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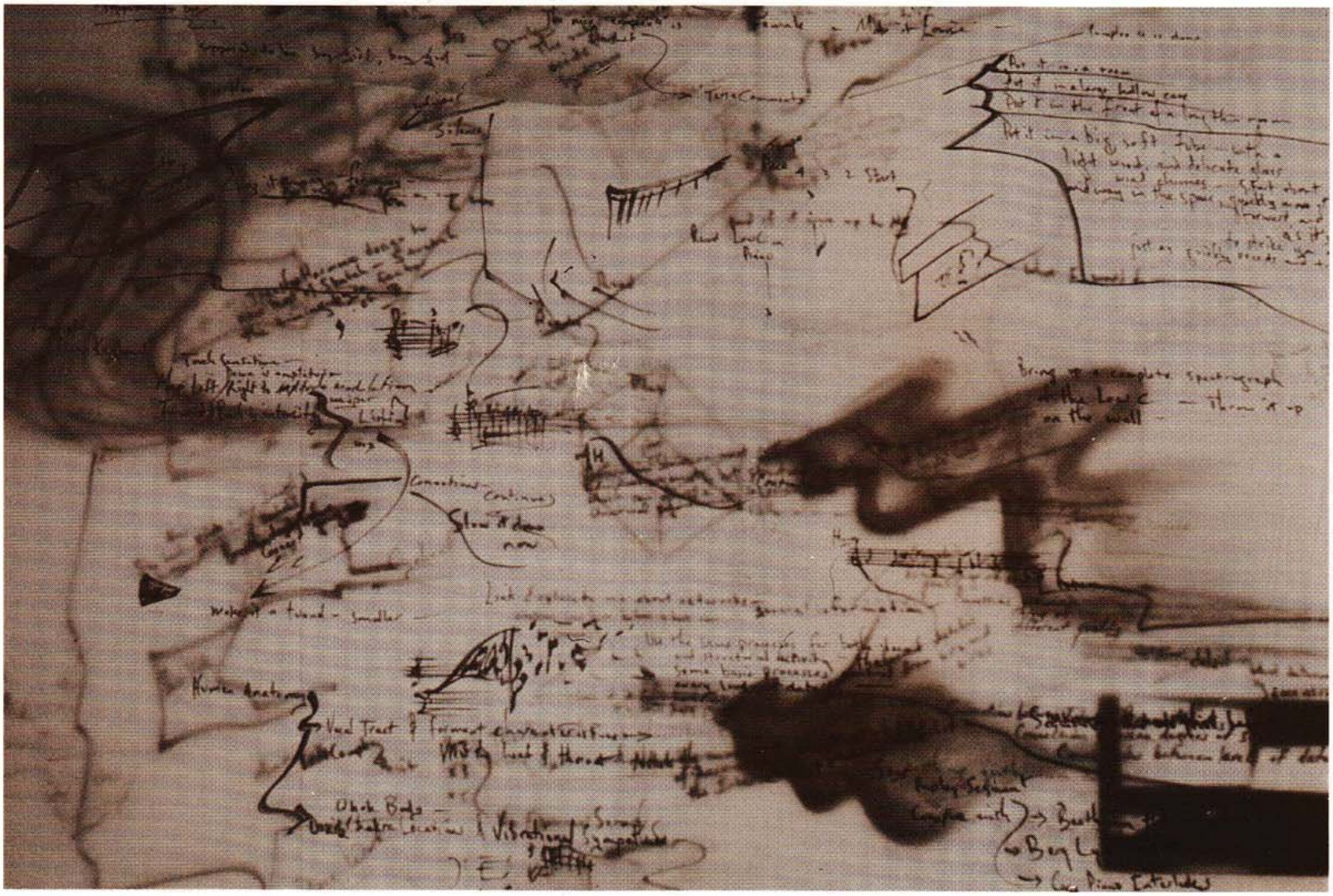

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ABOUT THE COVER

Craig Harris, *Room Talk,* one of approximately 750 photographs documenting the artist's series of *Configurable Space* installations created between 1989 and 1992. These installations reflect immersive environments that simulate the features and operations of future artists' studios. *Room Talk* characterizes a complex constellation of internal states, reflecting a broad range of emotions and activities occurring during the creation of a musical composition. The content incorporates traditional and extended musical notation, graphic images and text, existing at varying levels of specificity and on multiple degrees of clarity and focus. One traverses the web of links and connections within and between layers using a configurable, touch-sensitive surface. The design is meant to create expression of self that relates closely to the nature of being and to provide a paradigm for resources that facilitate exploration and communication.

Selected Papers from the

Fourth International Symposium on Electronic Art: The Art Factor

Minneapolis, Minnesota, U.S.A.
3–7 November 1993
Host Institution: Minneapolis College of Art and Design

"THE ART FACTOR" PAPERS

By way of introducing these papers [1] from the Fourth International Symposium on Electronic Art [2], I would like to say a few words about the term "electronic art" and about the theme of the Minneapolis symposium, "The Art Factor." In planning the call for participation, our program committee was forced to ask very specifically, "How do we define 'electronic art'?" In seeking an answer, the committee saw a need to identify relationships between emerging electronic technologies and arts traditions. Some felt that technological achievement placed in an arts context as "art" should be subjected to critical assessment as "art," perhaps rather than spending time discussing the technology. A symposium focused on "the art factor" could open doors toward the development of a critical basis for distinguishing between "art" and the technologies employed for creating that art.

ELECTRONIC ART

Recently a colleague called the term "electronic art" an oxymoron. By this I believe she meant a self-contradictory term. Several years ago when we contemplated this symposium I too questioned the use of the term "electronic art," as did our committees and many others. But no longer.

The use of changing technologies in the practice of art has been an ongoing phenomenon. The work of pioneering artists has not been easily recognized or fairly assessed. The medieval scriptorium included artists who practiced the art of "calligraphy," which produced great masterpieces such as the "Book of Kells." The advent of printing brought the art of "typography," which changed the art of the book as radically as the technology of printing changed Western culture. Yet how many contemporaries of Aldus Manutius (1449–1515) perceived or understood during the early years of the Aldine Press (from, say, 1495 to 1500) the immense impact the press would have? How many humanists at the turn of the sixteenth century failed to see that standardized movable type would alter the role of the artist's hand in both the design and production of the book? Are we not at a similar crossroads today?

Since World War II, electronics has achieved radically new capabilities and has attracted hundreds of artists to experiment with its use. There are more than 1800 entries in the 1993 edition of the *International Directory of Electronic Art*. Although reference to electronic music dates back to as early as the sine-wave tones of Leon Theremin in 1924, it was the perfection of the tape recorder in the 1940s that thrust electronic music forward. Referring to the arts in general, the term "electronic" has been in substantial use for several decades, with a pronounced presence since the founding of Ars Electronica in 1979 at Linz, Austria.

What is the post–WW II technology in electronics? It is the integrated circuit (1948) that makes the use of logic circuitry practical for almost any application—from automobile cruise control to automated bread-making. Today's electronic controllers exhibit uncanny abilities and a semblance of "intelligence," including simulating the human voice and controlling vast networks of information.

Can we identify aesthetic issues associated with the use of these "controllers" in the arts—controllers with seemingly intelligent behavior? Their use raises questions associated with authorship and the "hand" of the artist. One radical aesthetic challenge results from the use of "genetic algorithms" and "cellular automata" in art, which some artists and musicians are using to "breed" forms (e.g. *Biogenesis* by William Latham, U.K., FISEA 93 Electronic Theater; and the work of Eduardo Miranda, CAMUS [Cellular Automata MUSic], FISEA 93 presenter). Who (or what) is in charge?

Most FISEA 93 presenters, including authors of the papers in this special section, are artists whose work is radically "in-formed" by electronic procedures—work that may clearly be called "electronic." Others have collaborated with artists as electronic tool-makers. Some of these artists have wrestled with the giant for many years, prodding it to serve their artistic vision. To the earlier question, then, "Is electronic art an oxymoron?" we must say emphatically "no!"—not any more so than the terms "graphic art," "stained glass art," or "film art."

The Art Factor

In "electronic art" exhibits, we often see brilliant technology. But brilliant technology without "art" may be likened to a body without mind and soul—a floundering entity or a corpse. From the beginning, the FISEA 93 Program Committee, recognizing that the clamor of new technologies too easily takes center stage, centered its interest on artistic procedures and information-processing by artists. For this reason they chose to focus the Minneapolis symposium on "the art factor."

The symposium's call for participation identified the need for dialogue focused on the emerging artist-machine dialectic from the perspective of art criticism. This new cultural frontier has been changing the way we experience and interact with our world. Clearly, our machine culture will come to maturity by cultivating, celebrating and integrating "art," both intentionally and qualitatively.

The artistic work of the cyber culture manifests itself as a new edge preceding any art theory or criticism about itself. For this reason we saw a need to draw those involved with this new edge into a more focused sharing and discussion of their "art," both in theory and in practice. So FISEA 93 was orchestrated to foster dialogue about the "art factor," especially for those younger artists who have grown up more with joysticks than with paint brushes. The intention has been to promote a greater understanding of both the formal aspects of the work and its technology.

In keeping with our theme, the call for participation explicitly invited work that submitters considered to be "art," thus providing ground for the committees to discover the art factor through the window of submissions.

Why did we want to focus strongly on the critical language and the criteria we use for the "art" of machine culture? We did so because our relationships with each other, the world and the things we make are being radically transformed as "ubiquitous computing" invades our lives. This radical transformation includes serious changes in how we create and talk about cybernetic art. From the use of networks and form generators to genetic algorithms and computer viruses, we see artists using technologies that challenge assumptions about original art, individual style and private expression. In some instances the procedures are entirely executed from coded procedures. Shall we call this art?

While the "modern" dogma has served its time well, its critical language and assumptions pertain to a passing culture in which cybernetics was the stuff of science fiction. The "modern movements," like fashion, were in a dialectic with their predecessors—"art on art," as it were. But those artists who have pioneered the stuff of cybernetics have come to us somewhat sideways, intensely involved with the interaction between humans and machines. The whole range—from networks to artificial life—has seduced many to total commitment. This includes a growing number who come directly out of the sciences and cross over to the world of art.

What draws them? How are we to assess their work? The artists' statements and works in the Minneapolis show, and the papers published here, provide a ground for wrestling with these problems. From its inception in 1988, ISEA has been evolving terminology and formal categories for reviewing and exhibiting multifaceted art forms—cyber art, electronic art, computer art, digital media. Every ISEA symposium has two things in common—a commitment to the arts and serious involvement with the use of an electronic technology.

ISEA VOICES

The selection and publication of ISEA papers by *Leonardo* began with the first ISEA symposium in Utrecht in 1988; this relationship with *Leonardo* brings the annual ISEA dialogue to a larger audience. ISEA's published documents provide only a hint of an intense week of workshops, poster sessions, exhibitions and papers. These ISEA events are both the fruit and the stimulus for those with the common interest of coming together to share their visions, problems and aspirations. Many attendees of the first ISEA symposium in 1988 discovered others traversing a similar path.

Always, the shape of these symposia is defined by the participants—not just those who present papers or exhibit, but also all who submit works or take part in the discussions, both public and private. Juries and committees make it possible to come together in a meaningful way, but those who participate create the substance and meaning of the symposium as it unfolds and prepares ground for the next. So the process yielded one ambiance in Sidney (1992), another in Minneapolis (1993) and yet another in Helsinki (1994). For those who wish to join the dialogue, the ISEA symposia will continue in Montreal (1995), Rotterdam (1996) and Chicago (1997).

On behalf of all ISEA participants, I extend my gratitude to *Leonardo* for being a friend to the ISEA series and for publishing our announcements and selected papers.

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Notes

1. These introductory notes are based, in part, on those that appeared in the FISEA 93 Papers volume and the FISEA 93 Catalogue, which were distributed at the Fourth International Symposium on Electronic Art in Minneapolis.

2. ISEA is the acronym for the Inter-Society for Electronic Art, which gives the site approval each year for the International Symposium on Electronic Art. Up until 1994, meeting biannually, the symposium acronym included the letter of the series number thus: FISEA (First, Utrecht, 1988); SISEA (Second, Groningen, 1990); TISEA (Third, Sidney, 1992); and FISEA 93 (Fourth, Minneapolis). Beginning in 1994, the series dropped the first letter; thus: ISEA 94 (Helsinki); ISEA 95 (Montreal); ISEA 96 (Rotterdam); ISEA 97 (Chicago). The ISEA board address is: P.O. Box 8656, 3009 AR, Rotterdam, Netherlands. E-mail: <isea@mbr.frg.eur.nl>.

ISEA: An Introduction

The abbreviation ISEA stands for two things: the Inter-Society for the Electronic Arts, a member association, and the International Symposium on Electronic Art. The symposium series was initiated prior to the founding of the association, and the Inter-Society now coordinates the continued symposia. The idea for both the society and the symposium series dates back to 1985, when the chairman of the Dutch Foundation for Creative Computer Applications, Theo Hesper, decided that it was time for international and interdisciplinary cooperation in the electronic arts in order for them to grow to maturity. The aim of the first symposium, held in Utrecht, Holland, in 1988, was to found a "meta-organization"—an organization of organizations. The aim of the Inter-Society (the name was coined by Roger Malina) is to foster "a structured approach towards the problems and potentials of electronic art."

The Inter-Society was founded in 1990, just before the Second International Symposium on Electronic Art, held in Groningen, Holland, but has only been really active since the beginning of 1992, when it started publishing a monthly newsletter. That year the third ISEA symposium took place in Sydney, Australia.

Until that time, the symposia had been held biannually, but there was so much interest in them, with many young artists waiting for a chance to show their work and with such rapid developments in the technology (the improving accessibility of the Internet being one of them), that it was decided a symposium should be held every year.

So in 1993 the Minneapolis College of Art and Design (MCAD) hosted FISEA 93 (the "F" stands for "Fourth"; the more recent symposia are called ISEA 94, 95, etc.). Roman Verostko, who had fought for MCAD to host the symposium, organized it, together with his wife, Alice, and a staff drawn from MCAD, the Minneapolis Institute of Arts and the University of Minneapolis. The first three symposia had received direct and/or indirect financial aid from the governments of the host countries (Holland and Australia). FISEA 93 had no government support, which meant major sacrifices for MCAD and the MCAD staff, especially Verostko himself, to make FISEA 93 a success. The academic part of the symposium took place at the Minneapolis Hilton; the exhibition, workshops and poster sessions were held at MCAD. Other venues (for the concerts, performances, electronic theater, etc.) included the Walker Art Center and the university. The papers reprinted in this section of *Leonardo* give an impression of the academic part of FISEA 93.

Since that time, ISEA 94 took place in Helsinki, Finland. This year ISEA will be held in Montreal; in 1996 Rotterdam, Holland, will be the location; and for ISEA 97, Chicago has been chosen. The idea is that the symposium returns to Europe every other year, to accentuate its European origin.

The Inter-Society has approximately 350 members from over 30 countries. Besides the monthly newsletter, members may receive subscription discounts for other publications (15% off the regular *Leonardo* subscription rate, for example) and even a free subscription to the academic journal *Languages of Design*. The Inter-Society is growing and has started national branches in several countries now. However, it is still a volunteer organization, with membership fees as its only financial source.

For more information, contact: ISEA, P.O. Box 8656, 3009 AR Rotterdam, The Netherlands. Tel/fax: 31-10-4668705; E-mail: <ISEA@MBR.FRG.EUR.NL> (to contact the board); <ISEA@SARA.NL> (newsletter and membership information).

WIM VAN DER PLAS
ISEA Board Member and Founding Member

Aesthetics of a Virtual World

Carol Gigliotti

ABSTRACT

The author explores the emerging aesthetics of interactive technologies—such as virtual reality, multimedia and telecommunication—and the inherent commitment artists must assume in accepting responsibility for the impact of these aesthetics. By examining connections between ethics and aesthetics throughout Western history, the author attempts to transform the aesthetics of virtual worlds to impact ethical thought. She lists six factors integral to responsible aesthetics in virtual systems: interface, content, environment, perception, performance and plasticity.

Discussing virtual reality with another artist recently, I was asked, "What do ethics have to do with aesthetics?" I might have dismissed the question as coming from someone whose roots are strongly attached to the modernist tradition. He does not grasp, I might have said to myself, that things have changed—that now, in this period considered by many to be postmodern, aesthetics is no longer regulated to a matter of form or style, but once again encompasses a philosophical stance towards the artmaking process. With that response, however, I would have missed an opportunity to develop an answer to another central question about virtual systems—what the aesthetics of virtual systems have to do with ethics. My one word answer to both questions is: "Everything." The longer answer is less presumptive, more inquiring, and the subject of my ongoing research and this paper.

In my interviews with various artists, educators, cultural theorists, computer researchers and software/hardware developers, questions about the ethics of virtual systems often materialize as ambiguous but pressing matters. Substantial worries concerning virtual sex, political and corporate domination, military uses, and mind-numbing, violence-oriented entertainment continue to indicate the possible directions in the development of virtual systems. Ethical questions, after all, involve judgment. How should we act? The idea of judgment in ethics is all-encompassing—it involves one's entire being, for it is the way we choose among many possibilities. Those choices commit us to paths which are more or less consistent with our nature and the rest of our lives. The accountability of our judgments is "part of the condition of our existence as social, integrated, affectionate, language-using beings" [1] and touches on questions about the nature of knowledge. On what do we base those actions? How can we know if the knowledge on which we base those actions is true?

Decisions about what is right or wrong are inextricably linked to a grasp of what is real and what is true. We approach an understanding of reality and truth through a variety of means. Historically, philosophical thought has offered us various positions on whether ethical decisions are based on stable or shifting grounds. Current technology offers us countless means to reevaluate our perceptions of reality and truth. Consequently, it is necessary to briefly unravel the intricate connections among pertinent systems of ethics, the ontological and epistemological assumptions on which they are based, and the influence technology has had on those assumptions.

Historical Aspects of Ethics and Their Impact on Technological Design

Two underlying issues consistently emerge in writings about virtual reality: simulation and artificial reality [2-5]. Rather than viewing these two issues as relatively new, and only connected with current technology, it is more helpful for our purposes to understand the design of present virtual-reality technologies as habitual involvements with goals that have been sought for centuries. The emphasis on simulation and the development of artificial reality can be traced directly to the late sixteenth and early seventeenth centuries when Kepler, Bacon and Descartes set an artificial and unreachable limit for knowledge, specifically undertaken to advance the possibilities of modern science. Investigating these origins may prove helpful in understanding the ontological and epistemological assumptions of the designers of today's virtual systems—since these assumptions are the grounds upon which we grapple with ethical issues. In attempting to construct an ethical framework, then, for the design of virtual worlds, it is necessary to understand how we have come to agree or disagree about what reality is.

One of the effects of setting an unreachable limit for knowledge was the separation of moral and intellectual spheres, which has been occurring for decades. The repercussions of that division are evident in every aspect of Western culture. We have combined this misplaced need for epistemic certainty with the design of machines built to obligingly fill that need, and subsequently have eroded our faith in human judgment and human worth. We have begun to place our confidence instead in these machines, which are unsurpassed in those qualities we have come to value most: efficiency, quantification, speed, objectivity and innovation for its own sake. And in order to interact with the machines that have become most important in our culture, we have begun to try to think like them. Postman suggests the direction of this line of faulty thinking:

> From the proposition that humans are in some respects like machines, we move to the proposition that humans are little else but machines and, finally, that human beings are machines. And then, inevitably . . . to the proposition that machines are human beings. It follows that machines can be made that duplicate human intelligence, and thus research in the field known as artificial intelligence was inevitable [6].

To find this line of reasoning "inevitable" is to disregard the role that meaning plays in communication. Meaning includes

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feeling, experience and sensation—the same dimensions that inspired the original formulation of the term "aesthetics" by the German philosopher Alexander Baumgarten. Aesthetics did not refer only to art, but to all of human perception and sensation. It is in this realm that ethical decisions are made. Haraway, however, sees possibilities in

> refusing an anti-science metaphysics, a demonology of technology, and so . . . embracing the skillful task of reconstructing the boundaries of daily life, in partial connection with others, in communication with all of our parts [7].

