

Light and Dark Visions: The Relationship of Cultural Theory to Art That Uses Emerging Technologies

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Introduction: The Relationship of Critical Theory and Cultural Studies to Art that Focuses on Emerging Technologies

The impact of technology on contemporary life and culture is a vital issue in our age. Critical theory and cultural studies attempt to link the arts, literature, politics, sociology, anthropology, philosophy, and technology in an interdisciplinary search for relevant concepts and frameworks with which to understand the current world. Art practice and theory are being radically reshaped by this activity.

This hybrid world of culture/art criticism, which places great import on the impact of emerging technologies, has seemed unexpectedly uninterested in the work of artists who work with these very technologies. Similarly, the discourse in the art/technology world – and in the technical world in general – has not engaged deeply the concepts from cultural studies. This essay attempts to elucidate some reasons that might underlie this mutual lack of attention.

The essay has two objectives: It applies some concepts and lines of inquiry from cultural theory to inspect the practice of artists working with new technologies, and identifies ways their practice challenges these theoretical formulations. It then considers a range of theoretical stances artists can assume in relation to working with new technologies. Its goals are to help artists define for themselves a theoretical stance toward their work with technology and to advance the ability of art theory and art criticism to contend with new technologies.

I Survey of Themes from Critical Theory and Cultural Studies

This section briefly lists some interrelated concepts and themes from critical theory and culture studies that can be applied to the consideration of relationships between art and emerging technology. For a fuller elaboration of these themes, see the longer version of this paper which appeared in the *Siggraph93 Visual Proceedings*.

Post Industrialism: Our era is characterized by an "information economy" in which increasingly smaller proportions of the populace generate food and artifacts¹ and cultural structures and ideologies are seen as lagging behind the realities.

Electronic Media and Other Technologies: The pervasiveness and consciousness-transforming potentials of electronic media and other technologies – such as the ascension of hyperreality and the implosion of meaning – are seen as a critical feature of the post industrial landscape.

Postmodernism: Postmodernism is a theoretical approach that defines current "decentered" cultural practice and ideology as rejecting outdated modernist notions such as the belief in historical progress, rationalization of society, and univocal truths.

Structuralism, Semiotics, Post-Structuralism, and Deconstruction: These approaches seek to understand the underlying linguistic and non-linguistic structures that explain belief and behavior in all cultures with a special focus on the ways texts and discourses shape self representation and communication. Deconstruction is an activity focused on the unravelling and unveiling of the interplay of discourses with special emphasis revealing the cultural politics of white, male, Eurocentric hegemony.

* This paper is condensed version of a paper which appeared in the *Siggraph 93 Visual Proceedings* © Association for Computing Machinery (ACM), 1993

The Role of the Artist and the Disappearance of the Avant-Garde: The vision of the artist as a creative genius who uses his or her special sensitivities to cultivate awareness of important cultural themes and to invent compelling expressions is seen as an outdated notion that denies the ways art world discourses are similar to other cultural forms.

II Issues in Applying Cultural Theory to High Tech Art

Although these analyses are gaining widespread attention in the world of art theory and criticism, they have not yet been widely used to understand the work of artists who work with emerging technologies, despite the fact that high tech art is situated in a junction of culture and technology potentially rich for insights. The technologies explored by artists are the very ones some analysts see as key to structuring postmodern, postindustrial society. These technologies are essential components in creating the mediated vortex of free-floating significations and the implosion of meaning. They are also crucial in the creation of new cultural niches in which issues such as control, the body, and war become prominent. Many of these artists have feet in both the art world and popular culture.

Later sections will suggest that some kinds of high tech artistic practice challenge assumptions of cultural theory and thus serve as a useful source for reconsideration of these theories. As compelling as critical theory and cultural analysis are, it is essential to stop to question and inspect the claims they make.

Disjunctions Between Scientific World Views and Critical Theory

Many who work in science and technology still maintain faith in progress, the universality claims of their operations, and the independent status of the phenomena they work with outside of their discourse. They can point to an impressive record of ideas tested by methods of verification that approach objectivity, and to new knowledge, understanding, investigative tools and new technologies that have transformed life in almost every corner of the earth.

