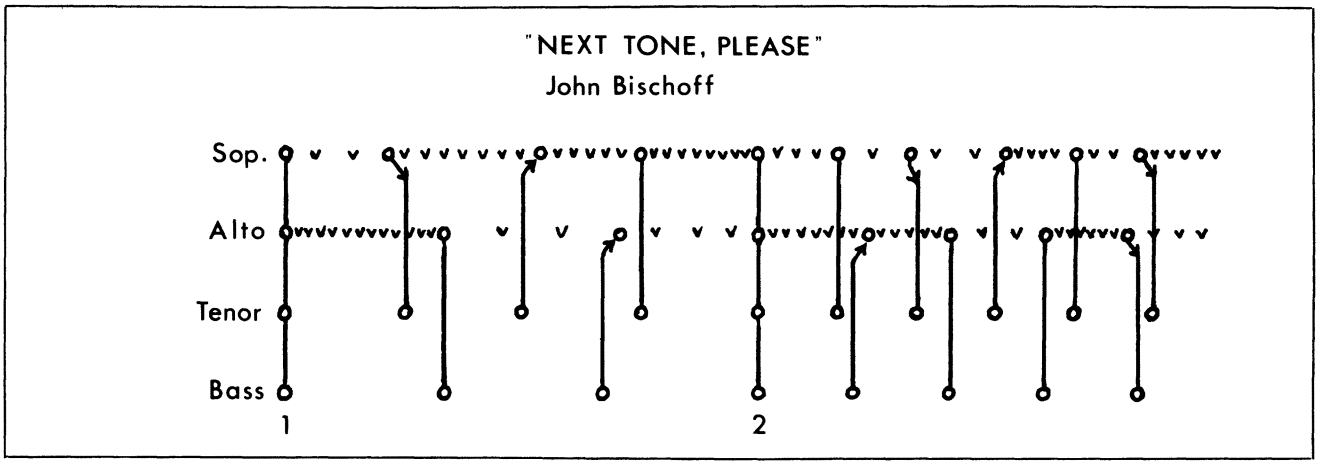
We have to determine which processes of compositional design could profit from automation. Taking the most recent compositional resources into account, we might best concentrate on urgent problems like the musician/machine interface. In an improved music programming environment, it would certainly be useful to automate specific compositional procedures, depending on the composition technique being used. For example, if one is a friend of stochastic music, why not have the computer generate the random numbers rather than throwing dice or coins, like composers did in the 1950s? Or if one is obsessed by patterns, why not have the computer generate them ad infinitum according to the composer's rules?

A complete automation of the composition process is of merely scientific interest. Among other things, composition involves emotions, and for some it is pure emotion. So complete automation of the composing process calls for a computer with feelings. I would not object to listening to a computer composition created from a programmed model of emotions. Let's hear what Maestro Computer wants to tell us!

Marc Battier: Automated musical processes are a general part of contemporary musical thought. The concept has been applied in instrumental music (for example, Michel Philippot) and in electroacoustic music studios (more evidently in American and Belgian studios). Computers offer a systematic way of investigating this subject.

Horacio Vaggione: The role of the composer in working with computers is to produce new musical situations by programming. Automated processes are an important part of this approach. However, the composer is not limited to strategies like pure determinism or pure stochastic processes. I am very interested in creating compositional systems in which the software is based on collections of autonomous musical objects, that is, modules that contain some kind of specific knowledge and are thus able to execute well-defined tasks. These modules can be made available permanently so they are available to form various networks of functions. A single message can activate any module, and the module must respond by sending messages to all relevant modules. Activating a module by sending it a message accomplishes a specific musical task. For example, one module might distribute sounds in time according to a law of evolution on another level, or direct the flux of sounds toward the inputs

Fig. 8. A graphic representation (not a score) of two sample phrases from John Bischoff's Next Tone, Please *(1985). Each circle represents a three-tone chord in the range specified to the left. The vertical lines indicate simultaneous chords. Lines with arrows indicate nearly simultaneous chords. The "v" symbols represent regularly modulated parameters within the sound of a chord, e.g., waveform or filter changes. The tempo is slow; for example, the first chord's duration is about four seconds.*



of an automatic digital mixer according to messages received from other modules.

What are the dangers of computer music?