In so doing, according to Haraway, we will take "responsibility for the social relations of science and technology"[8].

ETHICS AND AESTHETICS

In working with and becoming involved in the aesthetic development of virtual systems, we, as artists, are either accepting or rejecting, stabilizing or altering our assumptions about the necessity of our human judgment and worth. As we make aesthetic choices, artists have assumed certain ideas about the purposes and values of artmaking. Those assumptions have changed over time and have come from various sources, both internal and external to the artmaking process, but they have had primary impact on what was communicated by the art and about the art of any particular time. Both ethics and aesthetics can be defined in terms of judgment. It is this partnership that allows us to grapple conceptually with both areas of thought at once. However, it is their active involvement in the artmaking process that will allow us to understand the consequences of that partnership. The separation of moral and intellectual thought has also influenced our judgment in ethical choices, as well as our judgment in aesthetics.

Judgment in aesthetics can be taken to mean the evaluation of specific properties of a work of art, as well as an evaluation of the general quality of it. Though the history of issues referred to by the term aesthetic is as long as that of ethics, the term itself did not appear until Baumgarten coined it in 1750 to refer to this special area of philosophy. Taken from the Greek word for "sensory perception," it signaled a shift in attention from things themselves to perception of things [9], as well as a shift from thinking about separate qualities of a particular art object to underlying philosophies of art. It is this final sense of the word on which we will rely—limiting the description of artistic activity to choices about particular qualities of works of art, such as the use of light, line, form or shape in a particular time period, would leave us with less than half the story.

The underlying philosophy of art that has been most influential in thinking about aesthetics in Western culture is Kant's outline of the characteristics of aesthetic judgment in his *Critique of Judgement* [10], which can be viewed as a direct descendant of Descartes' position. Battersby contends that during the nineteenth century, Kant's notion of the aesthetic attitude as a "disinterested" withdrawal from all material and use-value was developed

> . . . to an extreme. The aesthetic was equated with a particular attitude of mind: with a blanking out of moral, social and political considerations . . . and with an indifference to bodily dictates and needs [11].

But even though Battersby rejects Kant's notion of "disinterestedness," she goes on to say:

> there is no way of escaping the necessity of judging aesthetically. . . . Even to give priority to political, ethical or utilitarian value judgments over aesthetic judgments is, in effect, to opt for a particular variety of aesthetic value [12].

This consideration of aesthetics is one that is echoed by Eagleton [13], and is one with which I agree. To judge aesthetically is to compare values, and those values emanate from the totality of the judge and his or her context. In order to move from the extreme interpretation of Kant's notion of aesthetics to more contemporary views, such as Battersby's, Eagleton's and my own, contemporary critics [14–16] suggest that aesthetics, like knowledge, has had to go through a period of relativism. The objectivity of judgments in aesthetics, the values on which those judgments are based, and who makes those judgments have been taken into serious consideration. Wolff says:

> The demonstration that knowledge (including science) is interest-related, that the practices of scientists are in one sense arbitrary, and that knowledge has a "provisional nature," has been widely accepted among sociologists of knowledge. Relativism has become respectable as one position within the society of knowledge. . . . But more recently . . . the problem of truth has emerged in a particular form in the sociology of art—namely, in terms of the question about true or valid art [17].

Though I would argue that art is still in this period of relativism, the most striking thing about technologically mediated artmaking is its potential for moving beyond this period into one in which aesthetic decisions will contribute to an ethic of care and responsibility. The focus of this much shared optimism about making art with current technology is a concept even an American arbiter of acceptance, *Newsweek* [18], has dubbed the "interactive" aesthetic—a year or so after this term became accepted in art circles. But what are the preeminent characteristics of an interactive aesthetic and what ethical issues could they possibly affect? Once again, in order to begin answering these questions, we might find it more helpful to view some of the historical tissues of a whole body of ideas based on interaction, rather than envisioning this "new aesthetic" as only connected to current ideas and technology.

It was not a coincidence that Kant's notion of disinterestedness in his critique of aesthetic judgment coincided with Baumgarten's naming of this area of thought. This emphasis on formalism may be viewed as an attempt to reconnect art with its capacity for communicating the qualitative aspects of human experience. This capacity was almost lost in the myriad of exploitations art has undergone in the past. The possibility of art being disconnected from this kind of value still exists. The two most challenging cultural experiences of this century have been the rise of industrial and electronic technology and the increasing rise of democratization embodied in capitalist form. Both have offered renewed possibilities for abuse of the power of art. Both have been central issues in aesthetic theories calling for involvement in social change.

Throughout the twentieth century both the most virulent attacks on the whole notion of art for art's sake and the most powerful examples of aesthetics connected to value outside the world of art have come from Marxists [19]. Whether the specific theory derives from Soviet socialist realism, anti-realist positions such as those of Bertolt Brecht or Walter Benjamin, or French Structuralist Marxism, all have in common the ultimate objective of struggling to transform a particular society's dominant values. This trend includes the Dada and Surrealist movements, both of which had members who were overtly Marxist in their politics [20]. Two of the most influential thinkers, respectively, in dramatic aesthetics and the aesthetics of the visual arts are Brecht and Benjamin. The objective of Brecht's theories of "epic theatre" [21,22] is to deliberately break the illusion of reality created on stage so as to make plain the social forces behind a dramatic situation. Benjamin's prophetic inquiry into the undermining of the authority of art by mechanical reproduction of the fine art object has at its source a political analysis of the value of art [23].

Contemporary Marxist critic Terry Eagleton insists that in the various manifestations of the contemporary postmodernist aesthetic, he finds both defenses and antagonisms of the integration of art and life, aesthetics and value. He sees these descriptions as applying simultaneously to postmodernist manifestations. For Eagleton, this is so because of contradictions between economics and culture:

> The avant garde's response to the cognitive, ethical and aesthetic is quite unequivocal. Truth is a lie; morality stinks; beauty is shit. And of course they are right. Truth is a White House communiqué; morality is the Moral Majority; beauty is a naked woman advertising perfume. Equally, of course, they are wrong. Truth, morality and beauty are too important to be handed contemptuously over to the political enemy [24].

Eagleton views the contradictory nature of contemporary aesthetics as mirrored in modern ethical thought. Both the aesthetic and the ethico-political are preoccupied with the relation between particular and universal. Modern ethical thought, according to Eagleton, has disabled us from seeing "the need, method, or possibility of extending this value (love) to a whole form of social life" [25]. In other words, one way to transform the limits of our ethical thought to include the right of every sentient being to have his or her difference respected is to transform the aesthetic.

Transforming the Aesthetics of Virtual Worlds to Impact Ethical Thought

This leads us back to the central question—what impact does an aesthetic based on interactivity and virtual systems have on ethical issues? Or put another way, how does transforming the aesthetic through interactive virtual systems transform the limits of our ethical thought? Three bodies of thought have been particularly helpful in guiding me through the maze of connections between traditional and emerging aesthetics, traditional and emerging ethical thought, and the seemingly new mix of aesthetics and ethics generated by the possibilities of virtual worlds. The first perspective is that of Ludwig Wittgenstein, the twentieth-century German philosopher. The second is found in Bertolt Brecht's theory of dramatic interaction. The third is contemporary feminist moral theory.

Wittgenstein was most successful in escaping the Cartesian prison in which we have found ourselves since Descartes decided

> to rid myself of all the opinions I had adopted, and of commencing anew the work of building from the foundation, if I desired to establish a firm and abiding superstructure in the sciences [26].

With Descartes, reality becomes external. We, as Cartesian beings who have to resort to our doubt that we exist to prove that we exist, find ourselves in an abstract universe, in which we can only exist if we answer the question, "Is it true?" According to Descartes, that question can only be answered by the mind's powers of representation because we are barred from knowing the world (reality) through any other method. Concrete experience is not enough justification for the existence of the bodiless mind to which Descartes has diminished us. Descartes' influence, not only on the sciences, for which he originally began his *Meditations,* but on the whole of Western thought and culture, is immense and has left us with a true fetish for accurate representation. This representation becomes the foundation upon which we are then, in the Cartesian paradigm, to build our belief and understanding of the world.

The obvious problems with this approach, with which succeeding generations of philosophers have had to contend, are Descartes' insistence on certainty, known as foundationalism, and his mind-body dualism, which has fostered continuing problems with the status of "other-minds." Simulation is directly connected to the former while artificial reality stems from the latter. The general consequence of the acceptance of the Cartesian paradigm has been the separation of thought from the rest of life, ostensibly a purifying measure and one that will ensure a correct path to knowledge. This consequence, however, has led to the continuing belief that disciplined thought is only possible in science and similar uses of thought. Therefore language, such as that used to discuss ethical issues, is unqualified to be ranked as true knowledge. Various philosophers have attempted to work under these constraints towards the goal of bringing questions of meaning back into the foreground of philosophical thought, while attempting to bring philosophical thought back into the center of all human activity. Wittgenstein responded to this enormous task by refusing to argue with the established canon of Cartesian knowledge on its own terms. Instead, he offered a different view, one involved with the idea of wonder at the world.

According to Descartes, only man has the ability to think, and this ability separates him from the rest of the world, even from that part of the world that houses "this thinking I": the body. This separation is what Morris Berman calls

> the final stage in the development of nonparticipating consciousness, that state of mind in which one knows phenomena precisely in the act of distancing oneself from them [27].

Berman goes on to say the result of this distancing of nature and consequent reduction of its mysterious whole into distinct and, therefore, understandable parts is the supposed ability to manipulate it to our advantage. The manipulation and control of nature is a very different rationale for the accumulation of knowledge than the impetus for knowledge of the Middle Ages. Instead of teleological purposes for the acquisition of knowledge, Descartes, and Galileo before him, had very different reasons for their scientific inquiries, the results of which continue to affect our relationship to knowledge. "How" became the important question, not "Why." Descartes makes this goal explicit in the *Discourse of Method*:

> [My discoveries] have satisfied me that it is possible to reach knowledge that will be of much utility in this life; and that instead of speculative philosophy now taught in the schools we can find a practical one, by which, knowing the nature and behavior of fire, water, air, stars, the heavens, and all the other bodies which surround us, as well as we now understand the different skills of our workers, we can employ these entities for all the purposes for which they are suited, and so make ourselves masters and possessors of nature [28].

In this quote, we can clearly understand the connection Descartes makes between knowledge and mastery. He compares the utility of understanding and possessing nature to the comprehension already acquired to utilize "our workers." "All the other bodies which surround us" included all of the natural environment, animals and human beings whose existence, for Descartes, was justified by their skills in working.

Berman, in his erudite history of the body in Western civilization, *Coming to Our Senses,* cites the relationship between animals and man as a telling indicator of how the people of the period of history in question relate to their own bodies:

> . . . knowledge of this takes us directly into the Self/Other relationship, which in turn "unpacks" the culture in question, or the historical period being studied [29].

With Descartes' "proof" of the mechanical philosophy, animals became automata, machines that could be used for a specific purpose—experimentation. Since the seventeenth century, the use of animals in experimentation has grown to a large-scale business, numbering millions of animals per year in this country alone [30]. And as Berman points out:

> . . . animals are now regarded as laboratory tools, experimental "equipment" no more significant on an invoice or order sheet than test tubes or graduated cylinders. They are literally "stuff," and this is the nadir of the Self/Other relationship. . . . [31]

Allucquere Roseanne Stone makes an equivalent connection between Cartesian mind-body dualism and the politics of power:

> Because of the way power works, it is important to remember that forgetting about the body is an old Cartesian trick, one that extracts a price from those bodies rendered invisible by the act of forgetting—those on the lower end of the social scale by whose labor that act of forgetting is made possible [32].

The later Wittgenstein proves to be enormously helpful in offering us a different vantage point from which to view the Cartesian paradigm involving the necessity of separating our bodies from our minds. In the previous section on foundationalism, we found Wittgenstein's offerings of an alternative image to the traditional Cartesian one based on rationality-as-representation. It is imperative to remind ourselves that Wittgenstein does not try to beat Descartes and the whole inherited Cartesian tradition by attempting to answer the need for Cartesian certainty. Answering that need for certainty as if it were a relevant question would then lead again to the concept of thought representing reality. And again our language, the external proof of our thought—and according to Descartes, our existence—would then be interpreted as merely reports of some reality. For Wittgenstein, language does not refer to sensation, but replaces it:

> Here is one possibility: words are connected to the primitive, the natural, expressions of the sensation and are used in their place. A child has hurt himself and he cries; and then adults talk to him and teach him exclamations and later, sentences. They teach the child new pain-behavior.
>
> "So you are saying that the word 'pain' really means crying?"
>
> On the contrary: the verbal expression of pain replaces crying and does not describe it [33].

Wittgenstein is putting before us an image of an entirely different view of the connection between internal and external, between the mind and the body. Wittgenstein shows us the possibility that our language is the embodiment of our sensation, thereby allowing us to imagine the possibility of the oneness of mind and body. Our "utterances" of pain do not represent our pain, they are the pain.

In his later work, Wittgenstein offers us a way to think about meaning that does not rely on the Cartesian assumption of the separation of knowledge and meaning. He also gives us the chance to see ourselves as part of the world, not as the primary source of knowledge. We are able to understand ourselves through communication with others. Once we understand that we are part of what we had considered to be the external world, we no longer have to build an intellectual superstructure to stand in for the world, one that we relied on to answer our questions about how and why to act in the world. Wittgenstein offers us the possibility of comprehending meaning through the use of language, if we understand language as a particular kind of action. Language is interactive. Once more part of the world we are able to understand interaction as meaning, which offers us immediate answers to our questions about how and why to act in the world.

Like Wittgenstein, Brecht was not only attempting to free his discipline from the particular theories that had dominated that art form since Aristotle, but, in so doing, he was offering it the opportunity of a decidedly different worldview. Elsewhere, I have detailed this difference more completely as it applies to dramatic interaction in the development of virtual worlds [34]. In this paper I would like to emphasize how the connected concepts of the universal and the particular are viewed differently by Aristotle and Brecht. Aristotle describes the poet and the historian as differing not in their styles of writing, but in what they express. For him, poetry expresses the universal, history the particular. We gain pleasure from the satisfaction of understanding something common to people of all times and places. He calls poetry ". . . a more philosophical and higher thing than history" [35]. Brecht takes issue with this judgment, when he says:

> The "historical conditions" must of course not be imagined (nor will they be constructed) as mysterious Powers (in the background); on the contrary, they are created and manipulated by men (and will in due course be altered by them): it is the actions taking place before us that allow us to see what they are [36].

Fate, or the gods, cannot be blamed for all the evils that man brings upon himself by his own actions. If one is able to understand the real causes of poverty, war, slavery, cruelty, murder, abuse, starvation and ecological disaster, one may be able to take action for change. For Brecht, context is all-important. The knowledge of it gives one the power to change:

> We need a type of theatre which not only releases the feelings, insights and impulses possible within the particular historical field of human relations in which the action takes place, but employs and encourages those thoughts and feelings which help transform the field itself [37].

It is this desire for change—called "empowerment" in postmodern terminology—that drives Brecht towards a dramatic theory that refuses to immobilize the viewer with a cathartic experience. Brecht wants to place the viewer in a powerful position. All of Brecht's directives are based on his desire to ". . . leave the spectator's intellect free and highly mobile" [38]. In this state, the viewer is able to clarify his thoughts and decide what action should be undertaken.

The two disparate worldviews of Aristotle and Brecht underlie very different approaches to the idea of designing a virtual world. Like myth, theatre, film and the visual arts, virtual reality is an attempt to understand ourselves and our place in the universe. Our reaction to that understanding may vary according to the ideas of the environment in which we come to that understanding. Brecht's theories of dramatic structure are vehicles for the imparting of knowledge, a means of understanding the context in which that knowledge is developed, and the encouragement to act on that knowledge.

This emphasis on the particular is echoed in contemporary feminist moral theory. Based largely on Carol Gilligan's ground-breaking empirical research and consequent seminal book on woman's developmental theory, *In a Different Voice* [39], contemporary philosophers and theorists [40–42] propose a conception of morality based on care, responsibility and relationship—in contrast to the morality of justice derived from the philosophical tradition of Kant. In Gilligan's own words, the far-reaching significance of the acknowledgement of a "care perspective"

> . . . in woman's moral thinking suggests that the study of women's development may provide a natural history of moral development in which care is ascendant, revealing the ways in which creating and sustaining responsive connection with others becomes a central moral concern. The promise in joining women and moral theory lies in the fact that human survival, in the late twentieth century, may depend less on formal argument than on human connection [43].

The idea that the ethic of care and responsibility might be extended—it cries to be extended—to the political sphere and to our social lives as a whole is affirmed by feminist political theorists, such as M.F. Katzenstein and D. Laitin. They explain that although the fundamental morality of the care perspective derives from the conviction that responsibility is owed to the contextualized individual and not to abstract principles of justice, that conviction also includes ideas about the political sphere:

> Central to this conviction was the belief that the private and public spheres could not be set apart. To foster mutual caring and responsibility in the private domain required the exercise of political power on the public stage. To achieve responsibility and caring in public life demanded that values learned and exercised in personal relationships and family life had to be transported into public arenas of authority [44].

This notion of the necessary relationship between public and private spheres is echoed in Eagleton's delineation of the "ideology of the aesthetic." As Eagleton asserts:

> The aesthetic is preoccupied among other things with the relation between particular and universal; and this is also a matter of great importance to the ethico-political [45].

It is the actual needs and desires of individual beings that render them at the same time different from and similar to other beings. The right to participate with others while having these differences respected is what the ethico-political is about. Eagleton makes the point that Aristotle's idea of the polis is gone. Eagleton critiques modern ethical thought as having

> . . failed to take Aristotle's point that ethics is a branch of politics, of the question of what it is to live well, to attain happiness and serenity, at the level of a whole society [46].

Eagleton explains, and I contend, that in the development of the political goal of recognizing and taking responsibility for the care of others as individuals with needs and desires as important and necessary as one's own, ethical values in the aesthetic tradition work both towards and against that goal. It is imperative that we understand the history of the connection between ethics and aesthetics. This connection has had, and will continue to have, great impact on how technology defines and is defined by culture.

Recommendations for the Design of Virtual Worlds

The preceding is a summary of connections and contrasts among several aesthetic and ethical spheres of thought I have found most helpful in contemplating making art with virtual systems. If virtual reality is to play a role in the emergence of a new cultural paradigm of interaction, one whose agenda encourages the participants to take responsibility for their actions and their world, then it is imperative that we begin to develop an interactive aesthetic based on those goals. What recommendations can I offer for the development of this ethical interactive aesthetic? Several general recommendations seem in order, as well as more specific ones. Elsewhere, I have listed six factors useful in critiquing current trends in the design of virtual systems [47]. These factors include, but are not limited to: interface, content, environment, perception, plasticity and performance. This list was constructed out of the factors emphasized by present virtual-reality design trends, and the factors that I believe to be integral to the project undertaken by the emerging aesthetic of interactivity.

The recommendation that virtual-reality systems must be open systems can be made across the six factors of interface, content, environment, perception, performance and plasticity. Access to the technology for all people in all segments of society is another inclusive recommendation. Distributed access involving telecommunications will provide a wide range of contextual interventions to impede any monopoly. Certainly Brecht's notions of how dramatic structure can encourage participation and responsibility may be applied to these factors in general. From Brecht, we have learned that an environment that is not completely immersive—one that provides us with reality checks and pointers to physical reality, with its jumble of perception, environment, content and behavior—is one that ultimately will be the most creative and productive where it counts most, not only for ourselves, but for others in the real world. Simultaneously, allowing the participants freedom in defining their world by allowing them to develop tools and contribute their own content will show them the importance of their involvement in determining the future of our relationships with technology. In looking at present trends in virtual-reality design, one has to account for where, how and why they are being made.

The following specific questions and accompanying recommendations address each of the factors' potential for opening up a multimodal information exchange, distributing control and contextualizing judgments, coupled with encouragement, concern or caring for the needs and desires of others as if they were our own. These descriptions were used originally for critiquing present trends in virtual reality design. Here, they are used for making recommendations for their use.