The enterprise of science and technology is by no means pure. Phenomena such as uncertainty and chaos theory have shaken some of its epistemological assumptions. Lyotard in The Postmodern Condition² notes that science's fundamental narratives of legitimization are in crisis, and that many of its statements can be described as "performative" utterances -- i.e., they express commitment to action rather than description of external realities. The sociology of science has shown that research is rarely disinterested; it is influenced by ideology and political, military, commercial, and other interests. Grants are awarded and publications approved for ideas that fall within ideologically defined discourses. Seemingly benign knowledge and technologies are perverted to ends never intended by their creators. Gender, race and nationality influence who can do science and whose opinions have weight. Post structuralist analysis has shown that the conceptualization of scientific research questions and professional communication are shaped by metanarratives, just as in other fields. Thomas Kuhn in The Structure of Scientific Revolutions³ has shown that scientific paradigms act as metanarratives that profoundly shape theorization and research; they change slowly through a combination of ideology and experimental results. Still, it is important to note that most practitioners believe in their enterprise and do not embrace the postmodern and deconstructive self questioning typical in the humanities and social sciences⁴.

In the fields of theoretical and applied sciences, there is an optimism very different from the skepticism that marks deconstructive thought. Scientists believe they can refine theory and make universally valid discoveries, and technologists believe they can create technologies that better human life and transform culture in positive ways.

The role of computers and information technologies is one area where views of cultural critics and scientists diverge. Many critical theorists emphasize the insidious

nature of pervasive, smoothly functioning information technologies that control and promote superficial thought and life. For example, Constance Penny and Andrew Ross note in Technoculture that technology is so much a part of the basic structure of society that innovations are immediately co-opted by the mainstream; thus, they dismiss the liberatory fantasies of the new technologies.⁵ Jonathan Crary notes the self-delusion of those who believe in positive revolutionary effects.

The charade of technological "revolution" is founded on the myth of the rationality and inevitability of a computer-centered world. From all sides a postindustrial society is depicted that renders invisible the very unworkability and disorder of present "industrial" systems of distribution and circulation.

Most often advocacy of "alternative" uses of telecommunications and computers goes hand in hand with a naive belief in the neutrality of digital languages and a blindness to the immanence of binary notation with a specific system of technocratic domination.⁶

Negative analyses from some not usually considered critical theorists include Theodore Roszak, who in the Cult of Information⁷ notes that fascination with information often works against real knowledge and deep thought, and Jerry Mander, in Absence of the Sacred⁸ who describes the ways in which technology distances people from essential human experience.

Other visions see the technology not running so smoothly, but nonetheless promoting a nightmare world. For example, Crary comments that Baudrillard's analysis assumes a level of functioning that is unlikely.

What his texts exclude is any sense of breakdown, of faulty circuits, of systemic malfunction; or of a body that cannot be fully colonized or pacified, of disease, and of the colossal dilapidation of everything that claims infallibility and sleekness.⁹

The movie Blade Runner is often cited as an example of this cyberpunk dystopia in which technology has helped to erode order and a sense of history. It is a place exemplifying Frederick Jameson's critical characteristics of postmodernism – pastiche (simultaneous juxtaposition and mutual quotation of styles from multiple eras) and schizophrenia (the breakdown of the referents of signifiers).

the city of Blade Runner is not the ultra modern, but the post modern city. It is not an orderly layout of skyscrapers and ultra comfortable, hypermechanized interiors. Rather, it creates an aesthetic of decay, exposing the dark side of technology, the process of disintegration, postindustrialization, and quick wearing out.¹⁰

Others, however, see information technologies as democratizing access to information, humanizing labor, increasing productivity, deepening thought, building community, and generally empowering increasing numbers of people throughout the world.¹¹ Stuart Brand propounds some of these beliefs in his account of MIT's Media Lab, one of the preeminent new technology research centers.

Is there any reason to believe that Personal Television, Personal Newspaper, Conversational Desktop, access to an infinite library of Electronic Publishing, a Vivarium of one's own and a fiberoptic connection to a Connection Machine would encourage Personal Renaissance?

There is. We have already seen the arrival of personal computers make multitudes broader in their skills and interests, less passive less traditionally role-bound. That's renaissance. We've seen people use VCR's to stop being jerked around by the vagaries of network scheduling, build libraries of well-loved films, and make their own videos.

We've seen satellite dishes by the quasi-legal million employed to break the urban monopoly on full-range entertainment...

Each violated what was known about audiences. No wonder. Each made audiences into something else - less "a group of spectators, listeners, or readers" and more a society of selectors, changers, makers. ¹²

John Sculley of Apple Computer describes a related vision of the technologically enabled future in the book Interactive Multimedia.

