Artistic Practice, Body Knowledge and the Enigneering World View

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"I don't share your nostalgia for the body." So spake an attendee at Ars Electronica 1995.[1] The notion that the body is "obsolete " has inexplicably become particularly fashionable in cybercultural circles. This desire to transcend the body via the technology of the day is to my mind not only peculiar, but much less futuristic than contemporary adherents would imagine. The privileging of "mind " over "body ", the abstract over the concrete, is a strong continuous thread in western philosophy, from Plato, through Christian theology, to Descartes and beyond. William Gibson's cyberpunks proclaimed that "the body is meat" but neglected to notice just how similar their position was to that of Saint Augustine. Roboticist Hans Moravec has envisioned a future in which we upload our consciousnesses into galactic gas cloud digital data banks and live as immortal disembodied digital entities. But he neglects to observe just how similar this idea is to "going to heaven ".[2] Australian performance artist Stelarc has argued for the need to hollow out and dry out the body, to develop synthetic skin and generally to re-engineer the body to make it amenable to a symbiotic union of technology and biology.[3]

Where and when did this desire to transcend the body become identified with "technology "? What are the implications of this identification on artistic practice with technological tools? I will attempt to address these questions in this paper by observing that what I call the Engineering World View perpetuates the Cartesian Duality and that the computer, the technology around which we focus our practice, is the epitome of this world view.

In case parts of the ensuing discussion might be found to be affronting to persons trained in engineering professions, I hasten to clarify that my critique is levied not at persons but at the accumulated and often implicit ideology of engineering, an ideology which we are all inoculated with. This argument is, at root, an internal debate. It is not about something outside me. I, like most of us in the West, have internalised the scientific method and the Engineering World View. It would be quite hypocritical of me to criticize engineering per se, since I take part in it every day. What I aim to question is the limits to its range of usefulness. My quintessentially interdisciplinary method is to examine "engineering " with the specula of literary and critical theory and artistic practice.[4]

The Engineering World View

Science and Engineering are not an homogeneous entity. Although we might construct an opposition between pure scientific research and the application of such scientific research for the efficient production of goods, it is more accurately a continuum, the boundaries are blurred. Nonetheless, there are core ideas which unite the scientific method, the logic of industrial production and capitalism. The first of these ideas, reductivism, allows that phenomena can be usefully studied in isolation from their contexts. This in turn allows that a holistic system can be rationalized into chosen vectors, vectors which maximise productive output, and hence profit, with respect to input: materials, energy, money and labor. This way of thinking is an "article of faith " for western culture for very pragmatic reasons: the instrumentalization of this method has led to industrialization, hence to wealth and power in the modern period. I would argue that [contrary to the usual direction of argument] the privileging of scientific discourses in our culture is entirely due to this wealth generating power. Noah Kennedy has emphasised the structural connection between the computer and the logic of industrial production:

"In a sense, the mechanical intelligence provided by computers is the quintessential phenomenon of capitalism.
To replace human judgment with mechanical judgment — to record and codify the logic by which the rational, profit-maximizing decisions are made — manifests the process that distinguishes capitalism: the rationalization and mechanization of productive processes in the pursuit of profit […]. The modern world has reached a point where industrialization is being pointed squarely at the human intellect."[5]

That mind is separable from body; that it is possible to observe a system without that observation affecting its outcome; that it is possible to understand a system by reducing it to its components and studying these components [that the whole is [no more than] the sum of its parts]; that the behavior of complex systems can be predicted: these ideas are hallmarks of a nineteenth and [early] twentieth century scientized approach to the world. When these ideas are instrumentalised, they become the ideology of efficient production, what I call the "Engineering World View ".