Interface

According to Brenda Laurel, editor of *The Art of Human-Computer Interface Design*,—the most complete compendium to date of ideas concerning this subject—the concept of interface has changed from one that only included the hardware and software through which the human and computer communicated to a concept that includes the ". . . cognitive and emotional aspects of the user's experience as well." She adds, "An interface is a contact surface. It reflects the physical properties of the interactors, the functions to be performed, and the balance of power and control" [48].

She also suggests that one of the reasons interface design is so hard to accomplish is that it is "interdisciplinary and highly political." These remarks by Laurel, one of the pioneers in virtual-reality design, are extremely applicable to a definition of interface that considers contexts in which the points of contact between humans and computers are developed. Perhaps Myron Krueger's ideas on unencumbered responsive environments have been on the right track all along. As an interface, they seem to solve many of the problems that encumbered immersive environments generate. Ultimately, the interface must reflect—since it will also direct—our sense of wholeness as physical beings and our trust in our ability to make judgments.

Content

The content of a virtual world can be defined as what that virtual world purports to be about—its meaning. In a virtual world designed by the Human Interface Technology Lab at the University of Washington, Seattle, one is immersed in a underwater shark-filled world in which one is directed to net the sharks. In this world, the goal, on one level, would always have to be netting enough sharks. Our relationship to the sharks can only be one of dominance and destruction since netting automatically disintegrates them. Meaning can be derived, however, from a combination of content and the context in which that content exists. The "angry god" face, which appears and announces that the game is over because not enough sharks were netted, provides the context of the world. In this world, the user has extremely limited control or choice—the author of the software program has given the computer control of this world. This world's meaning exists in the hierarchy and dominance demonstrated by the consequences of not netting the sharks. The content of a virtual world must be able to be defined by the participants, its meaning then reflecting the context of their physical reality. Engagement should not take precedence over the knowledge offered in meaning.

Environment

Environment includes the space in which the world exists and all the identifying physical qualities of that world. What relationship the participant has with this world will in some ways be determined by the environment. How changeable by the participant is the environment, how infinite, how limited? How much of it does the participant determine? The environment, also, must be able to be molded by the participants. Together, they will map meaning on the world.

Perception

How close to human perception—sight, touch, smell, hearing, kinesthesia—does the world allow us to come and how much control do we have over these perceptions? How much does our involvement in the virtual world depend on "amplifying" or manipulating our senses? Control over the participant's perceptions should, ultimately, be under the direction of the participant.

Performance

How and why do we interact with and in the virtual world? On what does our behavior depend? Does our behavior affect others inside or outside of the virtual world? In what way does our behavior affect the virtual world, or the actual world? Is it an open or closed system? How and why we are interacting with, and in, the virtual world should be made clear. On what our behavior depends and how our behavior affects others in the virtual world, or outside of it, should be made manifest. The consequences of our behavior in the virtual world and its consequences in the actual world should be transparent.

Plasticity

How moldable, flexible and pliable are the characteristics of the virtual world? How much does it push back? What does it give the participant back? It should be moldable, flexible, and pliable, but it should also push back. The cause of that pushing back should be the actual, physical reality of which virtual reality is a part.

Often overlooked is the fact that virtual reality is only a humanly constructed part of the actual physical reality in which we exist. We, after all, have created it in our image. Sometimes it mirrors all of the same nagging questions of how and why we act—questions we hoped we had left behind in the "real" world.

Contemplating any one of these six areas will necessarily bring up issues involving the other five areas. We may successfully engender enough thought to assist in developing other recommendations for an ethical aesthetic for virtual worlds. My hope is that the preceding text demonstrates not only the advantages of working towards an ethical aesthetic for virtual worlds, but the implausibility of doing anything else.

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Granular Synthesis of Sounds by Means of a Cellular Automaton

Eduardo Reck Miranda

ABSTRACT

Chaosynth is a new sound synthesis system being developed by the author and others working at Edinburgh University. Chaosynth functions by generating a large amount of short sonic events, or particles, in order to form larger, complex sound events. This synthesis technique is inspired by granular synthesis. Most granular synthesis techniques, however, use stochastic methods to control the formation of sound events, while Chaosynth uses a cellular automaton. Following an introduction to the basics of granular synthesis, the author explains how Chaosynth's technique works. He then introduces the basics of cellular automata and presents ChaOs, the cellular automaton used in Chaosynth. The article concludes with some final remarks and suggestions for further work.

GRANULAR SYNTHESIS AND CHAOSYNTH

The granular synthesis of sounds involves the production of thousands of short sonic particles—for example, 30-millisecond-long sounds—that are combined to form larger sound events. This synthesis technique was inspired by Denis Gabor's proposition that large, complex sound events are composed of simple acoustic particles, or sonic grains [1]; he suggested that a granular representation can be used to describe sounds with complex morphology. Norbert Wiener [2] also adopted a "granular" representation of sounds to measure the information content of a sonic message. It was the composer Iannis Xenakis [3], however, who suggested the first theory of granular synthesis for musical purposes. Since then, a few others (Barry Truax [4] and Curtis Roads [5], for example) have proposed granular synthesis systems.

So far, most of these systems use stochastic methods to control the production of sonic particles (for example, density and duration of particles). Chaosynth proposes a different method: the use of cellular automata (CA) [6–8].

THE BASICS OF CELLULAR AUTOMATA

Cellular automata are mathematical models of dynamic systems in which space and time are discrete and quantities take on a finite set of discrete values. A cellular automaton is often represented as a regular array with a discrete variable at each site, referred to as a cell. The state of a cellular automaton is specified by the values of the variables at each cell. The automaton evolves in synchronization with the tick of an imaginary clock according to an algorithm that determines the value of a cell based on the value of its neighborhood [9,10]. This algorithm is called global transition function, or simply F. As implemented on a computer, the cells are represented as a grid of tiny rectangles whose states are indicated by different colors.

Cellular automata were originally introduced in the 1960s by John von Neumann [11] as a model of biological self-reproduction. He wanted to know if it is possible for a machine to reproduce—that is, to automatically construct a copy of itself. His model consisted of a two-dimensional (2D) grid of cells, each of which was in one of a number of states; each state represented the components of the self-reproducing machine. Controlled completely by the global transition function designed by von Neumann, the machine (a pattern of cells in the grid) would extend an arm into a virgin portion of the universe (that is, the grid), then slowly scan it back and forth, creating a copy of itself.

A wide variety of cellular automata and transition functions have been invented and adapted for many modelling purposes. Cellular automata have also attracted the interest of musicians because of their organizational principles. Various composers and researchers have used cellular automata to aid the control of both higher-level musical structures (musical forms) and lower-level sound structures (the spectra of individual sound events) [12–18]. Chaosynth uses cellular automata to control the inner structure of sounds.

THE ChaOs CELLULAR AUTOMATON

The Metaphor

ChaOs (an abbreviation of Chemical Oscillator) is a metaphorical model of a neurophysiological phenomenon known as a neural reverberatory circuit [19,20]. ChaOs can be thought of as an array of identical electronic circuits called nerve cells. At any moment, a nerve cell can be in a quiescent, depolarized or burned state. The array tends to evolve from an initial random distribution of these three states in the grid to an oscillatory cycle of wave patterns. The behavior of ChaOs resembles the way in which most of the natural sounds produced by acoustic instruments evolve: sounds tend to converge from a wide distribution of their partials (for example, noise) to oscillatory patterns (for example, a sustained tone).

A nerve cell and its neighborhood interact through the flow of electric current between them. Minimum (Vmin) and maximum (Vmax) threshold values characterize the state of a nerve cell. If the nerve cell's voltage (Vi) is under Vmin, then the nerve cell is quiescent (or polarized). If it is between Vmin (inclusive) and Vmax values, then it is being depolarized. Each nerve cell has a potential divider that is aimed at maintaining Vi below Vmin. When the divider fails (that is, if Vi reaches Vmin) the nerve cell becomes depolarized. There is also an electric capacitor that regulates the rate of depolarization. Cells have a tendency, however, to become increasingly depolarized with time. When Vi reaches Vmax, the nerve cell fires and is burned. A burned nerve cell at time t is auto-

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matically replaced by a new, quiescent nerve cell at time t+1.

The behavior of ChaOs is specified by setting up a number of parameters:

- the number n of states, such that $n \geq 3$
- the resistances r1 and r2 of the potential divider
- the capacitance k of the rate of depolarization
- the speed t of the imaginary clock
- the dimension of the grid.

The Algorithm

The states of nerve cells are represented by a number between 0 and n–1 (n = amount of different states). A nerve cell in state 0 corresponds to a quiescent state, while a nerve cell in state n–1 corresponds to a burned state. All states between the two exhibit a degree of depolarization corresponding to their state number. The closer a nerve cell's state number gets to n–1, the more depolarized it becomes.

The global transition function F is defined by three rules simultaneously applied to each nerve cell, and selected according to its current state: quiescent, burned or depolarized. The rules are as follows:

1. If the cell is quiescent, it may or may not become depolarized at the next tick of the clock (t+1). This depends upon the number of polarized nerve cells (Pcells) in its neighborhood (eight neighbors), the number of burned nerve cells (Bcells) in its neighborhood and the resistance to fire (r1 and r2) of the nerve cell:

if $\mathbf{cell(n)_t = 0,}$
then $\mathbf{cell(n)_{t+1} = int(Pcells(n)/r1)_t}$
$\mathbf{+\ int(Bcells(n)/r2)_t}$

2. If the cell is depolarized, its tendency is to become more depolarized as the clock t evolves. Its state at the next tick of the clock (t+1) depends on two factors: the capacitance k of the nerve cell and the degree of polarization of its neighborhood. The degree of polarization of the neighborhood is the sum of the numbers that correspond to the states of the eight neighbors (Pdegree) divided by the number of polarized neighbors (Pcells):

if $\mathbf{0 < cell(n)_t < n-1}$
then $\mathbf{cell(n)_{t+1} = k + int(Pdegree(n)/}$
$\mathbf{Pcells(n))_t}$

3. If a cell is burned at time t, it generates a new, quiescent nerve cell at time t+1:

if $\mathbf{cell(n)_t = n-1}$
then $\mathbf{cell(n)_{t+1} = 0}$

The Mapping Technique

The organization principles of ChaOs intuitively suggest that it could be applied to control the production of large numbers of sonic particles that together form a complex sound event. Finding an effective way to map the behavior of ChaOs onto the parameters of a synthesis algorithm is not, however, a straightforward task. I have devised and tested several techniques, but only a few produced interesting sounds. Following is an introduction to the technique currently implemented in Chaosynth.

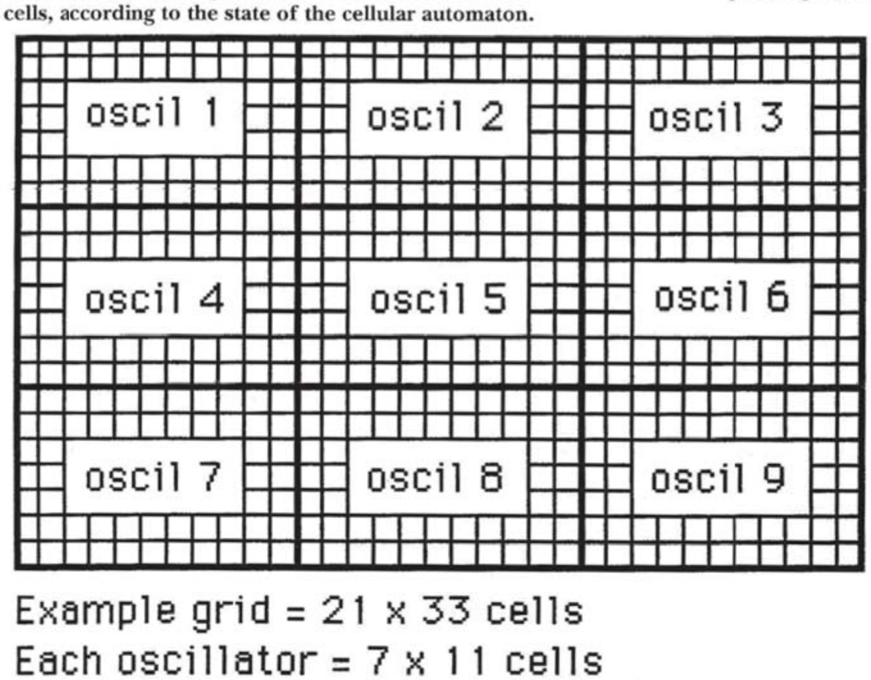
Each sonic particle produced by Chaosynth is composed of several partials. Each partial is a sine wave produced by an oscillator. An oscillator needs three parameters to function: frequency, amplitude and duration (in milliseconds) of the sine wave. ChaOs controls the frequency values and the duration of a particle, but the amplitude values are set up by the user beforehand. The states of nerve cells are associated with a frequency value and oscillators are associated with a certain number of nerve cells. The frequency values of partials at time t are therefore established by the arithmetic mean of the frequencies associated with the states of the nerve cells of the oscillators. The user also specifies the dimension of the grid, the amount of oscillators, the allocation of nerve cells to oscillators and the parameters of ChaOs (that is, the number of states, the resistances of the potential divider, the capacitance of cells and the number of iterations).

Each particle is, in fact, the product of the additive synthesis [21] of sine waves: at each iteration of ChaOs, all oscillators simultaneously produce sine waves whose frequencies are determined by the arithmetic mean over the frequency values of their corresponding nerve cells. The duration of a whole sound event is determined by the number of iterations and the duration of the particles. For example, 100 iterations of 30-millisecond particles result in a sound event of 10 seconds in duration. An example of a grid of 693 nerve cells allocated to 9 oscillators is shown in Fig. 1.

This mapping method is interesting because it explores the behavior of ChaOs in order to produce sounds in a way that resembles the functioning of some acoustic instruments (for example, the violin and the human voice). The random initialization of states in the grid produces an initial wide distribution of frequency values, which tend to settle into an oscillatory cycle. This behavior resembles the way in which the sounds produced by most acoustic instruments evolve during their production: their harmonics converge from a wide distribution (as in the noise of the attack part of a vocal sound, for example) to oscillatory patterns (the characteristic of a sustained tone).

We have synthesized sounds using up to 40 different ChaOs states (that is, 40

Fig. 1. An example of a grid of 693 nerve cells distributed to 9 oscillators; each oscillator, in this case, holds 77 nerve cells. The oscillators produce sine waves whose frequency values are determined by the arithmetic mean over the values of their corresponding nerve cells, according to the state of the cellular automaton.



different frequency values) and up to 25 oscillators on a 1,000,000 nerve-cell grid (1,000 × 1,000). The results resemble the sounds of flowing water. One can produce a wide range of gurgling sounds in various flow speeds with Chaosynth by varying the speed of the cellular automata's internal clock. Variations in tone color are achieved by varying the frequency values and the amount of nerve cells per oscillator. Different rates of transition from noise to oscillatory patterns are obtained by changing the values of r1, r2 and k.

The Chaosynth Program and the Parallelization Technique

The architecture of the program is shown in Fig. 2. The sounds are synthesized using Csound [22]. Csound is software for sound synthesis in which one specifies a synthesis algorithm in an orchestra file and a list of synthesis parameters in a score file. When the Csound compiler is activated, it reads these two files and produces a sound file for playback.

Chaosynth's user interface triggers the cellular automaton, which produces a Csound score file. The score file activates the Csound compiler and plays the sound.

The current version of Chaosynth (1.0) uses parallelization in order to speed up the cellular automata algorithm. To parallelize the cellular automata algorithm, we took advantage of the Parallel Utility Library–Regular Decomposition (PUL-RD) utility at the Edinburgh Parallel Computing Centre (EPCC) [23]. PUL-RD is a utility for the parallelization of grid-based problems using the regular domain-decomposition technique. The regular domain-decomposition technique involves arranging a very large set of data in a grid, then computing this data in parallel. The PUL-RD utility splits up a large grid of data elements into regular subgrids, then distributes them for concurrent processing. This allows much larger computations to be solved in shorter periods of time. Cellular automata are a typical case of regular domain decomposition.

In Chaosynth, PUL-RD is used to split the grid of nerve cells into subgrids; each subgrid corresponds to an oscillator. In this case, Chaosynth computes all oscillators in parallel.

We are currently parallelizing the sound-synthesis process of Chaosynth.

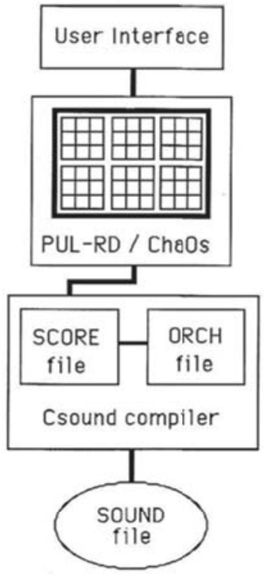


Fig. 2. The system architecture of Chaosynth. The system is divided into three main modules: the user interface, the cellular automata engine and the sound synthesis processor. The cellular automata engine benefits from parallel computing techniques; it provides the parameter values for the sound synthesis processor.

The Csound program takes too long to compile the sound files. Moreover, Csound is not suitable for synthesis in real time; it takes a few moments to produce a sound file for playback. Our aim is to provide Chaosynth with means for real-time sound synthesis. To accomplish this, we are devising ways to provide Chaosynth with its own sound synthesis module. This synthesis module will feature parallelization in order to speed up the synthesis process. We expect to be able to provide real-time changing of the parameters of Chaosynth, so that the user can actually "play" it as a musical instrument by using appropriate controllers (for example, joysticks, MIDI devices [24], the Dataglove and Biomuse [25]).

Conclusion and Further Work

In this article I introduced Chaosynth, a cellular automata–controlled additive synthesizer that generates a large amount of short sonic particles in order to form larger, complex sound events. Chaosynth can produce a wide variety of sounds; however, more research is needed to gain a better understanding of the role of Chaosynth's parameters.

The cellular automaton used by Chaosynth to control the production of the sonic particles is called ChaOs; it mimics a neurophysiological phenomenon. Of the many possible ways to map the behavior of ChaOs onto the parameters of the synthesis algorithm, we have implemented only one, which is capable of producing interesting sounds. We are, however, aware that instead of providing a system that uses only one mapping possibility, we should provide the means for user-specification of other mapping possibilities. We are currently studying how to provide this facility.

Although the parallelization of the cellular automata algorithm provides high performance computing to Chaosynth, the system still does not produce sounds in real time; the user has to wait a few seconds until the sound can actually be heard. We are currently parallelizing the synthesis module of Chaosynth (Fig. 2) in order to be able to produce sounds in real time. We intend to allow the user to change its parameter values during the production of the sound, as if he or she were playing a musical instrument, by using appropriate controllers.

We have produced an electroacoustic music composition, "Olivine Trees," using Chaosynth's sounds. "Olivine Trees" was inspired by a Van Gogh painting, "Olive Trees" (National Gallery of Scotland, Edinburgh). The varied and individually identifiable brush strokes of this painting inspired the composition of the sounds of this piece; in direct correlation, color relates to timbre and length of brush stroke relates to the duration of individual sounds. Olivine is the name of the EPCC workstation where we worked with Chaosynth to produce the sounds of the piece. Olivine Trees is perhaps the first piece of music ever composed using a parallel computer.

Chaosynth is available to composers as part of the EPCC's Computer Music Workstation set of programs.

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Interactive Journeys: Making Room to Move in the Cultural Territories of Interactivity

Norie Neumark

ABSTRACT

This paper explores the aesthetics and politics of popular cultural computer imagery in games, television and film. The author aims to map a ground for criticism of computer graphics and interactive works—by excavating cultural meanings underlying the dominant aesthetics in these images and asking what they do for their producers and users. Do the metallic bodies armor the user/producer for the fear (delight) of a machine world, producing fear (delight) in the process? Is morphing a technique to evade, or explore, the identity crisis precipitated by awareness of cultural difference? What desires produce and are produced by the gravity-less perspective and movement of three-dimensional animation? The author's theoretical project explores how popular cultural computer aesthetics and techniques express and (re)produce subjectivity in postmodern culture. These ideas are examined through everyday aesthetic experiences, representational practices and techniques, and the accompanying changes in perception.