The book you are holding is a beacon illuminating an exciting future for American education. Technologies described in this book will give us the ability to explore, convey, and create knowledge as never before. Teachers and students will command a rich learning environment that, had you described it to me when I was in school, would have seemed entirely magical.

Imagine a classroom with a window on all the world's knowledge. Imagine a teacher with the capability to bring to life any image, any sound, any event. Imagine a student with the power to visit any place on earth at any time in history. Imagine a screen that can display in vivid color the inner workings of a cell, the births, and deaths of stars... And then imagine that you have access to all of this and more by exerting little more effort than simply asking that it appear ...They are the tools of a near tomorrow and, like the printing press, they will empower individuals, unlock worlds of knowledge, and forge a new community of ideas. ¹³

Those who work in any number of emerging technologies –robotics, artificial intelligence, simulation, telecommunications, virtual reality, materials science, nanotechnology, and biotechnology – would describe the probable implications of their work in similar terms. Conferences, trade shows, and journals burn white hot with intellectual foment, excitement, and eagerness to invent the future.

Do these scientists and technologists live in the same world as the culture analysts? The discordance between the world views of those who work with new technologies and culture theoreticians may be an essential issue for understanding the contemporary era. One conceptualization is that one group is wrong because it lacks information. For example, a critical theorist might note that technologists delude themselves about the amount of autonomy they have in their research, the underlying metanarratives that shape their behavior, and the ultimate cultural ramifications of technology. Or perhaps the difference is more like the proverbial cup – half full to some and half empty to others based on experience and reference culture.

Artists working with emerging technologies are often caught in this discordance, which results in some of the critical confusion concerning their work. In the 1960's CP Snow identified the "two culture problem"¹⁴. He noted that those in the sciences and humanities were living in different worlds with different languages and norms and that the gulf was growing . It is possible that the dark interpretative tone of culture theorists stems from their experience of being acted upon by new technologies, while the optimism of scientists and technologists reflects their engagement in the processes of imagining, inventing, developing and enabling the new technologies.

Artists who work with emerging technologies face a dilemma. They stand with feet in both worlds. On one side they are invited to help create the new technologies and elaborate new cultural possibilities; on the other, they are asked to stand back and use their knowledge of the technology to critically comment on the underrepresented implications of the technology. It is no wonder that there is critical confusion in regard to the work of these artists because of the different stances they can assume. It is easy to see why the critical community might ignore or consider naive work which entertains the world views of the technologists. The section below on artist stances details different responses artists can make to this confrontation of zeitgeists.

The Status of Substantive Things and Organisms in a World Dominated by Image and Media

A basic theme explored by critical theory is the relative importance of information, codes, images and representations versus the material world. In a postindustrial, information economy most people are seen as working with mediated abstractions rather than with real things. Because of the power of computer representations, workers in many businesses don't see the real objects of their business during the work day. Telecommunication substitutions of mediated presence for physical presence highlight these trends. Baudrillard's conceptualization of a hyperreality dominated by media images and by circulating signifiers and codes increasingly disconnected from their referents speaks to the questionable status of things and organisms. Virtual reality technology, which combines visual, auditory, haptic and kinesthetic senses, promises to increase the power of representation to substitute for material experience. Some ecologists suggest that a mediated world might be good because endless production and consumption of things is suicidal. Donna Haraway's "Cyborg Manifesto"¹⁵ points toward a future where bodies themselves might be irrelevant. The perception and meaning of even fundamental "realities" such as disease and sex are profoundly shaped by ideology and discourse.

The assessment of the decline of the importance of the material world is a critical issue for the arts and culture at large. On a basic level the diminished importance of the physical seems overstated. Birth, death, health, disease and the everyday realities of eating, moving, and sex still seem important parts of most people's experience. Many of the world's peoples still struggle to survive and spend their days struggling with the physical world. Even in the developed world there is a growing uneasiness about incompleteness in even the most advanced computer simulations and representations of reality¹⁶. Eugene S. Ferguson comments in his article "How Engineers Lose Touch":

Despite the enormous effort and money that have been poured into creating analytical tools to add rigor and precision to the design of complex systems, a paradox remains. There has been a harrowing succession of flawed designs with fatal results – the *Challenger*, the *Stark*, the Aegis system in the *Vincennes*, and so on. Those failures exude a strong scent of inexperience or hubris or both and reflect an apparent ignorance of... the limits of stress in materials and people under chaotic conditions. Successful design still requires expert tacit knowledge and intuitive "feel" based on experience.¹⁷

Historically, the arts have spanned both the material and the representational - working with image at the same time as they celebrated the substantiality and sensuality of real things as in sculpture and architecture. As Walter Benjamin noted in "Works of Art in the Age of Mechanical Representation" technologies such as photography and cinema decreased the importance of presence and "aura".