Implicit in this discussion is the idea that, futuristic rhetoric notwithstanding, the computer is the pinnacle of achievement of the discipline of engineering and the values that characterise nineteenth century engineering ideology find their purest expression in the digital computer. Given this, there is a certain irony in the fact that the computational capability of modern computers has, in recent decades, brought key aspects of the engineering world view into question. In the seventies, Beno_ˆt Mandelbrot discovered geometrical monsters which he called Fractals by applying the power of the computer to a nineteenth century mathematical oddity. In a similar way, Crutchfield, Farmer, Packard and Shaw shook the scientific establishment with the revelation that simple deterministic systems can give rise to unpredictable and random behavior. They called this phenomenon Chaos and noted that it in principle placed limits on the power of determinism. More recently the reliability of the technique of reductivism has been called into question due to an increasing understanding of Complexity and Emergent Orders.[6]

If the pinnacle of Engineering is the computer, then the pinnacle of that pinnacle is Artificial Intelligence. In the sixties, the perceived failure of the cybernetic approach of modeling organic systems such as reflexes and neural networks had led to the exploration of automated logical systems. The early triumphs of Artificial Intelligence such as Newell and Simon‘s "General Problem Solver " found their success in rigorously confined logical domains, but difficulties arose in attempts to generalize these systems to deal with "real world" problems which have no such bounded domains. Computers were able to excel at logically complex but bounded problems such as playing chess, but were unable to deal with the day to day tasks such as crossing the road. The necessary addition of proliferations of contingency conditions led to the phenomenon of "brittleness ". It became clear that abstract logical reasoning was easy to automate, in comparison to the underlying substrate of learning which we call "common sense". I would say that abstract reasoning is easy to automate because such reasoning is an abstract "machine". Like knows like.

Typically, when AI techniques were applied to problems of robot navigation, data was gathered by sensors and a map of the environment of the robot was generated, over which a path was planned. Instructions were then sent to the output devices [usually motors]. As the robot proceeded down this path, the environment was re-measured, position plotted on the map, and the map corrected if necessary. This method had come to be known as the Top-Down paradigm. In practice these systems were very slow. It was observed that a cockroach was better at crossing a road than the most powerful computer! This led to the realization that

these situations demanded a type of "intelligence" heretofore unacknowledged by the AI community. Famously and iconoclastically, Rodney Brooks proposed that AI should stand for "Artificial Insects" rather than "Artificial Intelligence". He argued that a cockroach doesn't "map", that there was no need for the duplication of the real world in the abstract map, like some kind of floating platonic ideal. This kind of thinking led to a variety of research projects loosely categorised as Bottom-Up robotics. It should be noted in passing that the Top-Down paradigm, in its centralisation of control, inherently perpetuates panoptical models. Furthermore it exactly replicates and reinforces very traditional dualisms of master and slave, general and soldiers, boss and workers and more abstractly,nature/culture, body/mind, form/content and hardware/software. Bottom-up theories, on the other hand, implicitly oppose authoritarian power structures and endorse horizontal and rhizomatic power structures.

Out of Engineering

Numerous authors, from Neil Postman to Manuel DeLanda, have noted the diffusion of the Engineering World View into social and cultural realms.[7] Carolyn Marvin has documented the nineteenth century valorisation of the discipline of Engineering and the person of the engineer:

"For some generations […] natural depravity has been left to ministers, lawyers, editors, the mothers of families, to anyone, in fact, but the engineer; and this is where society makes a mistake. The best corrector of human depravity is the engineer […] No other man in the world has such stern and unceasing discipline, and so it comes about that no other man is so safe a moral guide as the engineer, with his passion for the truth and his faculty for thinking straight."[8]

If engineering models necessarily replicate the values of the cultural milieu of the engineer, then the technologies generated become themselves models, by virtue of their ability to generate wealth, power etc, as previously noted. J.D. Bolter calls these "paradigmatic" technologies.[9]

Browsing through a university course catalog, I reflected on the similarity between it and an automotive parts catalog. This line of reasoning led me to consider the process of a liberal arts education in these terms: Raw material [the student] is received and tested. If adequate, this material is subjected to a series of numbered processes in a certain order. At the end of each process, the raw material is tested to see if the process was successful. If so, it moves to the next process. If not, it is either re-processed, or scrapped. Certain processes are only effective if other processes have previously occurred. These processes are modular, they can be arranged in different combinations to produce different products, a pickup or a coupe, a psychologist or a dancer. The efficiency of the factory can be measured in terms of degrees produced per dollar input.