This is a story of journeys into interactivity—the story of what happened when a theorist and a visual artist journeyed into the terrain of interactive computer works. Or rather, this paper starts where that story ends. I want to begin by first navigating through some imaginary interactive journeys into the popular cultural interface, in order to focus on theoretical issues of aesthetics, politics and subjectivity. (I use the term "popular cultural interface" to refer to the computer interface at work in popular culture—particularly the computer-generated graphics, imagery and design in popular cultural artifacts from games to television to films.) In the second half of the paper, we will travel along some of the different interactive paths constructed by scientists, engineers and educators. At the crossroads of these interactive paths and those of popular culture lay the starting point of our own interactive project.

My broad aim in this paper is to map the ground for a criticism of computer imagery and techniques in popular games and educational/informational interactive works. To do so I will also need to venture into the broader territory of television and film computer graphics in order to excavate the cultural meanings underlying the dominant aesthetics of these images and interactive works and to ask what they do for their producers and users. My interest in these cultural terrains lies at the intersection of a theoretical project on computer culture and a practical project involving work with a visual artist on an informational interactive computer work. My theoretical project concerns how popular cultural computer aesthetics and techniques express and (re)produce subjectivity in postmodern culture—how they texture the ways in which technology operates as a "fundamental constraint in the production of subjectivity" [1]. These ideas are experienced and produced through everyday aesthetic experiences, representational practices and techniques and the accompanying changes in perception [2]. My political concern is how these ideas relate to different versions and subversions of computer culture, particularly across a spectrum of gender, age, ethnic and racial diversity.

Journeys into the Popular Cultural Interface

The first question, before we set out on our journey into the interface of popular interactivity and computer graphics, will be what to wear.

Dressed in Metal

Our first journey sees us wearing rather trendy outfits—the bright and shiny metallic look that is virtually *de rigeur* evening wear for the high-end popular cultural interface. This look fits a number of different bodies and suits us up for certain generally costly navigational paths on the small screen of television and the big screen of the cinema.

So, there we are at the interface, wearing our metal outfits, perhaps weighed down by clichés, perhaps ready for quick and strategic movement. As a landscape, the terrain of popular cultural computer imagery that one can survey and traverse while wearing a metal outfit can be like a desert, not a very rich ground for new life to spring from. But like the desert, the metallic landscape might also be beautiful and alluring, perhaps more complex and rich in the flesh than in its arid metaphor.

Navigating timescapes in our metallic wear, we may be reminded of another moment in the past. We may experience today as what science fiction in the past told us today would look like. The metallic look here risks being so overcoded as yesterday's future that it loses its fantasy edge. It is as if computers are stuck in a time warp where they have to look like what science fiction promised and where they are "destining their own future and past," according to cultural archeologist Albert Liu [3]. He traces a consistent genealogy from the chrome of the 1930s to the late 1960s Silver Surfer (a Marvel comics superhero with a silver metalloid body) to the high-tech future of post-technological beings. This genealogy follows the tracks of the people who invented rendering and computer imaging—people who came out of the whole aesthetic of science fiction and comics. These graphics producers' own science-fiction aesthetic became embedded in the "possibilities of the programs" [4]. What holds computer aesthetics in this time warp is not only the aesthetics of their pro-

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ducers, shaped in some measure by a certain male aesthetic, but also capitalism. The old "tried-and-true" is what is likely to sell, it is believed, resulting in an economically irrational refusal to see how much of a market is lost by keeping those limitations.

Chrome is a particular sort of metal that can color the timescape as well as the landscape in this journey to the interface. William Gibson, for instance, chrome-colored many of the metallic images in his book *Burning Chrome.* And in one of his stories, "The Gernsback Continuum," in which his science-fiction desert is colored with crystal and metal, art deco and science-fiction imagery merge [5]. If chrome reflects the future of the past (as in art deco) then perhaps when one wears it, the interface is colored by a retro feeling of safe familiarity, seductive with a promise of some fascinating future. And does this retro feeling, a typical postmodern perception and experience, work like its referent—art deco—to override cultural differences to the point of loss of visibility? [6]

The desert of metallic timewarp gains its science-fiction reflective surface not just from the aesthetics of science fiction and comics but also from high design. Chrome is a metal that reflects—one sees everything except the thing itself. Chrome is a metal that was used to cover surfaces during its heyday in the era of industrial design, when mechanical things emphasized surfaces and exteriors by hiding and suggesting. As Allucquere Roseanne Stone has suggested, the 1930s' modern culture hid the "guts and intestines and smells and tastes and workings of things . . . paying attention to the surface and metaphorizing the insides"—thus making/acknowledging them as both desirable and frightening and, increasingly, creatures of the imagination [7].

Chrome's reflective surface intensified and represented the modern move to an aesthetics of surface and skin. Chrome metallic images in computer graphics continue this lineage. Not surprisingly, one of the first computer-animated shorts was "Chromosaurus." Indeed, there is an etymological connection between chrome and skin, as Albert Liu has traced [8]. When we wear our metal outfits, do they feel like a second skin? A skin that enables movement (of a particular sort) or a skin that inhibits breathing or . . . ? Are we perceiving a deadening reflection and repetition of metal images all around us and suffering sensory deprivation without other colors and textures? Or are we excited by the glitter and glitz? A moment of interface is laden with historical determinations and readings, yet it is still open, perhaps, to political/cultural contestation.

BEAM ME UP, MORPH ME OVER

In this journey into the interface, the material that once held the promise of the future, a promising future, has become threatening [9]. A different, particularly filmic disordering by speed and motion characterizes the very latest in high-end metallic looks—a very different outfit than the armored representations often associated with metal beings. The metallic look in films is modelled on the smooth metalloid body of the Metalmorph. ("Metalmorph" is Albert Liu's generic term for boneless, liquid, metalloid beings.) Its metal is worn on the inside and can bring *Terminator 1000* delusions or desires. According to Albert Liu, this new generation *Terminator,* the prototype model morphing villain in the popular James Cameron film *Terminator 2* (1991), exhibits the ultimate phallic boneless rigidity, a body without organs—perfectly suited to the flat-surfaced computer-graphic terrain [10].

But the Metalmorph is also particularly slippery, flexible, flowing and mobile—well-suited for traveling. Not only a metal being, but also a liquid metal being, a border creature of liquid/solid form, like the alien pseudopod in the underwater science-fiction film *The Abyss,* (James Cameron, 1989), where its rendering program was first used. The pseudopod's rendering program achieved a breakthrough in computer simulation:

> Rendering . . . since it is capable of simulating a holographic realism unattainable in sculpture—by creating the Metalmorph, returns the human figure to a prototypical, subhuman facelessness, its unidealized anonymity reinforced by realism. . . . T-1000's liquidity incarnates the anticlassical possibility of Dionysian sculpture. Accordingly, the Metalmorph marked a moment not in the plastic arts but in the plasmatic (as in *plasmatikos,* "molding") arts [11].

The Metalmorph renders a move away not only from the classical but also the modern representation of sculpture—in its monumental form, which was so appropriate to the bourgeois ideal of solidity. This postmodern Metalmorph is marked by its movement and speed as well as its formlessness. And the Metalmorph is not only a metallic being but also a morphing being that changes form and shape and takes on, or flows into, other shapes. And with a multibillion-dollar film budget, one can morph more exciting things than with our more economical home version.

Morphing—is it a body technique to evade (explore) the identity crisis precipitated by awareness of cultural difference in the postmodern West? It is illuminating to track the major territorial invasions of morphing in order to excavate its meanings. It is a currently and increasingly popular technique in film and music videos and in advertising. Frequently its beginning and endpoints play around with racial, gender and, even, species difference. One may want to read this play as erasing or highlighting differences, homogenizing or exposing the tenuousness of a type of identity that made sense in the mechanical age of modern capitalism but no longer does in the postmodern age of information. Is it a technique driven by the desire to *be* "other," not just travel to other worlds? Is this a fantastic disruption of "reality" (leaving one with abject queasiness) or an erasure of the significance of difference by tampering with the signs of difference?

It depends in part on one's location in time, space, place or discourse, as the producer or reader of the morph. Morphing could be read, via Marjorie Garber, like cross-dressing, as the creation of a "third sex" and as a sign of the "anxieties of binarity," the "constructedness" of gender and the crisis of cultural categories [12]. From this view, morphing allows the taking on of different personas, allowing one to present oneself as a spectacle, transform oneself or be multimorphous, unbound by notions of the essential—typical of postmodern sensibilities and subjectivity. Thus morphing, like cross-dressing, allows for lots of mobility, irrespective of certain codes of race or gender [13]. Mobility, so basic a feature of computer culture, now moves beyond space and time to identity and persona.

However, from another viewpoint, both cross-dressing and morphing often fail as playful interceptions of the mainstream. In particular, playing with the boundaries of gender has been more difficult for women to benefit from than men. A look at Lucasfilms's multiple users game *Habitat,* for instance, reveals that at one level the cross-dressing and morph-like possibilities are wide open—body parts are interchangeable, one can "re-spray" one's color, one can change one's sex. And one will find lots of men cross-dressing as women [14]. But at the level of the graphics, the design of the imagery and the bodies is not particularly transgressive or diverse—it remains classically anglo, cute and "shapely." And while morphing may proliferate moments of boundary crossings on the plane of information and representation, the extent of their disruption of general cultural norms and pleasures is unclear.

In this critical light, one might read morphing techniques as a computer-culture version of cosmetic surgery or body building—as something that fails to disrupt or to dissolve structures [15]. For example, some of the most stunning versions of morphing involve two of U.S. popular culture's most exposed and fascinating examples of body building and cosmetic surgery—Arnold Schwarzenegger and Michael Jackson. Schwarzenegger, who built his own body, was paid well to be seen traveling around the interface with a morph (in the film *Terminator 2*), and was even apparently known to try it himself by having his color changed in a magazine image. Michael Jackson had what I remember as some of the earliest, most impressive examples of morphing across race and species in one of his music videos.

All this raises a political challenge facing us at each moment in the interface: to analyze what is going on culturally and politically with morphing, to trace the boundary destabilizations of its mobility and question whether they will end in restabilizations.

Speeding in Time, Floating in Space?

In this crossing, the issue is not just what one wears but how one moves. Does the metal outfit only shape one's body in a streamlined modernist way where form hides function—or does it also change function, enabling certain new movements? Does the flat iconic surface of the various screens on which computer graphics occur produce a desire for movements that create the illusion of depth?

We will find that in our metal outfits we are well-suited for gravity-free three-dimensional (3D) movement, so familiar in the computer graphics of television and film. Backwards and forwards through space, alongside those rendered metallic logos for television stations, the movements allow one to giddily float free and disrupt one's point of view, disturbing the staid position of classical perspective. But perhaps a movement can re-anchor one in a reality that has not changed—the reality of corporations that present "dazzling" ads. According to Judith Barry and Margaret Morse:

> When logos appear mysteriously on the screen, they seem to pass through our bodies on their way to our field of vision; when they swoop or tumble across the screen in elaborate trajectories, their controlled movements suggest not objects given momentum by some other force, but subjects with their own motive power. In this sense a logo can be thought of not only as the proper name of a station, but as a supernarrator that conveys us through various modes of discourse [16].

Judith Barry, following the path of Margaret Morse, tracks 3D computer graphics as they alter the place of the viewer and therefore subjectivity. While the continuous movement of metalloid figures locates the viewer deep inside space, in several places and planes at once, it is not only movement but also speed that gives them their meaning:

> Speed causes us to lose control, we give ourselves over to its exhilarating [sic] effects. It seems as though we are participating. . . . [I]n this universe of motion control to look is to be caught, not by an image but by something more powerful which delivers you to where it wants you to go [17].

The terrain we are pulled into here by speed and motion is one of a new sort of perspective, different from traditional cinematic space, which was a "believable, inhabitable representation" centered on "monocularly-based systems of perspective"—a space with a center at which the viewer is located and subjectivity ordered [18].

As we drive into the interface we may find ourselves navigating a fine line along a very repetitive road. Repetitive images can, however, play the soothing function of giving one something to hold onto in postmodern culture, where things disappear so quickly that they leave a gaping emptiness [19]. It is no surprise then that computer games, in which speed is crucial, are generally incredibly repetitive in their narratives and imagery.

What drives the movement and the drunken ecstasy of speed, which allows one to leave one's centered and controlled self behind—is it just the engine of capitalism and commodification? As we cross again into the interface, we can explore what drives speed.

The Pleasures and Compulsions of Swimming, Gliding and Surfing through the Interface

To think about the pleasures and compulsions of the interface in the computer graphics of popular culture's games, television and film, let us make four final crossings into the interface with four theorists, whom I asked to dress and go on this imaginary journey in a way that suited their sense of the interface.

The first crossing is with cultural archeologist Albert Liu, who chose scuba gear for his crossing into the interface. Scuba gear suggests and allows the crossing of media, which is how he imagines a crossing into the interface: a "submerging of the human body in another medium . . . a way to gain access to another . . . unnatural, inhuman experience . . . a human/inhuman fusion" [20]. Liu sees it as culturally significant that one chooses to experience these other realities via a machine, rather than, say, through drugs, meditation, reading or any of the other many possible ways in. That is not to ignore that these other methods may also be technological—but here technology takes a particular form, includes particular techniques and aesthetics, and shapes one's crossing into this landscape of other realities in particular ways [21].

For the second crossing, cultural critic Celeste Olalquiaga is wardrobe consultant. She is located in New York, a city where urban movement is a crucial concern outside the interface and fuels a desire to cross into it. We cross into the interface with her gliding on rollerblades. The roller-bladed styles on the streets are an image that is protective, fluid and robotic, reflecting the look on video-game monitors, appropriate to speed and violence. It is a look that allows one to glide in and out of the streets and the interface and realities in a merging or surfing-like manner [22], which recalls again the Silver Surfer and the resonance of computer games resembling comics in their look and significance to urban youth styles. This is a moment of interface between the city and the machine.

For the third crossing, on the other side of the continent, the guide is Katherine Hayles, a theorist at the boundary of science and literature, dressed in an iridescent body suit. Living in Los Angeles, hypersensitive to the pervasive traffic, Hayles crosses into the interface driven by an impatience with materiality, the desire to achieve infinite mobility and the exhilaration of speed. It is "a movement from materiality into information," a crossing that short-circuits the cognitive machinery by appealing more in a kinaesthetic sense. Being held up by traffic is certainly something one can escape in the cars at the video arcades. There one drives a car as fast as one wishes, crashing painlessly. Sometimes, the crashing is as exhilarating as the speed. The more adept, or those who get their thrills without spills, strive to improve technique and move ever faster in pursuit of their goals. And with the perfected techniques of computer games and video arcades, one's sensory channels are reconfigured [23].

And this brings us to the fourth crossing with cultural historian Klaus Theweleit. Clothing-free, he focuses on the sensory and the way one develops a whole new set of perceptions as one plays video games. Generations of youth follow generations of computers, differing in the way they perceive and react to/interact with images, movements and depth. In the timescape and landscape of computer games, the kinaesthetic sense of one's phenomenal body keeps up with that of the computer—the younger one is, the faster one sees and moves. For the generation that has grown up in the information age, the perception of time and the techniques with which they operate at the interface are very different from those who came later to computers. They move differently and at a different pace. Their aesthetic and kinaesthetic senses are being (re)shaped by computer culture [24].

After these four crossings we are perhaps ready to dive deeper into the way that desires, along with the senses, are being reconfigured at the interface—which takes us further into the question of driving. What drives one to cross into the interface? Sometimes it is the desire to enter another reality or extend or lose one's reality—perhaps even to have a radical experience and to test the limits of experience and desire. This desire may be to be in another time, space, place or medium with the intent of losing one's own particular perspective in time and space. As one moves from one's world through the screen, one becomes fluid and immaterial, no longer bound by the rules of the world. The move into the interface "is a movement from materiality into information . . . things exist in informational form [at the interface] where doors open that never could open in material form" [25]. Is this what makes doors such popular images on the interactive interface?

Via the machine, we are incredibly absorbed at the interface; we can supersede our symbolic faculties—senses are stimulated in ways that "confuse or obviate the brain." The whole design of computer games, for instance, allows one

> to assume a purely passive or automatic position with respect to technology, to allow it to access the senses without symbolic mediation, without going through the sign systems which have governed the production of meaning in our culture, namely language. . . . You enter [the interface] will-lessly, involuntarily, inconspicuously [26].

How this operates for the interactive interface of Sega computer/video games was described by one 14-year-old girl as an escape from "boredom, your mother, using your brain":

> it takes over your mind and you just get hooked on it til you've finished it. . . . It's an imaginary place where you can just relax and your mind goes free. . . . Your mind gets loose and stuff [27].

Are these games "fantasies" in the subversive way that Rosemary Jackson discusses?

> A fantastic text tells of an indomitable desire, a longing for that which does not yet exist, or which has not been allowed to exist, the unheard of, the unseen, the imaginary, as opposed to what already exists and is permitted as "really" visible [28].

Fig. 1. An image from the interactive computer work "Go For It" designed by Maria Miranda using MacroMind Director and produced by Norie Neumark, 1994. (Photo courtesy of Maria Miranda) The image demonstrates the attempt to generate computer graphics that speak to the aesthetics of a particular audience and add some of the pleasure and energy of a popular culture interface to an educational/informational interactive work.

Games are certainly fun, an escape, addictive even, but whether they are subversive fantasy or not depends in part on who plays and how, as well as what they play. Perhaps, just as with fantasy literature, computer games' subversive function resides in their structure rather than (only) their themes and content [29]. How computer games play with fantasy is determined at the graphic and technique level more than, or as much as, the narrative. When the narratives are located in "normally" violent, racist, sexist, romantic or realist territories, it may be only their disorienting speed and their low-resolution graphics that save them from performing a normalizing cultural function. These low-level "abject" bitmapped graphics may loosen the grip of "reality" on meaning and provide some room for the imaginations in the well-worn narrative and aesthetic grooves. The less intelligible it is, the more we can project fantasies and desire onto it. As David Humphrey suggests:

> A low-resolution image like a badly taken photograph, or an image produced after many generations of cheap copying, has the capacity to solicit the viewer's participation in a production of its sense. That degree of filling-in-the-details required to "recognize" or "define" the low-resolution image draws the viewer closer to the realm of memory and association . . . these vague images create an increased susceptibility to the unintended or subjective, exercised by the peculiarities of the maker and viewer. . . . Low resolution . . . translates as languid irresolution. The dumb simplicity of the dissolving gestures registers a low-intensity resolve to simply mark the surface without the burden of representation [30].

Journeys at the Crossroads of Art, Science, Education and Popular Culture

In conventional journeys to the heart of the machine with scientists, engineers and educators, one aims for the dead center of reality, bypassing the imagination as much as possible. No time for cross-dressing in this journey—"what you see is what you get." The drive seems to be to bypass the senses and plug the "brain" directly into databases or texts. Functionality is the starting point on this journey, navigational dexterity around hierarchically organized space is the priority. Scientists and engineers are generally more interested in playing around under the hood of the vehicle than giving it a new chrome finish. Their relation to the machine's insides follows the paradigm of science—constructing it as something to be conquered and controlled, and expressing their own power and subjectivity in these "useful" actions [31]. The cleaner and simpler the interface looks, the better, because it is less likely to bedazzle the user away from his or her main aim of following the well-laid navigational paths as quickly and efficiently as possible.

If an educator guides us on these journeys, our usual path can often be much the same as if we traveled with a scientist or engineer. So long as they can track our movements and we reach the proper destination, they are satisfied. And what does tracking as a technique of relating to the user do to the producer and the user? Although tracking has an element much like the commercial and government surveillance uses of computer, it is dressed up for this journey in the educational guise of "for your own good."

Of course there are engineers, scientists and educators whose perceptions exceed the boundaries of the knowledge system they work within, enabling them to see the significance of the graphic imagery interface. Still, this is not normal practice and many of the educational and informational interactive interfaces reveal the low level of awareness of the significance of aesthetics. Lack of concern with the graphics, music and speed factors tell teenage users that they are there for an educational rather than entertaining ride—which brings me to the question of how different it would be to travel to an interface where diverse young people can operate differently than in the usual educational or popular cultural mode, though with some of the pleasures and benefits of both.