Questions of materiality are especially critical for artists working with new technologies. The imaging, communications, and information technologies they work with are key facilitators of this mediated world. The work they do helps to explore and settle new worlds of representation. Yet, it is not inevitable that new technologies only work with representation. The technologies that manipulate physical things - for example, robotics, nanotechnology, material sciences, alternative energy research and biotechnology - have been less accessible to artists and the general public. These technologies will be increasingly important, and point toward futures where technologically mediated material things have increasing importance. Artists need not accept the inevitability of a vision in which materiality becomes unimportant.

The Difficulties of Locating a Rationale for Action in a Deconstructed Milieu

Postmodernism and deconstruction can lead to a classic double bind. If all claims to truth are invalid then why should one author's vision be privileged over any others'? If every work is a recombination of texts received from elsewhere and bounded by a limited discourse community, then why should it have meaning outside that community. If originality, genius, and avant-garde status are outdated, then what is the role of the intellectual, critic, or artist? What is the origin and justification of their need to create and what is the motivation of anyone else to listen?

Norris notes in What's Wrong with Postmodernism that some post structuralists used deconstruction in a way that was much more epistemologically radical than intended.

For Saussure, this exclusion (of referential aspects) was strictly a matter of methodological convenience, a heuristic device adopted for the purpose of describing the structural economy of language, that is, the network of relationships and differences that exist at the level of the signifier and the signified. For his followers, conversely, it became a high point of principle, a belief - as derived from the writing of theorists like Althusser, Barthes, and Lacan, - that 'the real' was a construct of intralinguistic processes and structures that allowed no access to a world outside the prison-house of discourse. ¹⁸

He further states that the validity of a writer's arguments depends on assumptions of truth and value even though their assumptions of validity would seem to contradict their theories. He quotes Derrida explaining this need:

(writers must) invoke rules of competence, criteria of discussion and of consensus, good faith, lucidity, rigor, criticism and pedagogy ...without these strictly indispensable protocols ... deconstruction will lack all critical force. ¹⁹

Similarly, he notes that Baudrillard's writings make no sense without some claims of truth.

his work is of value in so far as it accepts -albeit against the grain of his express belief - that there is still a difference between truth and falsehood, ...the way things are and the way they are commonly represented....it just does not follow from the fact that we are living through an age of widespread illusion and misinformation that therefore all questions of truth drop out of the picture. ²⁰

All artists, critics and intellectuals who entertain these critical theories must resolve these contradictions for themselves and their audiences. On what basis can artists claim that their productions deserve an audience and that their perspectives provide a view not generally available? What does it mean in the postmodern world to say that one person has a clearer vision than another?

III High Tech Artists' Stances Toward Cultural Theory

Critical theory and cultural studies pose significant challenges to the artist. How should they conceptualize their work? What sense can they make of the art world and its relationship to the larger culture? With the growing prevalence of critical theory and postmodern analysis in art world discourse, artists can stake out their own theoretical stance; they must choose which assessments and theoretical propositions to accept or reject. Clarity is especially important for those artists who work with emerging technologies.

The sections below describe three possible stances, which emphasize different ways to respond to the critiques and to address the special challenges of new technologies:

1. Continue a modernist practice of art linked with adjustments for the contemporary era.

2. Develop a unique postmodernist art built around deconstruction at its core. 3. Develop a practice focused on elaborating the possibilities of new technology. For the sake of clarity the interrelationships are de-emphasized.

Continue Modernist Practice of Art with Modifications for the Contemporary Era

Many in the art world reject substantial portions of critical theory. They still believe in the validity and cultural usefulness of a modernist, specialized art discourse that claims universal aesthetic truth. They believe art can have an avant-garde function, that individual vision and genius are still relevant, and that artists can transcend their particular niches in cultural discourse. They hold that the art world can be reformed, without fundamental change, to assimilate previously ignored voices such as those of women, people of color, and the third world. They see the high art/low art distinction as useful. They are confident that they can appropriately negotiate the inclusion of popular culture images and media and incorporate selective insights of cultural theory without necessitating revolutionary change in the nature of art.