Giuseppe Engelert: There was a time when, by singing Verdi's newest arias in the streets, people manifested their sympathy with the Italian independence movement and gave moral support to the activists, the *Carbonari*. Verdi's operas constituted a danger to the Austrian power. Times have changed; music does not trigger revolutions anymore. We have to admit that computer music is not dangerous.
Marc Battier: The time when computer music sounded more computer than music has gone. I see no danger, except the danger of being totally absorbed by computer programming. However, programming will be less and less associated with computer music in the future, in that musical tools will be offered to composers. These will partly fill the gap between the composer's intentions and the means of realizing them. The danger would be to lose control of the development of these tools, and as Phillipe Ménard used to say, let Radio Shack do it all.
John Bischoff: Computer music systems of any kind are so much more complicated than musical instruments of the past that there is a tendency for a composer to spend increasingly more time designing a piece and much less time playing it. This point is important because traditionally, making music has involved repeated playing and listening. I don't see why it would be any different for computer music. How does one try out ideas for a piece without actually defining and building the piece? In computer music, once design decisions are made, they are harder to change because of the large amount of development time invested in them. A related danger is to get stuck in a perpetual design state and never make it to reviewing or testing the aesthetic assumptions one's work is based on.
Joel Chadabe: Computer music is dangerous to performing musicians who depend on commercial jobs for living, because computers can produce acceptable orchestral sounds relatively inexpensively. The same could be said of set designers who were put out of work by computer graphics used in filmmaking. Overall, we're entering an age when people's ideas of what is amusing is changing, and I fear that the music literature that I grew up with, and the method of its delivery (i.e., performances in concert halls) will seem increasingly less rewarding.

What are the worst clichés of computer music?

Herbert Brün: The drone and the loop. It is not enough that they are the cheapest brag of "can-do-ism," they play a hapless tribute to just that which holds them in freezing contempt: well-tempered tonality.

Kaija Saariaho: Quite often computer music composers focus their ambitions on purely technical aspects, for example extremely complex algorithms for composition or synthesis. Little attention is paid to the fundamentally musical elements. This lack of attention does not stem from a radical approach that searches for musical solutions for new directions, but rather stems from a lack of interest. The consequence is that what is heard is often musically conventional, and the solutions are banal.

Too many computer pieces are like audible games, without any artistic content or depth. The worst cliché is a cold, technologically meaningless and boring-sounding piece that supposedly is made with ingenious algorithms. This strongly contradicts the searching spirit that is usual among computer music composers. Maybe the equipment has been too elementary to enable composers to save their energy for composition after the tiring programming. Probably also many computer music composers have until now been more interested in technological aspects than music itself.

David Jaffe: The assumption that loudspeaker placement is irrelevant and unimportant is counterproductive to the advancement of computer music. Although there have been composers such as [D.] Scarlatti who have written for only one instrument, most composers since the seventeenth century have written for a variety of musical forces. It will be a pity if computer musicians forget this and write all their music for four speakers in a square or two speakers in the front of a room. I would like to see more experimentation with nonstandard speaker placements and nonstandard speakers. The idea that speakers should be completely general is also counterproductive. I would like to see idiosyncratic "speaker-instruments" built to have a certain desirable sound and projection, in a manner analogous to a fine violin. Perhaps computer musicians will have to become loudspeaker artisans.

If you could change some aspect of current computer music practice, what would that be?

Jean-Claude Risset: I would want to have the wonderful programs that exist or are being developed be more portable, so that we could use them in my remote province.

Otto Laske: The most important aspect I would want to change is the way in which computer music is taught today. I would like to see the notion of a "computer" interpreted more broad-mindedly. A comprehensive computer music curriculum that deserves the name would have to include cognitive, historical, technological, and scientific topics. It would also have to include a "composition theory" that discusses musical planning, as well as topics relating to sonology (i.e., systematic orchestration based on insights into the score). Artificial intelligence topics such as planning paradigms, expert systems, and knowledge representations should be included as a matter of course, on a par with digital signal processing and software engineering.

At the present time, the limitations of "computer music" in the very narrow sense are becoming quite apparent. One knows a bunch of very idiosyncratic sound-synthesis techniques, displayed in overlong pieces, and they are giveaways. They classify a work based on the techniques it uses. But that is why we abandoned "electronic music"!

There is very little interest today in teaching computer music in the broad sense of a computer as a symbol manipulator (rather than a data processor), which would introduce a broad spectrum of related disciplines. This I would like to change.