An artist's approach to computer aesthetics makes room for possibilities to engage visual and aural pleasures and imagination and to disrupt "reality" at the educational/informational interface. How to do this is tricky because the techniques are not necessarily the same as those an artist can use when she is on her own turf. Issues such as these animated my interactive project with visual artist Maria Miranda. We worked in the context of an educational institution (University of Technology, Sydney) to produce an informational interactive work designed particularly for teenage girls from non-English–speaking and Aboriginal backgrounds. Our discussions with the girls raised a number of issues regarding how to interact differently with young people whose diverse aesthetics, pleasures, consciousnesses and bodies have been to a certain extent colonized and normalized by too narrow a repetition of dominant computer images and practices. It also brought up questions of how to work within the educational paradigms that focus not on the pleasure and subjectivity of the student but on the end product of knowledge/data to be accessed. Our political aesthetic strategy was to create a "real" world familiar/strange enough to excite curiosity, pleasure and engagement. We constructed paths that suited the desire for the "game" factor of surprise and challenge. The information was designed to fit the aesthetically pleasurable interface. The look was a lush, cartoony, non-"realist" world inhabited by culturally diverse bodies (Fig. 1). A "real" world (domestic and exterior) was animated expressively and fancifully, and an informational territory was infiltrated with the critical, "inconsistent" edge of the "art factor." When funding is limited and engineers, scientists and educators must be kept happy, the ability to transgress "realism" and speak to the aesthetic sensibilities of a culturally diverse audience of 15-year-old girls is a happy end and beginning of the story of these interactive journeys.

Acknowledgment

I would like to thank Maria Miranda for the discussion of ideas.

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Brain Wave Rider: A Human-Machine Interface

Keisuke Oki

ABSTRACT

Brain Wave Rider (BWR) is an interactive artwork produced by Digital Therapy Institute, an electronic-art group based in Tokyo. The author presents a brief description of the mechanics and ideas behind *BWR*. He then discusses various influences and related concepts, citing ethnographic accounts of religious rituals and postmodern theoretical writings.

Brain Wave Rider (BWR) is a game machine controlled by the player's brain. The player/rider commands a simulated vehicle by changing the state of his or her brain activity. The player can learn to make the vehicle speed up, slow down, shoot missiles and fly upwards.

BWR reads the player's brain waves, changing the speed of the vehicle as it moves forward in a computer-generated landscape. The brain-wave data are known as electroencephalograms (EEGs) in the medical field, and have been used primarily as measurements of brain activity. *BWR* uses the Interactive Brainwave Visual Analyzer (IBVA), a multimedia biofeedback system, to detect and analyze brain waves [1].

Standard brain-wave classification recognizes four kinds of waves: alpha, beta, theta and delta. *BWR* displays "symbols" corresponding to each brain-wave type and transmits the vibration of an imaginary engine to the player's body through a body-sonic board and chair (Fig. 1). Sound comes from speakers that are attached to the player's chair and helmet. In addition, flashing light-emitting diodes (LEDs) placed in the goggles worn by the player synchronize with brain-wave frequency.

Following is a list of brain-wave types and their corresponding symbols:

- alpha wave: missile launch (Fig. 2)
- beta wave: meteorite attack (Fig. 3)
- theta wave: explosion of substances in the brain (Fig. 4)
- delta wave: psychedelic patterns (Fig. 5)
- eye movement: flying image (Eye movement signifies ocular muscle signals with lower frequency than the brain waves.) Through these symbols, the player can visually recognize the waves his or her brain is emitting.

The most salient feature of *BWR*'s human-machine interface is that it uses the brain wave as a trigger that causes physical change without physical action.

Without button-pushing or other direct action upon an objective interface, the player can control the computer-graphic image, sound and vibration he or she perceives through meditation or mental calculation, i.e. by changing the state of his or her brain waves.

Digital Therapy Institute set up two *BWR* systems at "Psychoscape: Mind Observation through Art," an exhibition organized by ARTLAB [2].

BWR players begin by sitting down in a simulated cockpit, then put on a headband equipped with brain-wave detection sensors and don helmet and goggles (Color Plate B No. 4).

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Their brain-wave data are analyzed by two computers. A third computer reads the analyzed data and controls the devices for the sound and images [3].

The LEDs in the goggles flash in sync with the players' brain-wave frequencies, which are fed to the eye apparatus by the computers.

If player A should emit a higher-frequency wave, such as a beta wave, while player B emits a lower-frequency wave, such as a delta, B could be influenced to accelerate by A's brain waves and A could be influenced to slow down by B's brain waves, as brain frequencies tend to be influenced by the frequency of light or sound.

As mentioned earlier, the speed of the video image changes according to brain-wave frequency: higher frequencies cause the movement of the image to accelerate, while lower frequencies slow it down.

If both players emit higher-frequency waves, they can travel as if flying, while they will seem to crawl if both emit low-fre-

Fig. 1. Digital Therapy Institute, *Brain Wave Rider*, interactive computer game controlled by the player's brain waves, installed at ARTLAB's Psychoscape exhibition in Tokyo (1993). The player's headset is connected to computers that read and interpret his brain waves. He watches a terminal that displays imagery corresponding to his brain-wave type. The vibration of an imaginary engine is transmitted through a body-sonic board and chair. (Photo: ARTLAB, Canon, Inc.)

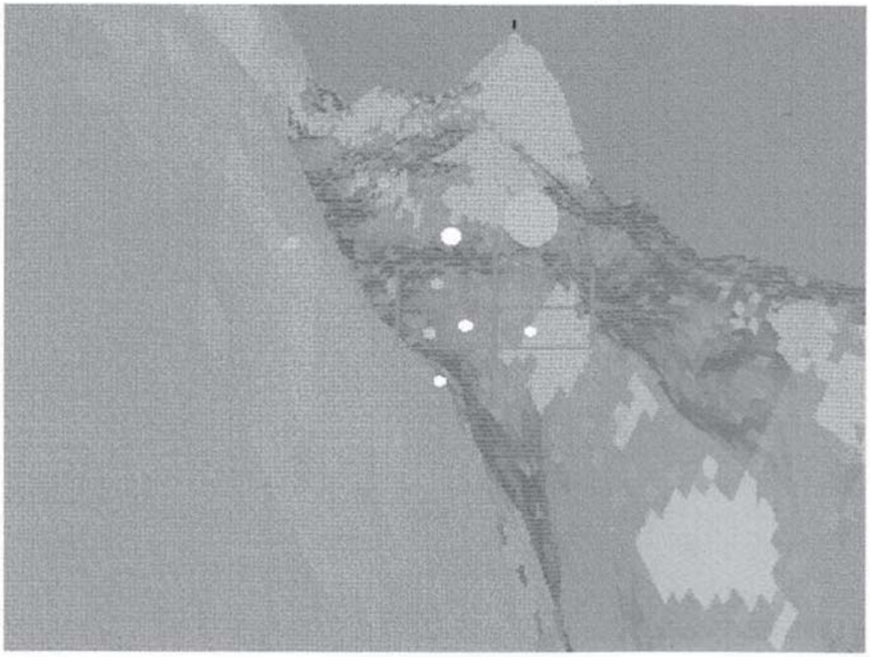


Fig. 2. Digital Therapy Institute, *Brain Wave Rider*, interactive computer game controlled by the player's brain waves. An alpha-wave image.

quency waves. When only one player drives *BWR*, he or she can attempt to control the vehicle's speed freely.

If two experienced players skilled in controlling their brain waves drive two *BWR*s simultaneously, they can fly forward together at very high speed; they also may constrain or interrupt each other's speed.

Vehicles and Images of Space

Participants in a voodoo ceremony are able to feel the energy emanating from worshipers in the transcendental state as a shock wave penetrating the real world from the spiritual world. Even those who have no previous knowledge of the ceremony or are just taking photographs of the goings-on can feel it.

In many religions, the energy coming from "the spiritual experience" may be thought of as something far removed from ordinary brain activity. However, we do not yet have a means of precisely measuring the values of this energy.

The energy released in certain religious ceremonies can make surrounding people sense the power of an explosion without producing the actual physical changes that would destroy the ceremonial situation (although small animals are sometimes sacrificed at religious ceremonies). Or, rather, it can make individuals sense an implosion in their bodies in the form of spasms and fainting, just as images can implode in one's brain. Stage props such as ornaments, patterns and incense merely play the role of fuse for the implosion.

The Digital Therapy Institute's activity began with the measuring of the brain waves of a Chinese Qigong master in the state of Qigong mental healing. We studied the various subliminal effects of audiovisual stimulation on the five senses, and looked at other aspects of brain activity. We have tried to grasp things generally thought of as properties of spiritual activity—religion, mental healing, art appreciation, etc.—at the materialistic level, as signals and data. *BWR* was born through a reversal of this attempt.

Paul Virilio contributed a short essay, "The Last Vehicle," to Dietmar Kamper and Christoph Wulf's *Looking Back on the End of the World*. In this essay, he describes

> the advent of a final generation of vehicles, of means of communication for distances that have nothing in common with those associated with the revolution of transport anymore—as if the conquest of space confirmed the conquest of the mere images of space. If in fact the end of the nineteenth century and the beginning of the twentieth experienced the advent of automotive vehicle, the dynamic vehicle of the railroad, the street, and then the air, then the end of this century seems to herald the next vehicle, the audiovisual one, a final mutation: static vehicle, substitute for the change of physical location, and extension of domestic inertia, a vehicle that ought at last to bring about the victory of sedentariness, this time an ultimate sedentariness [4].

The description of "the last vehicle" that Virilio portends surely applies to *BWR*. "The victory of sedentariness" is at the heart of *BWR*, which the player commands without moving even a finger.

It is natural that *BWR* correlates with Virilio's vehicle theory, as *BWR* is an interactive system that uses audiovisual equipment, computers and computer graphics for landscape simulation. Thus, the player can move through a multitude of "images of space" while remaining in the same physical location.

In religion, vehicles signify an important means of linking this world with the spiritual one. Vehicles and their images frequently play a part in religious ceremonies.

In the case of ceremonies performed on land, vehicles are hauled by people or by animals such as horses, cows or elephants during the ceremony; generally, the vehicles are retired to some sort of shelter afterward. The Chinese peoples of Southeast Asia, who maintain traditional religious customs more than the mainland Chinese do, burn paper effigies of money, houses, cars and so on as gifts to the dead during funerals. The

Fig. 3. Digital Therapy Institute, *Brain Wave Rider*, interactive computer game controlled by the player's brain waves. A beta-wave image.

vehicles cannot depart from this world if they are not burned.

Usually, a vehicle denotes a means of transportation over land. Once a vehicle leaves the land, however, its categorization is unclear. Vehicles that travel through space, for example, are known as spaceships. There are innumerable vehicles and ships flying through the sky in the world of religion and myth.

In the case of certain religious rites performed on the water, ceremonial ships sail for a very short distance in this world, then pass into the other. They transcend the boundary of the real world and its images of space.

At the Shaara boat ceremony, held on the last day of the Bon festival in Nishinoshima Mita, in the Oki islands, people build a straw boat and decorate it with small colored flags bearing the Buddhist sutra "Namuabidabutsu." They attach the flags to ropes stretched from the mast and send the boat out to sea, heaped with offerings. Some children actually climb aboard the Shaara boat and ride as a second boat tugs it out to sea, staying until the ceremonial boat starts to sink. Then the boat heads for the other world, with spirits of ancestors on board.

Voodoo also uses a boat for the ceremony of Agwe, God of the Sea. Each voodoo divinity is expressed as a symbol called a "vever." Agwe is represented by a sailboat on which the word "Immamou" is written. The boat used for the ceremony of Agwe, as depicted in Maya Deren's documentary film *Divine Horsemen: The Living Gods of Haiti* and her book of the same name [5], resembles the Shaara boat of the Oki islands. This boat is also decorated, and disappears with its burdens of offerings to the sea. In this case, Agwe first makes his appearance by transmigrating to the priests performing the ceremony on the boat, then the boat heads for the world of the gods.

Both the Shaara boat and Agwe's boat leave the shore to sail for only a short distance on the ocean, moving through images of religious space after they sink and their physical travel ends. These boats and *BWR* are alike in a certain respect: all three are vehicles that move through images of space.

LANDSCAPE

Anyone who has driven a car in the United States has probably noticed the warning that appears on many rear-view mirrors: "Caution: Objects in this mirror may be closer than they appear." It is necessary to be prepared for every contingency in the land of product liability.

Jean Baudrillard quotes this warning at the outset of "Vanishing Point," the first chapter in his book *America* [6]. He describes discovering the warning at the outset of his automobile trip through the vast southwestern desert, and uses the quote to express the emptiness of the United States.

The landscape that appears on the monitor of *BWR* was created through popular landscape-simulation software programs [7]. Such programs may be of limited business use, but they are nonetheless elaborate, and they allow the user to easily enjoy traveling through computer-generated landscape simulations. The high degree of detail they are able to achieve is evident when one looks up through the leaves in a digital tree to see blue computer sky beyond.

Interestingly, the companies that make these programs also produce pregenerated data that allow one to travel—in three dimensions—through the grand views of America: the Grand Canyon, Yosemite National Park, and so on. A new series of data has now jumped off the American continent and will take the consumer as far as the extraterrestrial landscape of Mars.

Baudrillard's *America* resembles a road movie, depicting a passage through the desert, talking about people and towns. However, this road movie belongs to the video age of the 1980s:

> We'd need the whole film of the trip in real time, including the unbearable heat and the music. We'd have to replay it all from end to end at home in a darkened room, rediscover the magic of the freeways and the distance and the ice-cold alcohol in the desert and the speed and live it all again on the video at home in real time, not simply for the pleasure of remembering but because the fascination of senseless repetition is already present in the abstraction of the journey [8].

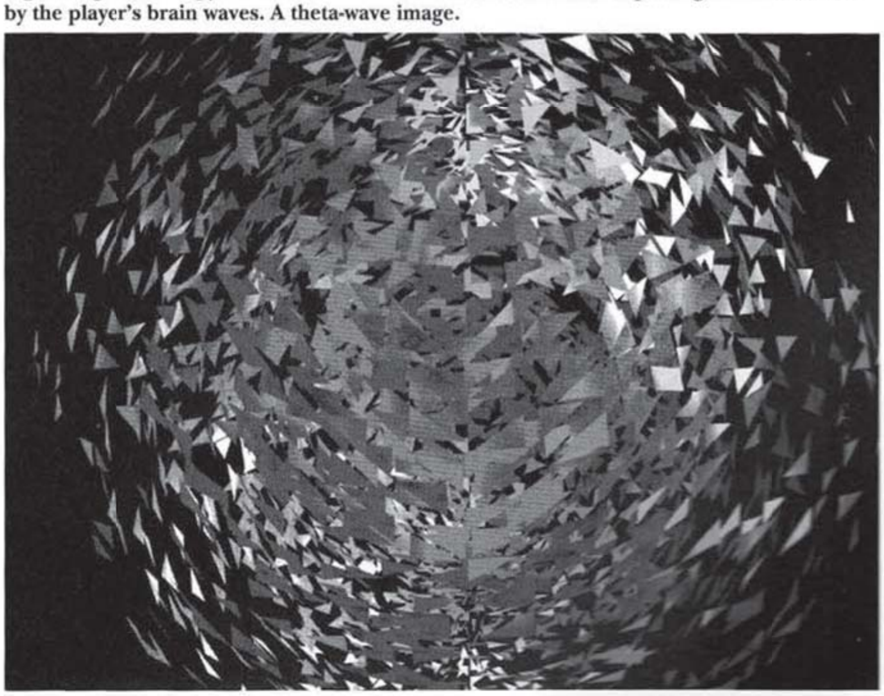
The trip through a computer landscape differs from the road trip in that Baudrillard actually drove through the real America. His trip was not a simulacrum: objects in his mirror just looked smaller. His trip becomes simulacrum only when recreated on video. The media—in this case, computer and video—make the difference.

Thus, in his book *Simulations*, Baudrillard writes,

> Abstraction today is no longer that of the map, the double, the mirror or the concept. Simulation is no longer that of a territory, a referential being or a substance. It is the generation by models of a real without origin or reality: a hyperreal. The territory no longer precedes the map, nor survives it. Henceforth, it is the map that precedes the territory—PRECESSION OF SIMULACRA—it is the map that engenders the territory [9].

The computer-generated landscape is a simulacrum, unlike the real landscape Baudrillard describes in *America*, as it can take infinite forms never seen before. It is "a real without origin or reality: a

Fig. 4. Digital Therapy Institute, *Brain Wave Rider*, interactive computer game controlled by the player's brain waves. A theta-wave image.



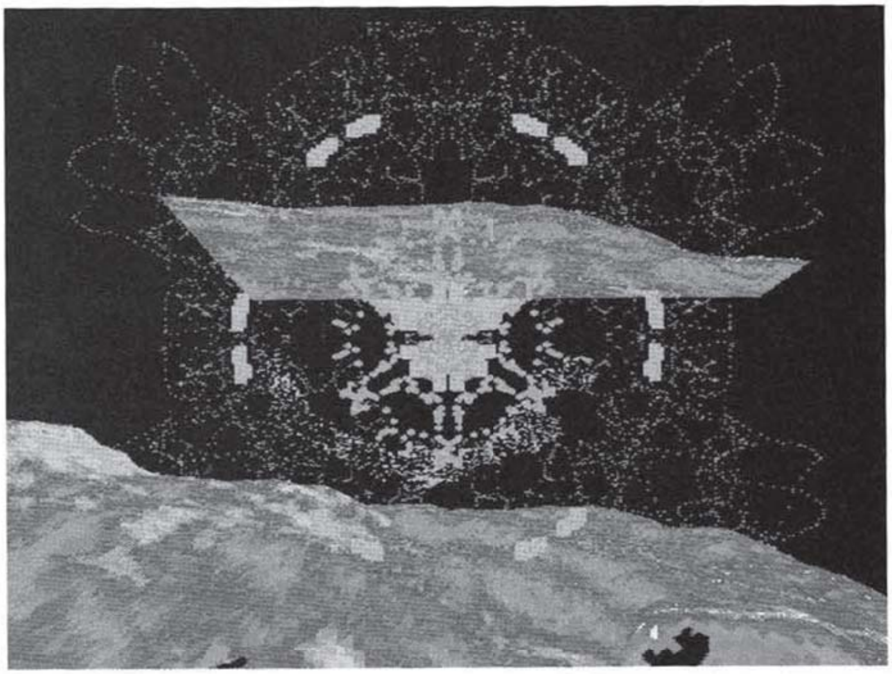


Fig. 5. Digital Therapy Institute, *Brain Wave Rider*, interactive computer game controlled by the player's brain waves. A delta-wave image.

hyperreal." The only person who can experience this hyperreality is the one operating the computer in order to enter the landscape. *BWR* allows the rider to travel through a hyperreal landscape at hyperreal speed, controlling them both with only his or her brain waves.

THE BRAIN AND SPEED

Preparing to ride in *BWR*, participants ostentatiously put on the helmet like old-time race-car drivers. But what exactly is the significance of speed to the brain controlling the speed of *BWR*?

"Education and Development," a chapter in Marvin Minsky's book *The Society of Mind*, starts with a question asked by a parent: "If those younger children take so long to acquire concepts like conservation of quantity, can't we help speed up their growth by teaching such things earlier?" [10]

The question is interesting here because it demonstrates that parents sometimes seem to hope only to speed up the processing going on in their children's brains. A Japanese expression for cleverness translates literally as "the rotation of the head is quick," and English has its share of speed-centered phrases, such as "quick-witted" or "a nimble mind."

Both examples reveal the importance that is placed upon the speed of the brain's functioning. According to a University of California study conducted in 1985, Einstein's brain had four times more "oligodendroglia"—helper cells that speed neural communication—than the brains of 11 merely gifted people [11].