The paradigmatic technology here is the assembly line. The modern serial processing computer can be thought of as an assembly line for digital data.The computer has become a structuring metaphor, the "paradigmatic technology" in a wide range of human activities, due in part to the adoption of the mechanisms of computation as structuring metaphors for human behavior, particularly in the strain of cognitive science called "Cognitivism". The application of these metaphors induces an accidental elision of ways in which human activity is different from that of the computer.

If the measures and definitions for human faculties are modeled on the computer, and the computer is an embodiment of a value system predicated on industrial methods of control and production for profit and efficiency, then the person has been successfully reduced to an entity only assessable within these criteria: its worth is determined by its productivity, its worth is purely economic.

We seem to accept the disciplinary regimes of engineering voluntarily. I have begun to observe that my relationship to time itself has taken on the qualities of the Engineering World View. I divide my day into units of time for tasks, the day is a succession of such blocks. I measure myself in terms of tasks achieved per unit time. I subject myself to a rigorous discipline of efficiency and optimisation.

Clever Meat

I will now attempt to argue for the non-existence of what has become for us a metaphor which structures the way we think. I will argue that "mind" does not exist. What do I mean by this absurd proposition? I mean that mind is a linguistic construction, a concept. The problem for us is not the existence of the concept per se, but that the concept "mind" has become reified, the assumption of the existence of something called a mind has led to the building of an entire conceptual and linguistic edifice. Hence, to argue for the non-existence of mind is an elusive task, not because mind does exist, but because the mind-body split is fully installed in our language. We struggle when there are no words, when the words that exist undermine the goal of the task at hand. So in this essay I try to employ terms like "sentience", "consciousness" and "knowing" rather than "think" and "mind".

I will not argue that we privilege "mind" too much, nor that we ought to privilege "body". This would be to perpetuate a dualistic model. I want to argue against dualism. This desire creates a philosophical impasse, as I mentioned earlier. To attempt to argue against dualism or to propose alteration to the hierarchical relationship of mind and body is nigh impossible in western philosophical discourse, because it is predicated on dualism and privileges the abstract and transcendent over the embodied and concrete. I am reminded that it is precisely the contradictions of theory which artists try to explore with practice.

Hubert Dreyfus argued many years ago that the fault at the root of what he called "Good Old-Fashioned Artificial Intelligence" is that we understand the world by virtue of having bodies and a machine without a body would never understand the world the way we do. If Hubert Dreyfus maintained that we have a human mind by virtue of having a human body, I want to argue more radically that any attempt to separate mind from body is flawed and that the presumed location of the mind in the brain is inaccurate. Why is it that we believe that consciousness is located exclusively in the brain? Why does this location fly in the face of folk wisdoms? Why do we put so much faith in "gut feelings", why do we describe some responses as "visceral "? Why do ancient Indian yogi and Chinese martial traditions locate the center of will in the belly [the "dantian"]?

I want in all seriousness to argue that I "think/know" with my arms and with my stomach. To maintain that the activity which we call "knowing" is isolated to a subsection of the body, is folly. Why am I pursuing this line of thought? Because firstly, the re-definition of human capability in terms of the computer resoundingly reinforces the separation of mind and body. And secondly, because dance, sculpture, painting and the variety of other fine and performing arts are premised on bodily training and bodily knowledge which implicitly deny the

mind/body duality. We believe that we think with our brains, because we have been taught that this is the case. What if we believed otherwise? How differently would we live our lives?

I will now cite several examples of recent neurological research to support my argument. It has been observed that in certain manual activities of high skill, such as playing violin, the action is so fast that the nerve signals could not travel up the arm, into the spine and brain, and back again. Motor "decisions" have been shown not to pass through the brain, but to remain in the limb. A neural closed circuit: the hand is thinking by itself!