Clarence Barlow: I would not want to change anything, but I wish all the same that I could be confronted with less music resulting from inscrutably abstract, extramusically autonomous processes inaudible to me as a listener. I want to hear more music resulting in an obvious way from a musically powerful idea, such as was desirable as a matter of course before computers entered the scene.

What is your assessment of the state of computer music in today's society?

Marc Battier: The French state radio has two programs devoted to culture and music. Computer music is often played on these programs, and also on other private stations. There have also been several educational programs. We may regret that these pro-

grams spend more time talking about the music than playing new pieces. Also, due to the fact that we have several music research centers in France, computer music can often be heard in concert.
Herbert Brün: Not being a fame-backed composer I can only assert with some evidence and full conviction that my six pieces in SAWDUST are (a) credible complimentary acknowledgments of the immense gift presented to me by technology, (b) the most radical display of "computer age composition" to date, and (c) one of the successful attempts to restore living interest in the function of composed music to contemporary listener's society.

Many musicians involved in the new musical technologies have noticed the danger of being "seduced" into programming or another extramusical agenda. Do you see this as a problem for yourself?

Giuseppe Englert: Some extraordinary pianists have been "seduced" into becoming composers. Percussionists have become conductors. This is not to speak of composers who become managers or manipulators. How comforting that in the fast field in and around music, where so many disciplines intermingle, one can be seduced by one activity rather than by others! In my case, I still compose and perform music, and love programming.
David Rosenboom: I don't see this as a problem particularly. I am often frustrated by the drudgery of programming, as I am by the drudgery of copying parts from a score. I have learned, however, to accept both as necessary parts of musical activity. I can, at times, even transform both into almost meditative, creative disciplines. I enjoy very much the creative aspects of programming and creation of circuitry, for both have led to many new musical concepts and methods.
David Jaffe: The problem is not a danger of being "seduced." The problem is that being a "composer" is still not considered an honest profession in the United States of America, although in some circles it is a fashionable hobby. Nearly all American composers have to support themselves doing something other than music composition. Some teach, some sell insurance, and some program computers. The most valuable commodity for a composer is time, enough time to compose. The time must be steady and must continue for a lifetime if the composer is to have a chance of developing a mature style.
Horacio Vaggione: Apropos the subject of the "composer seduced into programming" I recommend the reader to the article by Gareth Loy that appeared in *Perspectives of New Music* 1980–81. Before offering a well-articulated panorama of the dangers and advantages, and of the technical and subjective changes that can result from the interaction of the composer and the machine, Loy cites this statement by Harry Partch: "*I am not an instrument builder, but a philosophic music-man seduced into carpentry.*" Of course, Loy speaks of positive seduction, like that music students experience for their instruments. He also points out the aesthetic aspects of the practice of programming. Composers were the first to use the computer for artistic purposes. The resemblance of composing and programming is obvious, since both deal with processes that evolve in time defined by specific constraints. From a musical point of view, however, the finality of programming does not rest in itself, but in the musical results that the composer can produce with his digital partner.

Composers "seduced" into programming in the negative sense are people who lose their need to produce music in order to dedicate themselves exclusively to the exploration of communication with the machine. At this moment, we can say they are no longer musicians. But they can become good programmers if their interest takes them that far. In the same way, this ex-musician programmer can become a fine collaborator for a composer that doesn't understand computer science but who desires to work on certain ideas and musical images whose characteristics (e.g., complexity) could only be accomplished by means of computers.
Herbert Brün: I wish I were a brilliant programmer. My respect for those who are good programmers is deep and affectionate. Nothing whatever can belong to an "extramusical agenda" once I have used it for the composition and realization and implementation of a "piece of music."
Marc Battier: Generally speaking, I notice that those

composers who have had to write programs in order to compose have a different view of computer music. At IRCAM, we have composers who program, others who don't, and in between those who can transcribe traditional scores into data for a program such as the SCORE input language. However, we all know of musicians who have been completely eaten up by the computer, and who have completely quit their musical activities. The other side of the problem is the composer who only works with tools developed by another composer, and is thereby limited. Nevertheless, programming is a natural aspect of computing, and music is a field in progress, so programming new musical models seems now a part of contemporary musical thought.

Joel Chadabe: I do not think composers have a monopoly on creativity. I know researchers and equipment designers who are more creative than many composers. It is understandable that at this point in the development of computer music, the design of the instruments themselves is a primary concern. Many people are likely to become involved in this, including composers. It is fascinating, and should not be derided. In my own case, writing the PLAY program, I have noted the satisfaction one feels in doing something that others might find useful. But outside of that excursion into general-purpose software development, I have not been tempted by general-purpose work. That might well change, however, in the future.