Fast processing speed is all-important to computers. No matter how we may insist that "great talents mature late" with respect to human beings, we still tend to choose a computer based on how fast it is. The Chinese word for computer translates as "electric brain." It goes beyond the original English meaning—"that which computes"—to suggest artificial intelligence as the most developed form of computer. The fact that we should not forget is that the computer is an extension of the human brain, and thus we know that humans will continue to seek even faster brains in the future. The human brain will never slow down.

The value of experiencing *BWR* comes through discovering that one can effect a physical change in the speed of the system by varying the state of one's brain waves. Normally, we do not have the chance to observe our own brain waves (unless we receive EEG exams after suffering a head injury). Few people are likely to think of changing their own brain waves in order to effect physical change in an environment. However, *BWR* participants gradually master control over their own brain waves, which may not be as immediately useful as mastering, say, tax evasion, but is still a real expansion of ability.

SUPPLEMENT

One of the Marvel Comics superheroes, Weapon X, is a mutant with fearsome combat skills honed through training with a battle-simulator helmet—a helmet that creates virtual combat scenes. His fictional helmet resembles the *BWR* helmet in both form and function: by donning these helmets, one can acquire new talents. The discovery of new ways of using the brain opens the possibility for further mutation.

William S. Burroughs, expounding upon his thoughts in his book *The Job*, quotes from *The Living Brain*, by Gray Walter: "The rhythmic series of flashes appear to be breaking down some of the physiologic barriers between different regions of the brain"[12]. Burroughs points out that a consciousness-expanding experience can be induced by a flicker—that is, a rhythmic light flashing in the retina at the rate of 10 to 25 flashes per sec, which produces effects characteristic of consciousness-expanding drugs.

The *BWR* helmet can be both an audiovisual apparatus similar to the one Burroughs used for his consciousness-expanding experience and a talent-acquisition trainer like Weapon X's helmet.

References and Notes

1. The Interactive Brainwave Visual Analyzer is produced by Psychic Lab, Inc., and is used with a Macintosh computer.

2. ARTLAB is an artistic organization backed by Canon, Inc. "Psychoscape: Mind Observation through Art" was held from 27 March to 7 April 1993 at O Art Museum in Tokyo.

3. Two Macintosh computers analyze the data; an NEC PC-9801 reads the data and controls the devices.

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The Semiotics of the Digital Image

Patricia Search

ABSTRACT

Western formalism and postmodernist theory do not provide an adequate framework for interpreting many forms of digital art. Using artwork from the 1950s to the present, the author shows how the semiotic structure of the digital image defines a new visual aesthetic in which symbols become interpretations of symbols, and multiple levels of graphic encoding take on discursive characteristics similar to linguistic syntax. The author examines the semiotics of the digital image within the context of philosophical developments in mathematics and science.

Contemporary art criticism is deeply rooted in modernist and postmodernist theories. Modernism, which drew on the formalist theories of artist Ad Reinhardt and critic Clement Greenberg, was a period of art-for-art's-sake that called for "pure painting" that was free of "illustration, distortion, illusion, allusion or delusion"[1]. For Reinhardt and Greenberg, the physical dimensions of the medium defined "pure painting" and "pure sculpture." Modernist artists such as Reinhardt stripped their paintings of three-dimensional (3D) illusions and embarked on academic studies that emphasized "the flat surface, the [rectangular] shape of the support, the properties of pigment" [2]. This aesthetic gave rise to abstract expressionism, color-field painting and minimalism.

With his formalist theories, Greenberg sought to establish objective criteria for the evaluation of art based on the interaction of form and medium. Modernist theory, however, was highly deterministic, with only one approach to evaluating the aesthetic quality of artwork.

As formalism reached a peak in the 1960s, body, performance, pop and conceptual art rejected the modernist doctrine and ushered in the era of postmodernism, which challenged all restrictions on form and aesthetics. For many theorists, the fragmented pluralism of postmodernism led to ". . . depthless styles, refusing, eluding, interpretation" [3].

Out of this aesthetic chaos, new forms of art emerged, including works that use computer graphics as an integral part of the design process. However, much of this art is criticized for its lack of aesthetic quality, with critics maintaining that the work merely imitates earlier art forms. In many instances, the critical theories of modernist and postmodernist discourse define these evaluative criteria. Reminiscent of the modernist doctrine, many writings highlight characteristics of the digital medium—such as kinetics, interaction and networking, simulation, virtual reality, and numerical analysis—as the principle criteria for defining and evaluating the aesthetics of digital art. Critics often misinterpret works that do not exhibit these attributes as artwork that could have been done in another medium without the use of electronic technology.

This approach to evaluating digital art overlooks the semiotics of the digital image, in which symbols become interpretations of symbols, and multiple levels of graphic encoding take on discursive characteristics similar to linguistic syntax. As this conceptual environment of symbols and text replaces tactile and kinesthetic interaction with the artwork, new forms of creative expression codify form, space, action and time into diverse levels of abstraction. Unlike the fragmented visions of the postmodernist period, these works merge discrete concepts into fluid, integrated statements.

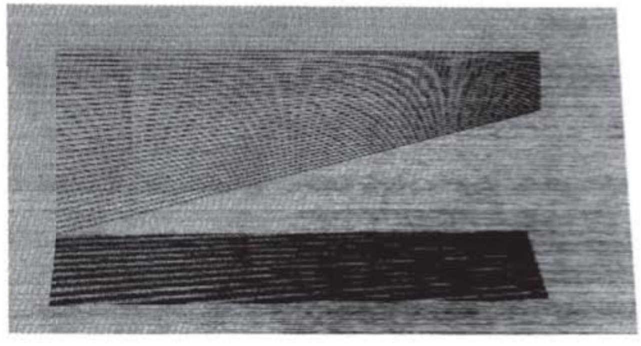
This paper examines the semiotics of the digital image within the context of philosophical developments in mathematics and physics. In these fields, causality and deterministic logic have been replaced by "descriptive" mathematics and scientific theories of relativity and quantum mechanics. The concepts behind these new scientific models of reality are also an integral part of the semantic-syntactic structure of the digital image.

The Visual Logic of Descriptive Geometry

Geometry is one of the oldest branches of mathematics and the architectural framework for computer graphics. The term *geometry* is derived from Greek words meaning "earth measurement," and early Euclidean geometry used deductive methods to study flat surfaces (plane geometry) and rigid 3D objects (solid geometry). These linear, static methodologies were based on sets of unproven assumptions called axioms, which were derived from perception and experience [4].

Mathematicians gradually realized that if these intuitive assumptions were replaced by abstract terms devoid of preconceived meaning, the resultant type of formal system would provide a more flexible structure for evaluating spatial relationships. In 1637, Descartes developed a branch of analytical

Fig. 1. Eudice Feder, *Separation,* Calcomp plot, 12 × 18 in, 1980. Artists such as Feder use precisely controlled linear modulations, rather than perspective projections, to define spatial relationships. (© 1980 Eudice Feder. All rights reserved.)



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geometry that used algebraic equations to visualize points, lines and forms, thus raising the study of geometry to a new level of abstraction by detaching it from its perceptual base. However, Cartesian geometry, like Euclidean geometry, was still founded on deterministic logic and deductive reasoning.

The 1800s brought new philosophical and scientific inquiries into the relationship between optical truth and interpretation. Mathematicians reevaluated traditional assumptions about space. New theories evolved that further underscored the need for geometric systems that were not based on the intuitive perception of space and time. In 1854, for example, a German mathematician named Georg Riemann postulated that space could be curved—a theory that Einstein later used to develop relativity. Riemann's research, along with the work of other mathematicians in the nineteenth century, required new methods of defining and visualizing spatiotemporal concepts. The linear determinism of Euclidean geometry was slowly replaced by mathematical models that described multidimensional, abstract relationships. The dynamic interaction of these spatiotemporal descriptions was reflected in new mathematical terms such as *betweenness, translation, reflection, projective* and *inversive* models, and *hyperplanes.*

In the 1960s, with the help of computer graphics, mathematicians bridged the gap between symbolic descriptions and perception by using patterns to visualize logical processes and simultaneous relationships. Mathematician Lynn Steen describes mathematics as a "science of patterns" with abstract levels of visual encoding in which "theories emerge as patterns of patterns" [5]. In this new descriptive geometry, perceptual references symbolize dynamic processes and interrelationships that change over time. Logical analysis is augmented by the perceptual, holistic synthesis of visual patterns. According to mathematician Jacques Hadamard, images are important to provide a "simultaneous view of all the arguments" [6].

The *visual logic* of descriptive geometry enables mathematicians to understand the structure of a problem and then reconstruct and improve their intuitive understanding of numerical relationships. Multiple levels of perceptual encoding create a model for describing "those aspects of visual modes of thought that appear to lie beyond the analogy of mere sight" [7]. Mathematicians can analyze the syntactical components of geometric space and then synthesize those relationships into an integrated system.

Metastructural Models in Physics

Like early Euclidean geometry, classical physics was built on deterministic logic and reductionist theories that limited the interpretation of physical forces to strict causation. Newtonian mechanics, for instance, was built on the reductionist theory that time and space were rigid and constant. Newton described time and space as follows:

> Absolute, True, and Mathematical Time . . . flows equably without regard to any thing external. . . . Absolute Space, in its own nature, without regard to any thing external, remains always similar and immovable [8].

According to classical physics, reality was an objective truth and the scientist was a passive observer looking on. However, in science, as in mathematics, theories of indeterminism eventually replaced the basic unit of Aristotelian logic, the syllogism, which is based on the "if—then" proposition. With the introduction of relativity and quantum physics, a new scientific model of the world emerged in which dynamic interactions replaced static, linear forces.

In his theories of relativity, Albert Einstein demonstrated that space and time are not absolute [9]. Both space and time are multidimensional forces that defy the limitations of perceptual interpretation. At the speed of light, for example, time encompasses both the present and the future. In effect, "time ceases to change because it contains all change" [10]. Spatial representations also merge at high speeds. As space is compressed, multiple views of objects are possible from a single perspective because planes and volumes become one [11].

Quantum physics continued to develop this pluralistic and highly abstract model of spatiotemporal interaction. Quantum theory emerged in 1900 when physicist Max Planck demonstrated that energy comes in discrete units (rather than a continuum) called "quanta," a term derived from the Greco-Latin word for "how much" [12]. Traditional observations about the physical world broke down in the microscopic world of quantum mechanics. Scientists needed new theories to explain the indeterministic and highly interactive nature of subatomic units.

In 1926 Niels Bohr developed the theory of complementarity to describe the antithetical duality of physical forces that appeared in quantum physics [13]. Light, for instance, is *both* a *wave* and a particle. However, light reveals only one attribute at a time, and the scientist determines that attribute by the type of measuring device used in an experiment. Scientists also learned that multiple forces such as gravitation, nuclear forces, and electromagnetism can operate simultaneously in the same place [14]. In this multidimensional model, physicists discovered the "quantum leap," the fact that electrons can move between orbits and simultaneously appear in another orbit without traversing the intervening space [15]. The linear dimensions of strict causation that characterized classical physics were replaced by a matrix of interactive relationships.

The world of quantum physics raised as many questions as answers. There was no longer any such thing as "objective" reality. Relationships were defined by the participation and interpretation of the observer. Scientists and mathematicians of the time learned that they could no longer rely on intuition and experience to define physical forces. They needed to build a flexible, abstract framework for a virtual world with tentative truths.

The Semiotics of the Digital Image

Mathematicians and physicists demonstrated that we cannot rely on our perceptual interpretations as accurate descriptions of reality. Instead, we must raise our intuitive knowledge of space and time to a higher level of abstraction that defines the dynamics between human perception and reality. Once we identify these interactive forces, we can create multidimensional models that integrate mathematical laws and interpretation into virtual extensions of the physical world.

Psychologists call this process of redefining perceptual knowledge "reflective abstraction." Computers have made it easier for mathematicians, scientists and artists to use this process to visualize and construct new knowledge beyond the boundaries of logic and expectation. In digital art, the result is a new visual aesthetic that echoes the philosophical perspectives of modern mathematics and physics in several semiotic structures:

- Metastructural Dynamics
- Cognitive Mapping
- Visual Logic.

This paper discusses each of these dimensions of the digital image and cites examples of representative artwork [16].

METASTRUCTURAL DYNAMICS

In computer graphics, terms such as *3D model, rendering* and *simulation* suggest an artificial retreat from reality. However, artists actually use these techniques to visualize scientific interpretations of reality by creating metastructural environments that expand the intuitive dimensions of space and time into abstract models of a dynamic, virtual world.

Using an architectonic system of mathematically defined forms, colors, compositions and perspectives, an artist can control the hierarchy of geometric relationships and redefine the geometric syntax of experiential space and time. The use of geometric coordinates to specify spatial relationships has shifted the artistic focus to linear and surface projections rather than perspective projections. Working with subtle changes in attributes of lines such as width, color, texture and position, artists transform the planar dimensions of linearity into volumetric extensions of space. This type of "linear space" is an integral part of works by artists such as Eudice Feder (*Separation* [1980]; *Permutations* [1980]; *Wind-Warn* [1985]), Herbert Franke (*Serie 1956* [1956]; *Grafik I* [1956]), and A. Michael Noll (*Ninety Computer-Generated Sinusoids with Linearly Increasing Period* [1965]). These artists use precise, geometrically controlled lines to create multiple levels of perceptual space (Fig. 1). Tony Longson's work adds a physical dimension to this concept of linear space. Longson creates line and "tonal" drawings on multiple panels of Plexiglas, then overlaps the panels to create 3D constructions (*Group Theory Grid* [1968]; *Square Tonal Drawing #2* [1980]).

For other artists, surface rather than linear projections shape the metastructural dynamics of space and time. In *Untitled* (1975) by Manuel Barbadillo and in Vera Molnar's series *Hypertransformations* (1973–1976), geometric progressions define randomly shaped, interlocking planes of color with ubiquitous perspectives and orientations (Fig. 2). In these works, the two-dimensional (2D) space becomes all-inclusive and folds into itself, much in the way that the curved space of modern geometry and physics does.

The medium of light in computer graphics also transforms the spatial dimensions of lines and planes. For example, in works by Ben Laposky (*Oscillon 40* [1952]; *Oscillon* [1956]) and Kathleen Dolberg (*Gossamer* [1984]), transparent filaments of light create flowing shapes that engulf the surrounding space and blur the perceptual boundaries between lines, surfaces, 3D space and infinity. The medium of light also defines different levels of linear and surface space in the "virtual sculptures" of Michael O'Rourke. In images such as *Manhattan Invitation* (1987), O'Rourke creates a visual interplay between light and space by juxtaposing definitive geometric lines and objects with diffuse areas of modulated colors (Fig. 3).

The reflective and refractive qualities of light also enable artists to visualize the spatial relationships *in* and *between* objects. In Yoichiro Kawaguchi's animations (*Origin* [1985]; *Ocean* [1988]), highly reflective and transparent surfaces display the surrounding environment, transforming organic forms into mirrored visions of space within space. The images embrace space and time from all directions, rather than limiting the vantage point to a unique perspective. Space becomes all-inclusive and *n*-dimensional, as in the works of Barbadillo and Molnar.

Time—in particular, the spatial representation of time—establishes a conceptual link between the physical and virtual dimensions of these metastructural models. Time is defined as an infinite extension of space and form through the mathematical abstraction of lines, angles and curves. The geometric syntax of the fractal image is an excellent example of this temporal link between the physical and virtual dimensions of reality. In other artwork, such as Kawaguchi's art, time is defined by reflective and transparent objects that visualize the passage of light through space. In these images, layers of visual data define multidimensional arrays that visualize simultaneous and sequential levels of spatiotemporal perception.

The metastructural dynamics of the digital image integrates structure and control into a spatiotemporal continuum that defines an infinite, virtual space. This visual dichotomy is especially evident in artwork that juxtaposes the definitive geometry of 3D objects with subtle gradations of texture, color, transparency or reflection. The computer paintings of David Em (*Redbal* [1980]; *Zotz* [1985]) and my own artwork (*Gossamer Lights* [1986]; *Coloratura 100* [1988]; *Kaleidoscope* [1992]) represent this type of visual model (Color Plate A No. 2). In these images, geometric objects anchor the work in the logical dimensions of space and time, while perceptual transformations challenge the limitations of experiential reality.

COGNITIVE MAPPING

The mathematical models of descriptive geometry, relativity and quantum mechanics emphasize interactive webs of sequential and simultaneous events. In many forms of digital art, perceptual and cognitive processes define a matrix of temporal relationships, resulting in a complex network of associations.

In some artwork, this multidimensional structure visualizes the geometric syntax of space and time. Bruce Hamilton and Susan Hamilton, for example, use computer graphics to create conceptual drawings for sculptures like *Tetrad* (1984), *Metamorphosis III* (1987), and *Scarab* (1989). In these works, mathematically defined proportions create a geometric balance between lines, planes, textures and color (Fig. 4). The mathematical syntax of these sculptures not only visualizes logical, sequential processes, but also provides a syntactic filter for simultaneously mapping multiple perspectives in space and time.

Other artists use a dynamic, visual-linguistic syntax to construct interactive webs of associations. In *Random Ransom* (1986) and *Indicted Invited* (1988), Tom Leeser extracts images and text from their original sources and integrates them into a "media archeology" that challenges their original meanings and context [17]. Paul Berger creates digital photographs that visualize the cognitive networks of information in a database. In works like *Print-Out* (1988), Berger uses photocopied lists of database entries as backgrounds for photographic portraits [18].

In interactive works of art, narrative intention increases the complexity of cognitive mapping. The viewer expects to construct meaningful relationships and must continually redefine the webs of interaction between expectations and reality. Abbe Don explores these issues in *We Make Memories*, an interactive program that allows viewers to create stories by experimenting with the associative links between content, structure and context [19].

Fig. 2. Vera Molnar, *Hypertransformations*, silkscreen, 20 × 20 in, 1974. In Molnar's prints, geometric progressions transform two-dimensional planes into interlocking spaces with multiple orientations. (© 1974 Vera Molnar. All rights reserved.)

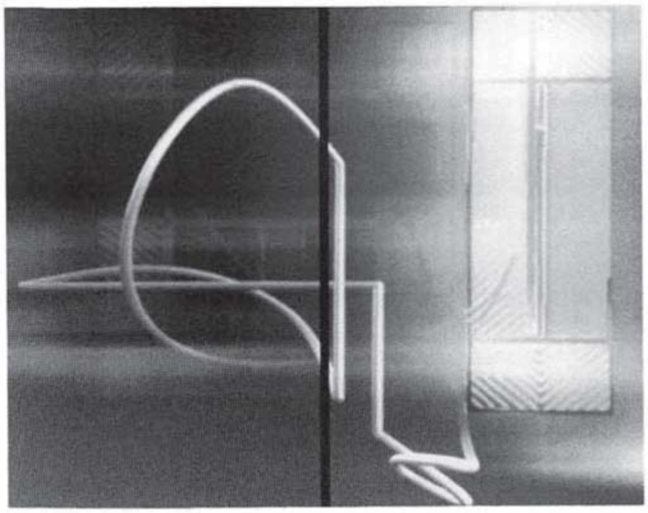


Fig. 3. Michael O'Rourke, *Manhattan Invitation*, diptych/ Cibachrome transparencies, 48 × 60 in, 1987. By integrating geometric lines and objects with diffuse areas of colored light, O'Rourke creates "virtual sculptures" that expand the dimensions of linear and surface space. (© 1987 Michael O'Rourke. All rights reserved.)

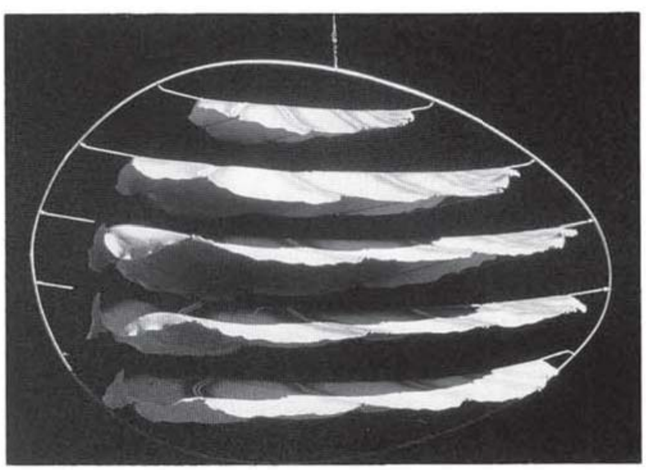


Fig. 4. Bruce Hamilton and Susan Hamilton, *Scarab*, 29 × 50 × 19 in, 1989. In the Hamiltons' sculptures, balance and proportion create a geometric syntax that defines simultaneous relationships in space and time [32]. (© 1989 Bruce Hamilton and Susan Hamilton. All rights reserved.)