Sten Grillner has proven, at least in the case of a simple fish, that the muscle coordination which results in locomotion arises not in the brain proper, but in entirely in the spinal chord and the adjacent muscles. He notes: "Some mammals [such as the common laboratory rat] can have their entire forebrain excised and are still able to walk, run and even maintain their balance to some extent."[10]

The human stomach is neurally far more complex than had been supposed.[11] It is feasible that the stomach might make some decisions "by itself". If the stomach is thinking, then why not the liver and the kidney? And if the arm can function as a neural closed circuit, then perhaps the organs are chatting amongst themselves. This kind of "bodily democracy" is antithetical to the top-down model of panoptical control common to the engineering-inspired disciplines and to the conventional notion of the brain "controlling " the body. Acceptance of this condition is not only in line with ideas of distributed processing and emergent complexity, but also lends new credibility to "pre-scientific" physiological theories such as the "doctrine of the humors".

Early in embryogenesis, a formation called the "neural crest" splits. Half forms the brain and the spinal chord. The other half becomes the nervous system of the gut. It was presumed in medical science, under the strong influence of Cartesian thought, that the gut, like all the rest of the body, was a kind of meat puppet, a slave of the master brain. It transpires that the gut has over 100 million neurons [more than the spinal chord]. The entire intestine is sheathed in two concentric sleeves of neural tissue, isolated with an equivalent to the blood/brain barrier.[12] Just exactly what the gut is thinking we don‘t quite know, but I‘m willing to wager that if you wired up the gut to a PET scan machine, you‘d find that the gut partook in consciousness. I believe that consciousness is physiologically a distributed bodily thing. If this is the case, then the basic premise of Cognitivism, that the brain, consciousness etc. can be understood using the analogy of a computer, is flawed.

In the sixties, Watson and Crick explicitly described DNA in computer terms as the genetic "code", comparing the egg cell to a computer tape. This school of thought is perpetuated in the more extreme versions of Artificial Life. Chris Langton talks of separating the "informational content" of life from its "material substrate". Though this is still the dominant paradigm, there is a trend away from reductive and dualistic thinking occurring at every [biological] level. New embryological research indicates that the self-organising behavior of large molecules provides [at least] a structural armature upon which the DNA can do its work. That is, some of the "information" necessary for reproduction and evolution is not in the DNA but elsewhere, integrated into the "material substrate". Alvaro Moreno argues for a "deeply entangled " relationship between explicit genetic information and the implicit self-organising capacity of organisms.[13]

Simulation and the Demise of Body Knowledge

Bill Buxton once remarked that if human society were destroyed apart from a computer shop, visiting Martian archeologists would determine that humans were monocular and had one hand with 29 digits on it.[14] All the remaining body senses and capabilities are irrelevant to the computer interface. These are the parts of sentience that the interface amputates. By defining intelligence in terms of the capabilities of the computer, the [bodily] intelligence, for instance, of the painter, is lost.

One of the least remarked aspects of the computer revolution is the way that the development of software simulation has reduced a great variety of various bodily activities into one. Although this process is in many ways "enabling", [we can prepare a publication, from writing text to typography, image placement and page layout at the same desk], the down side of this process is that it induces a "bodily monoculture". It destroys the complex ecology of body-knowledge, which we might call "cognitive diversity ".

The increase in simulation of bodily activities which results in a depletion of the difficult to formalize intelligences of the body which make up the traditional "skill-base" [as opposed to knowledge base] of the visual arts is a problem. The traditional artistic skillbase is in danger of being "disappeared" in the race to total simulation.[15] To elaborate: previously, one learnt a set of bodily behaviors in order to use a machine lathe, another set of activities to set type, another to paint a picture and another to write. All these activities are now achieved by tapping a keyboard while starring at a video screen at close range.[16] Not simply is the range of body knowledge [body intelligence] being vastly limited [the body is being de-skilled], but the process which links conceptualization to physical realization is destroyed.