The work of some artists with emerging technology can be viewed as continuous with the work of artists who work with traditional media. They see themselves engaged in specialized aesthetic discourse and nurture their personal sensitivity, creativity, and vision. They aspire to be accepted by the mainstream world of museums, galleries, collectors, and critics (or for some, cinema and video). They work on concerns and in modes developed for art in the last decades such as realism, expressionism, abstraction, surrealism, conceptual work. They believe that art will continue to renew itself, find ways to appropriately connect with its host cultures and develop relevant new movements in the future. In fact they see themselves as essential to progress in art, and seek to cultivate the unique and "revolutionary" expressive capabilities of their new media and tools. They believe that the art world will ultimately incorporate even unprecedented technologies and approaches such as image processing, interactivity, algorithmic systems and virtual reality. The claim by some that these approaches so radically challenge fundamental art substructures that they cannot be assimilated will require significant critical analysis.

Deconstruction as Art Practice

Many artists who have found these theory-based analyses compelling have been attempting to develop an approach in which deconstruction itself is a main agenda. The theories provide concepts, themes, and methodologies for creating art works that examine and expose the texts, narratives, and representations that underlie contemporary life. Even more, the work can reflexively examine the processes of representation itself within art.

Technology and its associated cultural contexts are prime candidates for theory based analysis because they are critical in creating the mediated sign systems and contexts that shape the contemporary world. In this kind of practice artists learn as much as they can about working with the technologies so that they can function as knowledgeable commentators. In one typical strategy, artists become technically proficient so they can produce works that look legitimately part of the output of that technology world while introducing discordant elements that reflect upon that technology. Thomas Lawson describes this approach as it might be used in painting, but the strategy applies in all media.

But by resorting to subterfuge, using an unsuspecting vehicle as camouflage, the radical artist can manipulate their viewer's faith to dislodge his or her certainty. The intention of that artist must therefore be to unsettle conventional thought from within, to cast doubt on the normalized perceptions of the "natural," by destabilizing the means used to represent it.²¹

Invention and Elaboration of New Technologies and their Cultural Possibilities as Art Practice

This century is characterized by an orgy of research and invention. Knowledge is accumulating at high speed; branches of knowledge, industries, social contexts, and technologies have appeared that could not have been anticipated. These developments are affecting everything from the paraphernalia of everyday life to ontological categories. As the pace continues, predictions about future discoveries and their consequences are impossible.

Artists can establish a practice in which they participate at the core of this activity rather than as distant commentators, even while maintaining postmodern reservations about the meaning of the technological explosion. Some analysts see scientific and technological research as the central creative core of the present era. As Paul Brown suggests in his essay in the SIGGRAPH 92 Visual Proceedings, historians may ultimately see aspects of science as the main art of our era.

I believe that the art historian of the future may look back at this period and see that the major aesthetic inputs have come from science and not from art....Maybe science is evolving into a new science called art, a polymath subject once again.²²

As this author has described in previous articles, "Research and Development as a Source of Ideas and Inspiration for Artists"²³ and "Industrial Research Artist: a Proposal"²⁴ artists can participate in the cycle of research, invention, and development in many ways. They can learn enough to become researchers and inventors themselves. From the time of Leonardo until recently, the merger of scientific and artistic activity was not uncommon. The claim that this unified method of functioning is impossible now because scientific or technological research requires mastery of too much specialized knowledge and access to an elaborate research infrastructure must be critically scrutinized.

Artists can function in other ways. Free from the demands of the market and the socialization of particular disciplines, they can explore and extend the principles and technologies in unanticipated ways. They can pursue lines of inquiry abandoned because they were deemed unprofitable, outside established research priorities, or strange. They can integrate disciplines and create events that expose the cultural implications, costs and possibilities of the new knowledge and technologies.

This practice does not accept the output or the conceptual frameworks of the science and technology world as givens. Rather it seeks to update the notion of the arts as a zone of integration, questioning and rebellion to serve as an independent center of technological innovation and development.