Are you interested in combining your musical works with other media?

Giuseppe Englert: Between 1976 and 1981 our Groupe Art et Informatique de Vincennes gave many concerts, with great success. In these concerts, visual artists (Bret, Huitric, Nahas) displayed on a video screen animated images realized in real time by the COLORX system (L. Audoire) controlled by a DEC LSI-11 computer. Accompanying the visuals were musicians (M. Battier, G. Dalmasso, Holleville, Hunstiger, and me) playing on hybrid computer/synthesizers (computer-controlled analog synthesizers), and then on the Synclavier I digital computer/synthesizer. The relation between image and music was improvised and not strict.

Since 1981 visual artists have become more ambitious concerning resolution and color, and they are no longer satisfied with portable equipment. The very high cost of renting video equipment for concert spaces has become an obstacle to our combined performances.

The fact that the performance of computer music is not visually spectacular has deprived us of the support of television. This may partially account for the difficulty of inserting computer music into general musical life.

Joel Chadabe: The idea of interactive composing is easily extendible to video, computer graphics, and dance. Video images can be used in parallel with the music. Since the performance device in an interactive composing system can be freely chosen, a device that translates physical dance motions into music information can allow dancers to be performers of music.

David Rosenboom: I have been involved with multimedia work a long time, certainly before my first work with computers. Most recently, I have created two works in this category. *In the Beginning* (*The Story*) was written in 1980 for chamber orchestra, film, and synthetic speech. A complex fabric of music created with a model of proportional structures (pitch and rhythm), melodic shape contours, stochastic selection processes, and other subjective musical concerns was created in part with the aid of a computer.

This music was combined with a text, a dialogue of synthetic speech, and a film (photographed by George Manupelli). The film depicted surreal scenes of clay-covered figures acting in relation to the text. The artistic subject concerns modeling behavior, evolution, and the development of global human consciousness.

The second work, *Daytime Viewing*, was created over the period from 1979 to 1982 in collaboration with the artist Jacqueline Humbert. It involves music performed with computer-aided instruments, visual material created by mixing photographic, drawing, and computer graphics processes, electronic processing of sung and spoken text, video, fashion and costume design, and theatrical perfor-

mance. The work is concerned with modern communication media, television, and images of women in contemporary society.

Kaija Saariaho: In my piece *Study for Life* (1980) I combined white light and dancer with electronic tape and soprano. The light part is very precisely scored. It represents in my mind a visual parameter for some musical ideas in the piece, since all the material on tape consists of sounds made with glass, which in turn gave me associations of reflections, different intensities, and shadings. After this piece I have had many plans to continue work in this direction. For example, I would like to try to realize my formal ideas with video. I see in video and in music many common factors, the most important being that they are both arts in time. In my compositional work I use much drawing, and I would also like to try to realize these ideas in visual form.

Artistic experience can be used to enlarge several senses, and the senses are naturally intertwined. In my score for *Study for Life* I ask that the room be filled with scents. I am also interested in multidimensional works of art, but in the abstract, strict sense. Right now I am working with a spectacle, where music is connected to actors' movements. The amplified, well-controlled breathing of the actors is part of the music, which also consists of tapes and live processing of sound.

Otto Laske: Since 1980 I have repeatedly collaborated with a modern dance choreographer (my wife, Peggy Brightman), and have come to appreciate the more than musical concerns that enter into such a collaboration. I am particularly interested in works where choreographer and composer use a common plan but different computer programs (planning aids) to accomplish it. An example of this way of working is *Windshadows* (1982) for flute, dancer, and mobile, with Peggy Brightman.

In *Windshadows*, the choreography is based on output from G. M. Koenig's Project One program, and the music is based on output from Iannis Xenakis's ST program. These programs act as planning aids for designing and realizing a form. In *Windshadows*, both the dance and the music are based on the idea of a sequence of events whose distribution in time and space increases up to a midpoint, and then returns to its initial state. To realize this idea musically, I defined a form in five sections for solo flute with the aid of the ST program. Peggy Brightman used Koenig's program to yield a blueprint for each section that would correspond in certain ways to my structure. This blueprint was interpreted by the choreographer/dancer team in terms of Rudolf Laban's Effort/Shape theory of movement.