One may argue that some digital tools simulate analog procedures while others do not. I would suggest that all digital techniques are based on pre-digital techniques. [Where else can they have come from?] Manipulation of abstract, symbolic quantities is premised on bodily, physiological experience. Why do we call a high note "high"? Could it be because when we sing a high note the physiological experience is in the head, as opposed to the throat or chest? Mark Johnson argues: "In considering abstract mathematical properties [such as "equality of magnitudes"] we sometimes forget the mundane bases in experience which are both necessary for comprehending those abstractions and from which the abstractions have developed.[…] Balance, therefore, appears to be the bodily basis of the mathematical notion of equivalence."[17] As Dreyfus‘ argued, we have a human mind by virtue of having a human body.

Among young children, continuous use of computers, video games and TV seems to impair the development of basic "common sense" and motor skills. I have heard that certain [German] insurance companies now sponsor summer schools in which children are "taught" that open flame and red-hot things can cause pain and burns, that you can fall off a bicycle and it hurts, etc.[18] One assumes that the motivation of these companies is not entirely philanthropic, that it saves money to help children avoid simple accidents. This erosion of "common sense" by computer use is a curious mirror of the "common-sense problem" which defined the limitations of Artificial Intelligence.[19]

Prosthetical Bondage and Mechanistic Mimesis

In engaging the computer as an artistic tool, the artist must consider the potential conflict of interests between the value systems reified in the architecture of the machine and the logic of the software, and the interests of artistic practice. The very existence of artistic practice with the computer must be seen in the context of these ideas as a kind of "intervention" which

brings into question issues such as those I have been discussing: the conflict of world views inherent in digital art practice, the demise of bodily knowledge, etc.

Freedom and Liberation are catch-phrases of cyber rhetoric, but what price do we pay for the liberty of the virtual? Bondage of the physical![20] In order to make conquering strides across cyberspace, we sit, neck cramped, arms locked, tapping a keyboard, our vision fixed on a small plane 50cm ahead. As the image becomes more mobile [VR] the viewer becomes less mobile. Held in a bondage of straps and cables, the question, "Are you a man or a mouse?" acquires new relevance!

As digital media artists, we are continually reminded of the fact that when making digital artworks we are building virtual machines. Any tool [soft or hard] is a mechanistic approximation of a narrow and codified aspect of human behavior. On a day to day level, the task that confronts us is how to "shoehorn" the kind of cognitive fluidity we enjoy in our interaction with the world into the proscribed and proscriptive language of the machine. This dilemma is no different whether writing code or building a washing machine. The computer is as pedantic and rule bound as any other mechanical contrivance. Tasks which are simple and open to variation for a person must be specified and constrained when embodied in a machine.

All technology is prosthetic, contrived according to mechanistic approximations of specific task domains which optimize a particular function. This is clear in the case of a chainsaw; it cuts wood fast, but is useless for anything else. A Scanning Tunneling Electron Microscope, though it extends the range of human vision, is a chainsaw in this respect. Cognitive prosthetics such as robot vision systems, unlike human vision, are to a greater or lesser extent, task specific. Computer programs are virtual machines, indeed they are sometimes referred to as "engines" in the computer science community. The same compartmentalizing reductive process is at work. Such a method can never reproduce the holism of body experience, it will remain just an accumulation of parts. By contrast, certain human activities, among them the production and consumption of art, integrate human faculties in a way that resists reductive compartmentalization.[21]

Machines, hard or soft, are codifications of solutions to problems. Often the sorts of problems artists deal with are as yet uncodified, or are uncodifiable! It has been observed that although CAD systems allow architectural design projects to be completed more quickly, they reduce the possible range of variation. The same may be said for any software package. I believe it is still a fair question to ask, "What constraints does the utilisation of the computer put on the invention and realisation of artistic practice?"