In the digital work, a semantic-syntactic network of images, text and sound directs actions and expectations. The viewer constructs a system of relational codes that becomes an integral part of the interpretation of the work. Multiple levels of perception and cognition may exist within individual symbols. James Johnson, for instance, creates artists' books that make use of symbols that integrate visual and linguistic semiotics. Using computer graphics, Johnson designed a "Skeletons" font, which is derived from silhouette drawings of skeletons. In the book *Dead Air* (1991), he uses this font to form words that complete phrases beginning with the word "dead," such as dead wrong and dead last [20]. Another of his books, entitled *Index* (1992), maps pictures of unusual objects to individual letters of the English alphabet. Johnson uses this pictographic alphabet to create visual compositions that are "subject to verbal structures" [21]. The title of each composition indicates the corresponding verbal meaning (Fig. 5).

The work of artist Jim Rosenberg adds another level of inquiry to these visual-linguistic maps. He uses "word clusters" to experiment with the syntax of words that occupy the same point in logical and physical space. In his interactive program *Intergrams* (1990), a group of phrases is indecipherable when the phrases overlap each other in the same space. However, moving the computer mouse over the cluster discloses individual phrases and hides the remaining ones, revealing the meaning of the cluster [22].

The use of symbols to map perceptual and cognitive associations is an important dimension in the semiotics of the digital image. Like recursive patterns in mathematics, symbols become interpretations of symbols. Thorne Shipley conducts theoretical research in "pattern and matrix vision" [23]. His work investigates the different levels of perception and cognition that are defined by visual patterns or textures in linguistic messages. Unlike Johnson, who maps synonymic associations between words and images, Shipley is exploring what he terms "heterological message duality" or "message multiplicity" [24]. He illustrates this concept using words that are typographically constructed from other words. For example, in one of his illustrations, the text for the word "yes" is repeated in a pattern that forms the shapes of the letters in the word "no." Similarly, the text for the word "you" forms the shape of an "I," and the word "will" creates each of the letters in the word "won't." When these typographical constructions appear in phrases such as "No, I won't," the visual patterns within each word communicate a secondary message—"Yes, you will" [25].

Future research and investigation will expand the semantic-syntactic dynamics of these types of cognitive maps. As artists continue to explore the potential of interactive multimedia in artwork, they will find new ways to add levels of sensory interaction to the layers of relational encoding that exist in these cognitive maps. Artists will also learn how to integrate the linguistic patterns of user interfaces and programming languages into visual symbols, adding still more interpretive links to the semiotic structure of the digital image.

VISUAL LOGIC

Just as writing fostered the development of abstract thinking with the implementation of symbols and sounds to designate thoughts, the mathematical syntax of computer graphics defines another level of abstract thinking called visual logic. However, unlike writing, which separates data from interpretation, this new abstract symbolism uses visual perception to synthesize data and interpretation into an integrated whole.

Artists, like mathematicians and scientists, use visual patterns to improve their intuitive understanding of logical and perceptual relationships. Many artists, for example, use computer graphics to investigate the logical and intuitive dimensions of design. The grid, which postmodernists rejected as a symbol of structural control, has resurfaced as an intuitive symbol of the underlying structure of spatiotemporal procedures. Daniela Bertol's collage *Bending and Twisting: Hypothesis #3* (1988) uses a twisted geometric grid to visualize the algorithmic dynamics of space and time. The grid is also an integral part of Andrew Glassner's *Celtic Knot* series (1986), black-and-white drawings that investigate the geometry and form of Celtic knot weaving (Fig. 6). Glassner uses an invisible grid to create a visual pattern that symbolizes the spatiotemporal relationships involved in the perception and comprehension of this intricate weaving procedure.

Some artists use design techniques to create a multidimensional syntax that articulates the interaction of perception and cognition. For more than 20 years, Manfred Mohr has been using computer graphics to analyze the relationships of lines in the cube. Mohr uses the 12 lines that make up a cube to create a new visual language that "disrupts the symmetry of the cube" [26]. In prints and paintings such as *P-26/2 Inversion Logique* (1969), *P-155 Cubic Limit* (1974–1976), and *P-306 Divisibility I* (1980–1983), individual lines form discrete units of information and define a visual syntax that signifies the sequential steps in the perception of geometric forms and space. At the same time, Mohr's designs form an integrated whole in which black and gray lines establish contrasting layers of perceptual events that disrupt the sequentiality and order of the mathematical logic.

Artists also use the visual logic of computer graphics to explore the intuitive synthesis of logical events. By juxtaposing text and images that symbolize procedures or actions with images that represent the end results of those actions, the artist constructs an interpretive dialogue that visualizes the temporal transformation of ideas. For Colette Bangert and Charles Bangert, this dialogue begins with the development of computer-graphics software. In works like *Large Landscape: Ochre & Black* (1970), *Grass Series* (1979–1983), *Circe's Window* (1985) and *Katie Series* (1986–1987), the Bangerts use original software to translate mathematical models into lines and forms in space (Fig. 7). The software enables them to explore the relationships between algorithmically defined numerical functions and the drawing process: "At the time the programs were written, we thought of the transforms and the interactions of the instances. Now we think of the whole drawing as a picture of a single line in a high dimensional space" [27].

Margot Lovejoy uses mathematical symbols to visualize the roles that perception and logic play in the interpreta-

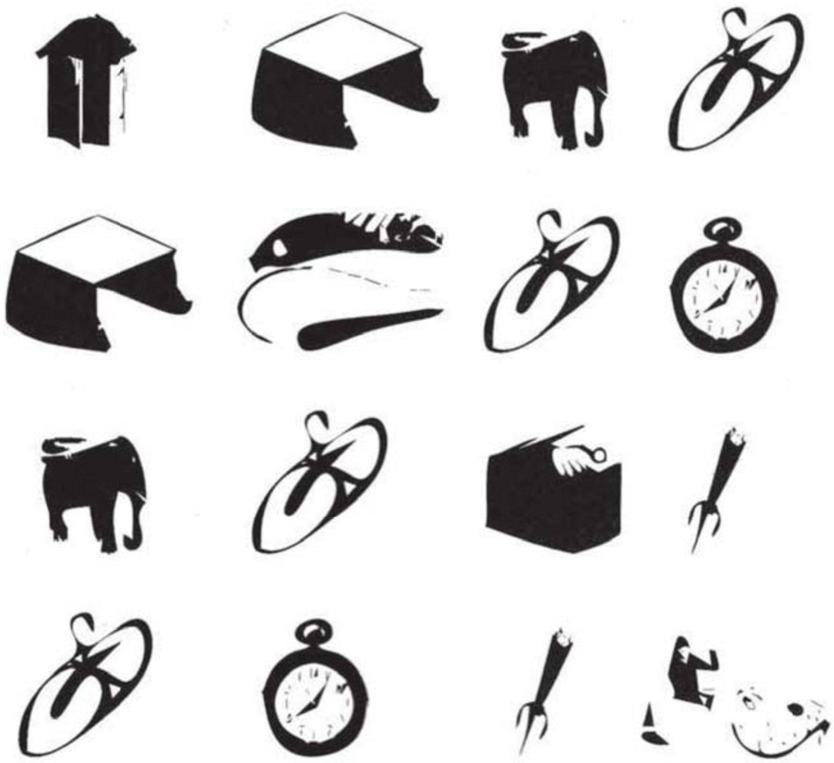
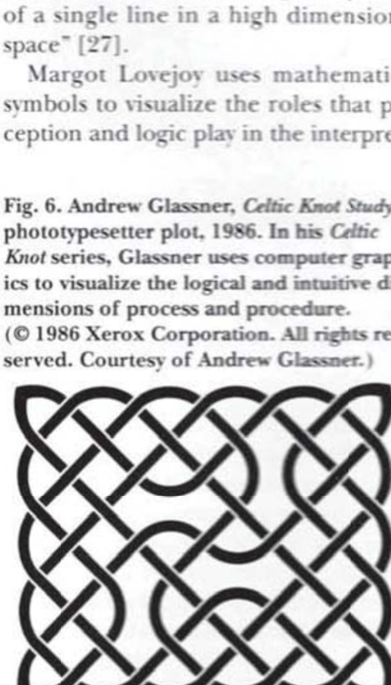


Fig. 5. James Johnson, *LineIdeaNetsEasy*, laser print, 1994. Mapping symbols to letters of the English alphabet, Johnson creates compositions that integrate visual and linguistic semiotics. (© 1994 James Johnson. All rights reserved.)

Fig. 6. Andrew Glassner, *Celtic Knot Study I*, phototypesetter plot, 1986. In his *Celtic Knot* series, Glassner uses computer graphics to visualize the logical and intuitive dimensions of process and procedure. (© 1986 Xerox Corporation. All rights reserved. Courtesy of Andrew Glassner.)



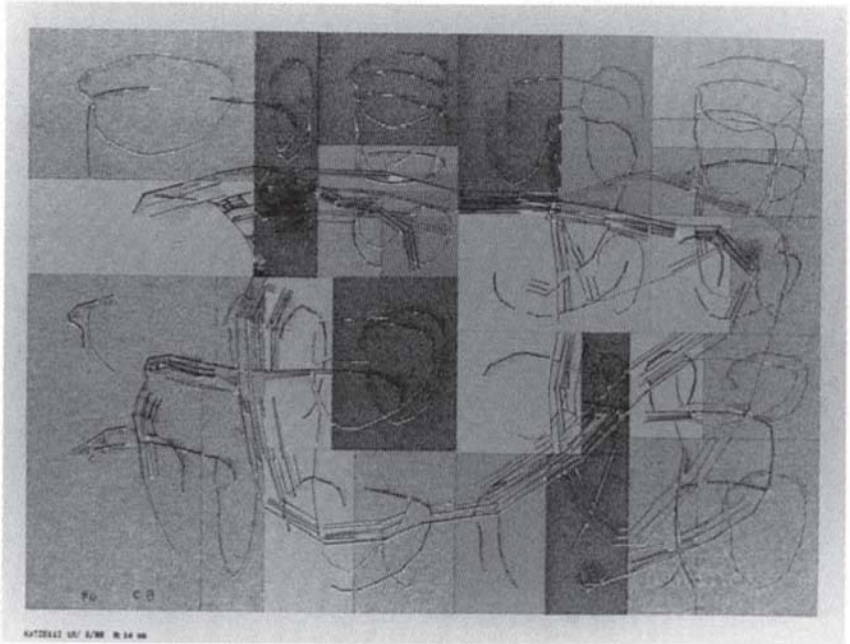


Fig. 7. Colette Bangert and Charles Bangert, *Katie Series: Field Greyed*, computer plot, colored inks on paper, 8 ½ × 11 in, 1986. The Bangerts use mathematical algorithms to explore the underlying structure of line and form. (© 1986 by Colette Bangert and Charles Bangert. All rights reserved.)

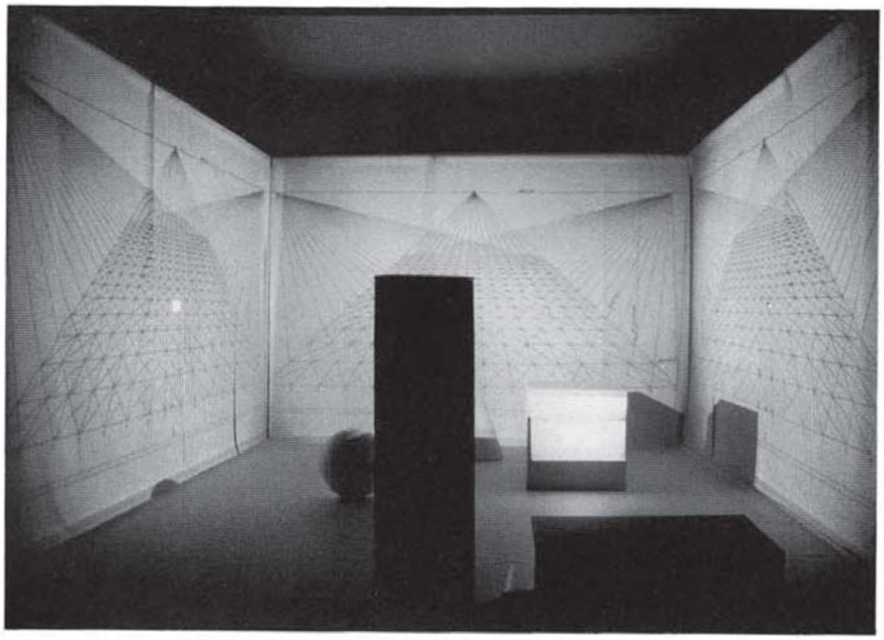


Fig. 8. Margot Lovejoy, *Azimuth XX*, projection installation, 12 × 12 × 8 ft, 1986. By juxtaposing two-dimensional representations of space with three-dimensional objects, Lovejoy visualizes the logical and intuitive dimensions of spatiotemporal perception. (© 1986 Margot Lovejoy. All rights reserved.)

tion of space. In 2D works such as *Azimuth I* (1983) and *Azimuth II* (1983), geometric shapes, angled lines and architectural drawings create a visual syntax that signifies the perceptual and cognitive processes involved in the interpretation of 2D representations of space. Lovejoy's 3D installations integrate physical space and time into the visual logic of spatial perception. *Azimuth XX* (1986), for example, juxtaposes 3D geometric forms existing in "real" space and time with 2D projections of linear perspective grids (Fig. 8). Lovejoy describes her work as "the struggle to control, represent, and construct meaning in the 'gap between art and life'"[28].

The visual logic of the digital image is highly modular. Visual symbols can be rearranged to create new syntactical relationships. Digital images can assume many characteristics of linguistic syntax without jeopardizing their perceptual immediacy. The high level of abstraction in this visual system transcends the constraints of verbal language. The visual logic of the digital image shares many of the conceptual attributes of "metaphorms," visual metaphors that Todd Siler creates to describe the temporal and procedural relationships between objects or ideas. For example, Siler uses the following metaphorms to symbolize the complementary relationships between art and science: parallel lines, spirals, intersecting planes and woven fabric. Siler defines a metaphorm as a "means of implying the likeness between things," and he describes the power of metaphorms as follows:

> In metaphorming something, we can traverse the constraints of logic and verbal thought, transferring or relating from one object to another a new meaning, pattern, or set of associations. Like the language of pure mathematics, which can describe abstract *n*-dimensional processes and forms, the symbolic language of metaphorms is also multidimensional. It operates simultaneously on many planes of associations, nuances, and meanings [29].

Conclusion

Modern mathematics and physics demonstrated that we need to develop abstract models of reality that are flexible enough to accommodate the shifting dynamics of a wide range of variables, including the subjective decisions and interpretations of the observer. In order to build flexible models that can change with new perspectives and observations, we need to understand differences as well as interactive relationships between these variables. As Marvin Minsky points out in *The Society of Mind*,

> We usually like to think in positive terms about how various parts of systems interact. But to do that, we must first have good ideas about which aspects of a system do *not* interact. . . . In other words, we have to understand *insulations* before we can comprehend interactions [30].

For mathematicians, scientists and artists, computer graphics provides a powerful tool for visualizing the insulations *and* interactions of a multidimensional system. The digital image integrates the structural control of analytical processes with the holistic powers of perception and interpretation. Artists are abandoning the predictable, deterministic logic of the modernist period and the random, irrational infrastructures of postmodernism. In the digital image, the geometry of mathematics and the logical syntax of programming languages create a conceptual framework for synthesizing complex webs of interactions.

In the future, new technology will alter the semiotics of the digital image. High-definition television, for example, will modify established perceptions in space and time. High-resolution displays will place an added emphasis on detail and text and increase the prominence of background imagery. As the size of digital displays approaches the scale of actual walls, the syntactic structure of the image will become an integral part of the surrounding architectural space. In addition, the electronic dissemination of art, coupled with interactivity and collaborative networking, will increase the temporal dynamics of the digital image.

All of these developments further mandate the need for a new design discourse—perhaps based on an interactive audiovisual language—that reflects the dynamic structure of the digital image. Artists, mathematicians and scientists are no longer concerned with a single view or interpretation of reality. Instead, the emphasis is on using digital technology to modify perspectives and restructure information. Models of reality, defined by abstract descriptions of tentative truths, are subject to constant reevaluation. The ensuing dialogue between logic and perception leads to an eternal quest for new perspectives—a quest that Minsky describes as the interaction of two types of complementary knowledge: "We search for 'islands of consistency' within which ordinary reasoning seems safe. We work also to find and mark the unsafe boundaries of those domains" [31].

The semiotic structure of the digital image visualizes these complementary forces and helps us understand the limitations of perception and reason, thus enabling us to transform those "unsafe" boundaries into new knowledge and insights about the complex world around us.

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32. For a full-color reproduction of this illustration, see *Digital Image—Digital Cinema*, SIGGRAPH '90 Art Show Catalog, Supplemental Issue of *Leonardo* (1990) p. 97.

Glossary

axiom—a self-evident proposition or rule that does not require demonstration or proof.

betweenness—in geometry, a relation connecting certain sets of three points. That is, given that points A, B and C are in "the relation of betweenness," it is possible to define various relationships concerning A, B, C, in which B is a point between A and C. For example, ABC may be points on lines AB and BC that are perpendicular to each other, in which case B will always be *between* A and C.

descriptive geometry—the use of pictures or diagrams, as opposed to algebraic or arithmetic methods, to visualize spatial relationships.

hyperplanes—a figure in hyperspace (space with more than three dimensions) corresponding to a plane in 3D space.

inversive mode—in geometry, figures derived from the use of inverse functions (two mathematical operations that can be performed in succession on a quantity to reproduce that quantity).

projective model—geometry that creates a one-to-one correspondence between the points and lines in two geometric figures.

reflection—in mathematics, a geometric relationship describing points equidistant from each other on either side of a line that is perpendicular to a given line.

translation—the displacement of a point, line or object in space.

Qualitative, Dialectical and Experiential Domains of Electronic Art

Rejane Spitz

ABSTRACT

This article draws attention to the critical role of electronic artists in the light of an examination of the differences between the First and Third Worlds. The author suggests that electronic artists are opening new venues for the use of computers as a human-centered technology by taking into account the complexity of human-machine relationships in a socio-cultural perspective. Artistic experiments are giving rise to combinations of the expressive potentials of human natural languages—which extend over aesthetic, metaphoric, artistic, affective and moral domains—and the objective, quantitative and procedural characteristics of computer-related languages. The author proposes that, in a world of social, cultural and economic disparities, the contemporary electronic artist's major struggle must be for balance between uniqueness and uniformity.

This paper originated from the ideas I presented during the seminar "The Culture of Misery versus the Misery of Culture," which was held in August 1993 in Rio de Janeiro as part of the activities of the Brazilian national campaign "Action against Hunger and Misery and for Life." In my talk, I raised issues related to the role of electronic artists in developing countries, who produce art using new technologies within a context of extreme poverty.

I am immersed in a dualistic, clashing reality. On my way to the university where I teach computer graphics to upper– and high–middle class art students—using expensive, imported equipment in an aseptic-looking lab—I pass by undernourished children selling chewing gum by traffic lights and beggars living in subhuman conditions under highways, people who are completely excluded from all benefits of technological progress. Social welfare was once considered a consequence of economic growth. But gains in economic performance and technological advances do not necessarily lead to corresponding gains in people's general welfare, especially when these improvements are directed toward the needs of a minority. In my classes, we discuss social issues related to the advent of new technologies. Artistic and technological aspects of electronic art are seen as dependent variables that must be combined in relation to their objectives and social contexts.