An example from just one area of technological foment will illustrate. Many electronic artists are interested in the new possibilities created by telecommunications technology and seem interested in inventing and extending the technology. Certainly, they are interested in the issues cultural theorists might raise: for example, Who controls and has access to this technology? How is it represented to consumers and to developers? What larger cultural movements is it part of? What fantasies does it tie into? Even though these topics might be substantive focuses of their work, their tone is basically optimistic about the potential meanings of these developments.

Roy Ascott, a long time pioneer in this work, illustrates this optimistic outlook in his article "Art and Education in the Telematic Culture."

But the art of our time is one of system, process, behavior, interaction....This is precisely the potential of telematic systems. Rather than limiting the individual to a narrow parochial level of exchange, computer-mediated cable and satellite links spanning the whole planet open up a whole world community, in all its diversity, with which we can interact....With electronic media, its flow of images and texts, and the ubiquitous connectivity of telematic systems this isolation and separateness must

eventually disappear, and new architectural structures and forms of cultural association will emerge. And in this emergence we can expect to see, as we are beginning to see, new orders of art practice, with new strategies and theories, new forms of public accessibility, new methods of presentation and display, new learning networks – in short, whole new cultural configurations.²⁵

Telecommunications is just one of many fields of technoscientific research that promise culture transforming possibilities. Taking advantage of unique traditions of the arts, such as valuing iconoclasm and interdisciplinary perspectives, artists can choose to be a part of the efforts to create these new technologies and fields of knowledge. Furthermore, this artistic stance calls for artist participation in other fields beyond the digital technologies that are focused on in this essay such as new biology, materials science, and space exploration.

Crossing Boundaries

The artistic stances described above outline a range of responses artists can and have taken toward emerging technologies. Real practice, of course, is not so clearly demarcated as these categories. As they go about their work artists cross over. For example, consider how this analysis might be applied to artists' work with virtual reality (VR) technology.

Many artists seem to want to work within historically recognizable artistic traditions, with virtual reality seen primarily as a new medium. They want to create highly interactive compositions that will be judged by their thematic, dramatic, visual and sound accomplishment just as traditional media have been. New aesthetic categories focused specifically on the interactivity and kinetic engagement will no doubt be developed but the social niche of VR as entertainment or art form is not that different from what already exists. The interest expressed in this technology by the entertainment industry attest to its readiness to assimilate this technology to traditional forms. And as with traditional media, independent artists are developing works based on this technology, which elaborate poetic, expressive, craft, sensual or conceptual directions likely to be ignored by commercial interests.

One direction for artists using the VR technology in a conceptual or social commentary mode might be to use it reflexively on the technology itself. For example, they might explore the origins of the technology in military simulation, the language used to promote it, or the social niches in which it is adapted. They also might use its unique potential to offer new perspectives on body or gender (for example, allowing individuals to constitute themselves to other VR travelers in any gender desired). These explorations pass over into the deconstructive, theory based practice described above.

Other artists might be interested in pushing the functioning of the technology- for example, by extending the ways it senses body motions or the way it represents worlds. Alternatively, they might work on inventing or investigating new non-commercial applications such as ways of experiencing being in two locations at once or experiencing the life of animals or inanimate objects.. This work passes over into the technology extending practice described above.

Summary: How Can the Arts be Part of a Technological Era?

There is an acknowledged danger that technology is advancing much faster than the culture's ability to make sense of it. The arts have traditionally been a place where understanding, integration and preparation for future developments takes place. There are several competing visions of how artists can most fruitfully work with emerging technologies: treat them as new media, deconstruct their cultural implications, or participate in the processes of invention and extension.

Critical theory and cultural studies offer compelling tools for understanding some aspects of contemporary technological society. Furthermore, these theory based approaches offer powerful concepts and methodologies for practicing artists to use in responding to the realities of an electronically mediated world. However, while these approaches are useful for understanding what exists, they are problematic for envisioning what might be. Furthermore, these approaches, in their skepticism about progress and about the possibility of innovation to transcend specific contextual discourses, are at odds with values of the researchers and inventors who believe they are working to create new cultural possibilities. Artists who work with emerging technologies are faced with the challenge of positioning themselves in these conflicting world views.

* This paper is condensed version of a paper which appeared in the Siggraph 93 Visual Proceedings © Association for Computing Machinery (ACM)

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¹²Brand, Stewart. Media Lab, Penguin, New York, 1987. p. 252

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¹⁹ Ibid p. 45

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