In 1990, Marvin Minsky proposed that we should "go beyond these VR instruments and implant a little computer in the brain and send signals back and forth from it, which would give us the ability to extend our motivation and the signals inside ourselves to cause things to happen in the outside world." Although this sentiment is a familiar one in technological discourse, it is nonetheless peculiar: I thought that was why we have arms and legs and eyes and ears! Minsky went on to say of this implant idea, "Maybe most of us who are not artists could be artists if we could express our subconscious wants."[22] I have to admit to being deeply offended by this pronouncement. Minsky here presumes the right to make pronouncements outside his field of expertise. Its interesting to learn from him that artmaking is simply a matter of subconscious"self-expression" without the intervention of either skill or intellect! Seemingly [according to the perspective of traditional artificial intelligence] the complex bodily practices and sensibilities which define art practice can be easily dismissed as

insignificant motor skills, hardware problems. According to his pop-psychoanalytic approach, our "subconscious wants", once encoded as digital data, could be realized by some mechanical prosthetic. This, according to Minsky, would result in art! [I doubt if Minsky would allow that a similar implant would enable us to be famous Artificial Intelligence experts.]

Negotiating Engineering and Art

Within my proscribed space limitiations here, I do not claim to have dealt with these ideas in any exhaustive way.[23] I hope simply to have raised some issues which I believe demand further consideration.

The Engineering world view has demonstrably proliferated into many aspect of culture.The effects of art practice "going digital" include the ephemeralization of the art object and elimination of substantial dimensions of bodily involvement.[24] Whereas the scientific method seeks the abstract, essential laws "hidden" in the natural order, and expresses them in a generalized logical language, art is a sensorial communication, it is not the downloading of raw data. The making of and the consuming of "art" has traditionally been both kinesthetically broad-bandwidth and sinesthetically complex. The reductive method, epitomised in the hard and soft architecture of the computer [a tool not originally designed for art production or consumption] may cause the eradication of a great range of the intelligences which have been central to art.

The mind/body split concept is a key component of the enlightenment world view and structures the way we think about ourselves and the world. Computer discourse is a direct descendant of that world view, made more extreme by the pragmatism of engineering. The reification of the mind/body split within computer systems and computer discourse has lent the idea new force. But contemporary thinking in many fields is bringing many basic premises of computer science into question. A concerted effort is now necessary to de-naturalize the mind/body split and to re-learn that subjectivity is not subject to reductive analysis. Subjecthood is anchored in the body. What we call "the mind" permeates the body and is not located in any one organ. To believe otherwise is to deny traditional intelligences of the arts.

[1] The speaker was McKenzie Wark, in response
to a paper by Steven Kurtz of Critical Art Ensemble at Ars Electronica Symposium, Linz 1995 [personal notes]

[2] In the history of engineering, as in the history of Christianity, the vast majority of actors have been male. Recent research into the lives of female medieval mystics indicates that their mystical experiences, unlike those of their male counterparts, were firmly embodied. Simone de Beauvoir argued that masculine culture "identifies women with the sphere of the body while reserving for men the privilege of disembodiment, a non-corporeal identity." [Quoted in *Homeless/global: Scaling places, Neil Smith*, in *Mapping the Futures: local cultures, global changes*, Eds Bird, Curtis et al, Routledge, 1993.] Little wonder that enthusiasts for the prospect of the virtual body seem exclusively to be male.

[3] see Stelarc: *Redesigning the Human Body*, Stanford Conference on Design, July 1983. Stelarc: *Beyond the Body: Amplified Body, Laser Eyes and Third Hand*, NMA#6, 1986 [?]. Stelarc: *Prosthetics, Robotics and Remote Existence: Post Evolutionary Strategies, Statement for SISEA* Grongingen, 1990. etc.

[4] Because the issues I am attempting to discuss are the products of a new socio-cultural technological complex, conventional disciplinary approaches are inadequate. My quintessentially interdisciplinary approach is to examine "engineering" with the specula of literary and critical theory and artistic practice. This exercise is itself reflexive, it also allows me a perspective from which to view artistic practice, "from the outside". The best argument I can make for interdisciplinary practice is that a viewpoint from outside a discipline can render starkly visible aspects of a discipline which remain invisible for insiders. Of course one is seldom thanked for making

such observations. Disciplines are not quite as permanent as they might appear, housed in institutional buildings. Cultural Studies and Womens' Studies are two among numerous examples of new "disciplines" , Cognitive Science is an example of a "discipline" which seems to be breaking apart.