A critical view and a questioning attitude are deeply rooted in my actions as a citizen of a developing nation. But the striking figures and the impressive materials on social disparities that I came across while preparing my talk for that seminar clarified my critical role as an electronic artist in a country with an accentuated social polarization, which is itself part of a world of sharp social contrast. This awareness led to a radical shift of the focus of this paper. How could I discuss the artistic potential offered by the advent of new technologies without considering the social cost of the Brazilian developmental model, where a third of the population lives in miserably poor conditions, 20 million people are illiterate and 32 million people starve to death? How could I simply talk about the aesthetics of the computer or present new trends in electronic art without considering the circumstances that surround these subjects and discussing their causes and effects? Is the role of the artist who uses emergent technologies in the Third World different from the role of those who deal with electronic art in developed nations? How can electronic artists interfere so that human, social and cultural aspects are considered in the process of the development of computer-related technologies?

For the many questions I will raise throughout this paper, I have only a few certainties. One of them is that the art factor is not a neutral issue, but part of a socially constructed reality.

Culture, Technology and Development

Perhaps there was once a time when people in all cultures handled relatively similar objects, needed similar skills to operate them and used them for the same sorts of tasks. Seen from the perspective of the present day—a time when technological developments are rapidly and enormously increasing the differences between societies—this egalitarian view appears absurd and naive. Countries are now mainly categorized according to their technological stage of development, in spite of their natural resources, territories, people or cultures. The world has been divided into the First and the Third, and technology plays a decisive role in the maintenance of this segregation.

The overwhelming bulk of research and development of new technologies takes place in developed nations. Yet, developing countries require these new technologies if they are to maintain or increase their rate of economic growth. According to Raphael Kaplinsky, the resulting transfer of technology from developed to developing economies is almost always associated with a conflict of interests between the supplier and the recipient of technology. He argues that "where this conflict arises control is exerted by the more powerful party to ensure that the conflict is settled in its favor" [1]. In the case of Brazil, Andre G. Frank [2] points out that multi- or transnational monopolies control a very substantial part of the country's industry through mixed enterprises with national and state capital. He stresses the phenomenon of the "de-Brazilianization" of the economy, a process that transfers the power of decision to centers of international capital. The increase in imports of technology, equipment and intermediary inputs and services for transnational and national industries is the other side of the coin.

A wide range of instruments and mechanisms can be used by the technology supplier in order to exercise control. The

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so-called modern way of living that characterizes consumer society—a model that originated in the First World—forces itself on both developed and developing countries. This model jeopardizes or, in most cases, destroys the generation of technological alternatives that differ according to the cultural, social and economic parameters of a given context. It ultimately leads to a remaking of the Third World in the image of the First. But, as Eduardo Galeano stresses, the big cities of the south of our planet are like those of the north seen through a distorting mirror: the copying effect of modernization multiplies the model's errors and defects [3].

Different groups usually invent different solutions to the same problem. In India, camels are still vastly used in many cities as a means of transportation. In Thailand, millions of mopeds have been transformed into covered three-wheeled machines known as "tuc-tuc." A sort of rickshaw pulled by a person riding a bike is another widely used means of transportation in many Asian countries. Horse coaches and ox carts are commonly seen in rural areas of Brazil. And bicycles—of all sorts, sizes and shapes—are the most popular means of transportation in China. Creativity, inventiveness, the power to adapt and the adequacy of the solution to each group's needs are the only common denominators of these devices. But cars look basically the same in India, Thailand, China and Brazil—just as they do in Europe and North America. This is not a result of the international spread of an optimum product development design that has prevailed over others because of its inherent qualities. It is a consequence of technological dominance.

But although automobiles, refrigerators, motorcycles and telephones look pretty much the same everywhere in the world, computers undoubtedly represent the most threatening example of technological and cultural dominance in our time. Computer technology's potential to transform the world into a great network of communication may be its most dangerous aspect for developing nations. The egalitarian appearance of this potential hides the fact that leadership in the development of new technologies and the design of new trends, as well as the power to spread and control these new developments, will still be restricted to a few hands. Computers are being introduced in the Third World at an exponential rate. Until now, their use in most of these countries has been confined mainly to industries, offices and universities. But the scale of technological development seems set for inexorable growth. It is predicted that, in the near future, people living in the Third World will need to interface with computing devices in order to accomplish many of their daily tasks, as is already the case in developed nations. According to Nicholas Negroponte, in "the modern world" every person uses at least 12 computers a day, from fax machines to cooking equipment [4].

Computers in the Third World: The Phenomenon of Double Illiteracy

The expansion of the use of computer technology poses new problems for developing nations and forces us to reconsider the idea that technology is always a synonym for progress. This expansion affects the Third World in both cultural and economic terms. As far as cultural aspects are concerned, Brenda Laurel asks: "How [are we] to empower people from non-Western cultures to use computer technology without confining them to the Western constructs that are so deeply embedded in our interfaces, computer languages and the architecture of technology itself?" [5] In the same way that many other technologies have spread, a unique, basic computer model—uniform in terms of both hardware and software—is already spreading all over the world. Some features, such as the what-you-see-is-what-you-get forms of selection, for instance, are becoming increasingly rooted in our minds when we think of computers, in the same way that the steering wheel has become associated with our idea of an automobile. If, in essence, this basic computer model reflects the predominant logic, attitudes and views of so-called Western culture, how will this cybernetic globalization affect non-Western cultures, in terms of perception, behavior and traditions?

Michael J. Streibel stresses that the computer is an environment that is associated with many values and biases [6]. As a technology that can only manipulate explicit data and symbols according to formal, syntactic rules, the computer tends to legitimize those types of knowledge that fit into its framework and to delegitimize other types of knowledge. Epistemological methods such as interpretation, intuition, introspection and dialectical synthesis of multiple and contradictory realities are not legitimated by computer technology. Streibel believes that computers force us to objectify ourselves as agents of prediction, calculation and control, even if we are active, constructive and intuitive in our approach to the world. He emphasizes that the more computers are used as intellectual tools, the more this process of legitimization and delegitimization takes place [7].

But it is also necessary to consider the social implications of the expansion of computer technology in the Third World. Would these countries benefit in economic terms from a replacement of the work force by computerized processes? What is the social cost of the adoption of such a model? Will it improve social welfare, or will it increase the existing gap between those who benefit from technology and the rest, for whom it is a nonexistent entity?

It is also important to note that there are different forms of use of this technology. The presence of computer technology is not always apparent to the user, but is often hidden or invisible, as is the case with microwave ovens and much sound equipment. Some computer applications allow the user to participate actively in the creation of rules, codes and meanings, while others limit the user to a set of predetermined actions. In the first case, the computer is considered an intellectual tool, but what is it in the second case? Some people will have access to the creation, development and control of computer technology, while others will have to follow—and fit into—the designs, rules and logic established by the first group. One does not have to be a visionary to predict who will be part of each group—economics, technological progress and education are interdependent variables.

Moreover, the continuing growth of the use of computer-related technologies in developing countries—where illiteracy often reaches high figures and represents a major social problem—may lead to a critical situation. Unlike other technologies, such as radio and television, which are very popular among illiterate people in these countries, computers are still highly based on written, verbal communication. So, the prospect of an increasing use of computer technology in the Third World brings the issue of computer literacy to light.

As Paulo Freire discusses in *Pedagogy of the Oppressed* [8], literacy is not a question of being able to read and write, but of being able "to say one's own word" as a culture generator. It goes beyond the ability to encode and decode abstract meanings and focuses on the ability to create meanings within an interpretive community. It is the significance of the content of the message that counts in an intersubjective dialogue, not merely the mechanical repetition of words. One may ask, then, what "computer literacy" means. Is it related to the pressing of keys and reading of icons, or to the grasping of the underlying logic of computers as symbol-processing machines? Is it measured by the level of one's knowledge of computer devices and jargons, or by the level of one's ability to create meanings that can be shared with others within a given community?

In most developing nations, we are witnessing the advent of what can be called "double illiteracy." People who are already on the fringe because they do not share the codes of a reading and writing society are now even further outside of the system because they have not mastered the use of computers.

In Brazil, the direct interaction of the lower-income class with computer interfaces today is basically restricted to bank transactions. It is perhaps appropriate here to clarify some issues related to the extensive use of banks in Brazilian daily life. In a country where inflation reaches 30% or more a month, people cannot put their money under a mattress, but need to invest it. Saving accounts are the most popular type of investment today. The minimum amount required to open a savings account was reduced last month to Cr$500,00 (approximately $3 U.S.) as a result of the demands of the lower-income class. This amount corresponds to about 4% of this month's national minimum wage. The payment of most bills—such as gas, other energy and telephone bills—is also made through banks.

Credit cards are not as popular in Brazil as in other countries, and money transactions are often made with checks, which means more cash and deposit operations are necessary. Many workers receive their monthly salaries through banks, even when they earn no more than minimum wage. In summary, Brazilian banks are crowded places that are not the exclusive domains of the upper and middle classes, as they are many other countries.

After Brazilian banks introduced magnetic cards and automatic cash machines, aiming at making the client's life easier, things have become more complex for many of their users. One can observe a high degree of difficulty when illiterate or semi-literate people interface with a computer—even when what is required is simply entering their code number in a 12-button keyboard or pointing to an amount on a touch-screen monitor. And the impressive number of illiterate people in Brazil—20 million—does not include the millions of people that are considered semi-literate just because they can write their own names. Although even illiterate adults frequently master the use of numbers and can perform simple arithmetical operations in their daily routine—such as giving the right change at the street market, using a telephone to dial a number or choosing the right bus to catch—for some reason it seems more complex for them to deal with this new devil's machine. If interactivity is considered the core of computer-related technologies, then it is necessary to analyze the implications of an interactivity primarily based on verbal written communication in countries where a great portion of the population is illiterate or semi-literate. As a whole, this situation may be compared to the one experienced by elderly people, who also find it difficult to deal with computers. For different reasons, most elderly people may also be considered computer illiterate, in both developed and developing countries. If, on the one hand, the expressive facet of computers has been greatly improved by the advent of multimedia resources, on the other hand, computers' capability of receiving human input is still very limited. Most of the time, our emotions and ideas are funneled and restricted to the pressing of alphanumerical keys, the touching of a screen or the manipulation of a point-and-click device. Simon Penny observes that the interface is a prime concern for many artists, since it is "the place where the machine meets culture; it is the place where the machine meets the body" [9].

Given this scenario, we must ask what our responsibility is as electronic artists. How can artists interfere in this process so that human, social and cultural aspects are considered in the development of computer-related technologies? Is the role of the artist who uses emergent technologies in the Third World different from the role of those who deal with electronic art in the First World?

Different Perspectives

These issues encompass two different perspectives that are, however, closely related. The first concerns the governing rules of the development and implementation of computer-related technologies. The second perspective is related to the interdisciplinary dialogue between artists and scientists. From the first perspective, it is important to consider the development of computer technology as an international issue. Operating on a global scale brings problems related to the top-down transfer of technology from First to Third World countries, and exacerbates the issue of cultural dominance. Laurel addresses the issues of access and colonialism in a discussion of the design of cyberspace environments and tools. She asks: "Should first-world white heterosexuals build little virtual terrariums for Blacks, Latinos, gays and lesbians—based on their own ideas of what such cultures are like?"[10]

Kaplinsky focuses on aspects of potential conflict in the transfer of technology. He says that any set of complex relationships between different individuals or groups is likely to lead to some misunderstanding and conflict. In the case of the transfer of technology, however, "conflict does not result merely from misunderstanding others' motives and intentions, but it is fundamentally built into the nature of the transactions" [11]. According to him, the reason is that the technology that is transferred is a primary input for the generation of surplus. "Control over this technology is thus crucial, not only because it leads to control over the generation of this surplus, but also because it is an important element in the control of the distribution of the surplus" [12].

On a national scale, the already existent gap in most developing countries between the elite and the poor is likely to increase as a result of the introduction of computer technologies. Economic growth is oriented toward the needs of a rich minority in many Third World countries, accentuating the phenomenon of social polarization. The small percentage of the population that participates in and benefits from technological advances stands in contrast to the massive number of people who are absolutely or relatively marginalized, excluded from all the benefits of technological accumulation and progress. The illiterate person from a developing country will suffer the doubly unfavorable condition of being neither a citizen of the First World—with all the technological advantages that entails—nor a part of the restricted group of Third World citizens who have access to computers and can master the logic and skills required to use them. For the disenfranchised, the introduction of computers in everyday life will be an aggression, as they will not be able to gradually learn, master or interfere with this new technology. Yet, in the end, computers will be imposed on them.

In light of these problems, we may conclude that the introduction of computer technologies may not lead to an improved social yield in developing nations. But there is still hope.

Roger F. Malina calls contemporary artists "technology colonizers" [13] and quotes McLuhan as saying that the artist's role is to explore and spread the new environments made possible by technology. As colonizers, artists explore and establish new territories, guided by intuition, perception and sensitivity. For Stephen Wilson, the artist's most important function has been to keep watch on the cultural frontier: "Artists have cultivated sensitivities and expressive capabilities that enabled them to anticipate and interpret cultural trends. . . . They have revealed unrecognized aspects of their contemporary worlds and offered guidance toward more humanistic futures" [14]. Much, however, depends on our awareness of the actual situation, on our understanding of the frontiers and possibilities and on our participation in technological research.

This issue brings the second perspective into discussion: the interdisciplinary dialogue between artists and scientists. Although the basic approaches of these professional groups usually differ, it is misleading to segregate human actions into "art," "science" and "technology": new areas of research are emerging as a consequence of collaborations between artists and scientists. Artistic focus must be incorporated in the process of new technological developments in order for them to reach their original goal of meeting human needs and desires. As artists, we can criticize, interfere in and deviate from inadequate technological trends. When the stick is crooked, it bends to one side, and it is not enough to place it in its correct position in order to straighten it. One has to bend it in the opposite direction. This is one of the things electronic artists can do with and for emerging technological developments. Most, though not all, technologists working in isolation are far from discovering the intricacies of social and cultural issues, and their views may bend technology to its utilitarian extreme. As artists, we need to bend it to the other side by taking into account the complexity of human-machine relationships in a sociocultural perspective. As a result of these opposed and complementary views and attitudes, technology may be perceived and used by the general public in its intermediate final shape, as a sum of scientific and humanistic perspectives. Human, social and technological areas of knowledge should have never been divorced, as they are complementary parts of the holistic human experience.

Penny points to the advent of a new professional identity: "the interactive media artist, an interdisciplinarian as comfortable with cultural coding as with computer code" [15]. Although only some of us have become part of this new professional group by crossing between the still segregated areas of art and technology, for Penny, the era of those who are at home with both art and technology is arriving.

One of the major challenges we face today is to create computers that have a degree of good sense and comprehension. Computers still do not recognize the user as a specific individual: the human is treated by the computer as a generic type, not as an actual person. Bork points out that, although human-computer dialogues aim at resembling interpersonal conversations, these dialogues are a form of behavioral technology in which dialogical interactions are controlled by an author who is not part of the actual interaction [16]. While interpersonal interactions have a conjoint control as their essential component, interactive computer programs only permit the user to make decisions from a predefined set of choices. For Erkki Huhtamo, "the existence of interactive systems doesn't automatically imply a democratic turn, a redistribution of power from 'the producer' to 'the consumer,' or a reorganization of the information traffic" [17].

Computers have no understanding of the information units they process. If communication channels could recognize information contents, personalized systems that could filter and generate information for a one-person audience could be developed. Darley says that if new technologies are to enable "egalitarian, more democratic, constructive forms, offering new kinds of interaction, knowledge, and understanding" [18], these possibilities have to be struggled for.

Some electronic artists seem to be engaged in this process. Artistic experiments are opening new venues for the use of computers as a human-centered technology, focusing broadly on human pleasure and satisfaction. As a result, they are gradually discovering combinations of the expressive potential of human natural languages—which extend over aesthetic, metaphoric, artistic, affective and moral domains—and the objective, quantitative and procedural characteristics of computer technology.

Yet, artists' views are not decontextualized or isolated from sociohistorical situations. Geographic, cultural, political and economic factors affect artists' perceptions and guide their actions. Electronic artists working in the First World greatly differ from those working in the Third World, not only in terms of their approaches and resources, but mainly in terms of their access to computer-related technology developers.

The diverse realities in which electronic artists are immersed tend to direct their focus into different concerns. While many electronic artists in developing nations are increasingly discussing basic issues such as human rights, social injustice, misery and hunger—which are at the core of their daily struggle for the improvement of their living conditions—these issues are not commonly debated in art conferences in the First World. But if, on the one hand, artists from the First World see Third World critical problems from an outside perspective, on the other hand, First World artists may be insiders when it comes to many decisions that will deeply affect the quality of life in developing nations.

In terms of access, electronic artists in the First World can interfere in a more direct way than their colleagues in the Third World, as they have more opportunities to take part in the development of new trends in computer-related technologies. Although such opportunities are still restricted to a small group of artists even in the First World, the chances for artists from developed countries to research, interfere with and collaborate on computer-related technological developments are remarkably greater than the chances for those who live in developing countries to participate in such capacities.

Artists as Technology Colonizers: Possible Actions

But—in both the First and the Third Worlds—what can we electronic artists actually do, as technology colonizers? Laurel suggests the construction of convivial tools—"tools which give each person who uses them the greatest opportunity to enrich the environment with the fruits of his or her vision" [19]. She says: "I believe that our strategy should be to collaborate with native people in other cultures to build a core of technological expertise. Empowered indigenous programmers will strap themselves to their own user-communities and commence the processes of understanding and ultimately, expropriation." But, in light of the issues discussed earlier, one may guess that the "empowered indigenous programmers" might be trapped in an intricate net of international and national political and economic interests, and may not go too far.

From Henry See's point of view, this discussion gives rise to some crucial questions: "Is the role of the artist to improve the technology so that the established economic/political order can use this technology better? Is improving the technology the answer or is it changing the system which produces it? Can you change the system by changing the technology? Is the role of the artist to change the system?" [20]

The answer to these questions possibly resides in a combination of long- and short-term actions. Electronic artists must have both a worldwide perspective and a critical view of the social implications of the development and use of electronic technologies. It is our responsibility as citizens of this planet to contribute to the improvement of the quality of life on earth in every sense. Neutrality does not exist. A political view is embedded in every person's action or thought. A careful and deep consideration of social and cultural issues may certainly lead to improvements that will make new technologies more appropriate to their users' needs and desires. It is definitely a long way, but it begins with the first step.

In the short-term, much can be done with simple actions. The exchange of information and experiences is a good start. Issues such as the one I am presenting now may be a way of introducing a new challenge for electronic artists. In this sense, the Fourth International Symposium on Electronic Art (FISEA) became a very important forum for such discussions, as a symposium where electronic artists from different countries and continents exchanged their views during several days of intense debates. At the Third International Symposium on Electronic Art (TISEA), in Australia, very important issues on cultural diversity were raised, and I do believe that, as a result, many of us today are listening to each other with less ethnocentric views. Different groups' approaches and perspectives should serve as inputs for new trends in the development of computer-related technologies.

Many of us who are also involved in teaching have a responsibility to introduce sociocultural aspects as part of the discussion of art-related issues. We must open our students' minds and hearts to a broad understanding of our social role.

Another issue concerns participation. In my activities as the Inter-Society on the Electronic Arts (ISEA) South American Representative, I have realized the great interest that South American artists have in talking to the universe, the great desire we have to exchange our thoughts and practices with the rest of the world and the need we have to question our similarities and point to our differences. Formal and informal associations may be a good conduit for funneling individual energy into more effective and productive collective actions.

It is our role to lead computer technology into an era of new values concerning cultural issues, as part of the interactive dialogue between humans and machines. Artists and technologists from the First and the Third Worlds should join their different perceptions and knowledge in order to enable the construction of a qualitative, dialectical, experiential and expressive electronic language.

The time is right for the adoption of such an approach. The main challenge of this decade is to establish a sociotechnical commitment capable of addressing problems of both local and global scope. In a world of social, cultural and economic disparities, a balance between uniqueness and uniformity must be the object of the contemporary electronic artists' major struggle. Better times may be on the way.

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