[5] Noah Kennedy, *The Industrialization of Intelligence: Mind and Machine in the Modern Age*, London: Unwin Hyman, 1989, p. 6

[6] As Frank Durham and Richard Purrington have noted : "Perhaps the most remarkable thing about the universe is that it appears to be linear. Is this because we have been indoctrinated by three hundred years of [Newtonian] dynamics, or is it [sic] because human beings experience the universe in domains of time and frequency which admit of an approximately linear description? Is quasilinearity becoming a hypothesis we no longer need?" in: Frank Durham and Richard Purrington: *Newton Nonlinearity and Determinism*, in *Some Truer Method, reflections on the heritage of Newton*, Eds.Frank Durham and Richard Purrington, Columbia University Press 1990, p. 221

[7] See Postman Technopoly and DeLanda *War in The Age of Intelligent Machines*

[8] From *The Mental and Moral Influence of an Engineering Training*, in *Electrical World*, Aug 13, 1898, p. 158-9, quoted in C. Marvin *When Old Technologies were New*, Oxford 1988, p. 32

[9] see J.D. Bolter *Turing's Man*, North Carolina University Press 1984

[10] Sten Grillner, *Neural Networks for Vertebrate Locomotion*, Scient. American Jan 1996, p 64

[11] Research by Dr Terrence Powley et al, at Purdue University, rep. in *Discover*, May 95, p. 26

[12] See *Complex and Hidden Brain in the Gut*, New York Times, Jan 23, 1996 p. B5

[13] see *Universality Without Matter?* Alvaro Moreno, Arantza Etxeberria and Jon Umerez, *Artificial Life IV*, MIT Press 1994

[14] Bill Buxton, keynote address, ISEA conference 1988, personal notes

[15] Harold Cohen interview April 18 1995, personal notes

[16] If one held a competition to design the worst technological interface for the production of painting and drawing, I doubt anyone could come up with a worse one than the keyboard and monitor.

[17] M. Johnson, *The Body in the Mind*. Chicago Press, p. 98. This quotation is thought-provoking for me because I had begun to wonder, independently, whether my dyslexia was related to the sense of disorientation I feel in the face of abstract mathematical arguments for which inverse and reciprocal relationships are key.

[18] Helen Michaelson, ZKM museum [Karlsruhe] interview, personal notes

[19] Several years ago I was speaking at a symposium. After my talk a woman came up and related this story: Her daughter was beginning to learn to write. She wrote, determined that she had made a mistake, and searched in vain for the delete button on her pad of paper! She was extremely upset when the "bad" letter did not immediately disappear! Likewise, my students seem to be so used to their computers that when they conceptualize an idea they assume it will materialize by itself, as if they had pressed "print".

[20] This condition is part of an historical progression. In the cinema, while taking virtual journeys, the body must remain still and silent. The subject who attempts to capture the world with the perspectival grid is monocular, pinned through his open eye with the cone of vision.

[21] Whether we are examining Artificial Life or the building of digital prosthetics, the most interesting aspect of this desire to simulate life within the machine is the fact that this desire exists and is so persistent. The desire for the "mechanical bride" is as consistent a drive in the west as is the desire to be rid of the body! See my

"Essay", *Scientific American*, 150th anniversary issue, Sept 95 and *Anthropomorphism as a cultural virus*, SISEA proceedings 1990

[22] Marvin Minsky, Ars Electronica 1990, quoted by Catherine Richards in *Virtual Bodies*, Public 11:Thoughtput, Toronto 1995

[23] This paper is, in fact, composed of excerpts from a larger, currenly unpublished paper: *Body Knowledge, Digital Prostheses and Cognitive Diversity*

[24] There is a certain historical irony in the in the fact that this trend to ephemeralization began in the visual arts before computers were readily available. See my argument concerning conceptual art as cultural software in Consumer Culture and the Technoslogical Imperative, Simon Penny, in *Critical Issues in Electronic Media*, Ed Simon Penny, SUNY Press, USA 1995