WATERWORKS: AN ARTIST'S INQUIRY INTO THE DEVELOPMENT OF SPACES THAT PROMOTE CREATIVE INTERACTION
by
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Submitted to the Department of Architecture on May 16, 1985 in partial fulfillment of the requirements for the degree of Master of Science In Visual Studies.

Abstract

"To Function In His Fullest Scope, Man Must Restore The Unity Of His Experiences So That He Can Register Sensory, Emotional And Intellectual Dimensions Of The Present In An Indivisible Whole." [Kepes]

The objective of this thesis will be to begin to formalize an artist's inquiry into the development of environments that promote creative interaction. The term "creative interaction" as it will be used within the context of this thesis refers to a dynamic relationship in which an individual(s) responds to the environment with a well integrated sense of exploration, introspection and regard. Waterworks swim through sculptures are intended to encourage the development of an awareness of alternative ways of relating to space. By presenting the participant-viewer with new possibilities for spatial interaction, it is proposed that the environment will stimulate a sense of exploration. By enhancing feedback to the participant viewer, it is proposed that the sculpture will provide the opportunity for reflection and introspection. Through facilitating new found awareness, it is hoped that the environment will foster a sense of regard that extends beyond immediate self-concern.
Dedication

This is dedicated to the ones I love.
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The views expressed in this paper exist within a philosophical context that affirms a belief in an order within the natural universe; that humankind is part of that order; that expressions of this order are manifest in the structures and processes in nature and that the function of humankind is to perceive, comprehend and express these structures and processes so as to enhance and contribute to the expression of order in our world. This view affirms the belief that we are part of the community of processes and structures, inextricably interrelated that together make up the planet Earth. Art and science are the names we have given to the range of human activity that endeavors to understand and express the natural order of the universe. They share a common purpose: the apprehension, comprehension and or expression
of some aspect of the natural universe. The will to explore and express is the essential quality of humankind and is the birthright of each individual.

Our awareness of order in the natural universe has been greatly enhanced by technologies that allow us to perceive beyond the normal capabilities of our biological sensory systems. Thanks to the likes of microscopes, oscilloscopes and spectrometers, we gain access to

Aprehension and comprehension or experience and thought are viewed as domains in a continuum in basic agreement with the ecological theory of perception as proposed by J.J. Gibson in his book *The Senses Considered as Perceptual Systems*

Perceptual development and perceptual learning are seen as a process of distinguishing the features of a rich input not of enriching the data of a bare and meaningless input. A perceptual system hunts for a state of what we call "clarity". Whatever this state is physiologically, it has probably governed the evolution of the perception of the species, the maturation of the perception in the young, and the learning of perception in the adult.

Gibson addresses the notion of perception in terms of systems that extract varying orders of stimulus information from a flux of stimulus energy implying a transactional relationship between the various components (senses) of these systems as well as in between systems themselves. This interrelationship functions in such a way so that the component parts of one system may be included in another depending on the task at hand. The distinctions between systems and senses are not fixed. I suggest that there may be a similar relationship between experience and thought. [Gibson]
knowledge about events in nature that are too fast, too small or too far away for us to have perceived them unaided by these instruments. Yet for all this achievement our machines are just beginning to approach the functional capabilities of even the simplest life forms.

Alan Kay, in his address Too Many Smart People, delivered in March 1984 as part of the MIT Dept. of Electrical Engineering and Computer Science Distinguished Lecturer Series, decried society's expectations regarding the "technological fix". He advocated an attempt at an understanding of the larger context in order to determine whether or not a "problem" indeed required fixing, or if the problem was really with the way it was being looked at. In a pertinent aside he noted his background in molecular biology and said that he had done a "work-up" on E.coli bacterium;

1/500 the size of a standard mammalian cell" contains the equivalent of "100,000,000,000 bytes (of information) or 12,000,000 8K Atari (computer) games or 50,000 2Meg Lisa systems.

The implication being that nature knows something about information processing that we have yet to discover. In another example Helmut Tributsch in his book When the Snakes Awake [Tributsch82] cites evidence of a wide range of animals accurately predicting earthquakes, something human technology has yet to accomplish. The theory
proposed by Tributch is that a specific function in the nervous system of these animals is sensitive to positively ionized aerosols produced by the piezo-electric effect generated by the mounting pressure of the impending quake on the quartzite substrate of the earth surface. The neurophysiological processes that appear to be responsible for this sensitivity to positive ions have been observed in humans.

One implication of this observation is that humans as a species are possessed of the capabilities to extract a more comprehensive body of information about our environment than is generally presumed to be normal. If our nervous systems are responsive to the same phenomena that alert animals to earthquakes, why should we not be able to teach ourselves to predict them as well? What remains for us to accomplish as a species or more accurately as a civilization, is to develop, indeed evolve an awareness, understanding and facility to employ the processes that facilitate these capabilities.

Professor of Philosophy, Paul Churchland puts it this way:

We have a large variety of internal states and processes. We also have certain innate mechanisms for discriminating the occurrence of some of these states and processes from their nonoccurrence, and for discriminating them one from another. And when we invoke and attend to that discriminatory activity, we can respond to it with explicitly conceptual moves--that is, with more or less
appropriate judgments about those internal states and processes, judgements framed in the familiar concepts of common sense: "I have a sensation of pink", "I have a pain", and so forth. We thus have some access however incomplete, to our own internal activities. Self knowledge is supposed to be a good thing according to almost everyone's ideology. How then might we improve or enhance this introspective access? Surgical or genetic modification of our innate introspective mechanisms is one possibility, but not a realistic one in the short term. Short of this, perhaps we can learn to make more refined and penetrating use of the discriminatory mechanisms we already possess.

Professor Churchland goes on to suggest that we train

...our native mechanisms to make a new and more detailed set of discriminations, a set that corresponded not to the primitive psychological taxonomy of ordinary language, but some more penetrating taxonomy of states drawn from a 'completed' neuroscience. [Churchland]

The position taken in this paper is that the development of this consciousness is dependent upon an integrated approach incorporating a collaboration between the artistic and scientific modes of inquiry. To paraphrase an observation brought up at a CAVS Fellows Meeting, the artist seeks the case that expresses all laws, while the scientist looks for the law that explains all cases. [Bruner]

Systems in the natural universe while unique and often discrete, acknowledge in their very design an interrelationship with the rest of the natural universe. We might call this form-al expression of
interrelationships between natural systems, the ecological principle of design. That animal nervous systems are sensitive to a subtle by product of natural cataclysm is a nice example of what I mean by ecological design. That is, each part of the system functions in relationship to the system as a whole and to every other part of the system.

This thesis attempts to describe and express something of the author's exploration into the domain of body images that are an expression of mind body consciousness. The exploration as presented here, has been undertaken through the development of a sculptural system known as Waterworks. The term image refers to a perceptual entity that is not restricted to a single sense (eg. vision), but may overlap several sensory systems.

The primary perceptual matrix addressed by Waterworks is a combination of the haptic system and the visual system. The term sculpture is used here in the four dimensional conception, that is the aesthetic ordering of materials and events with respect to height, width, depth and time.

In addition, the beginings of a secondary inquiry into the relationship between the formalistic, and the interactive aspects of people in space is presented in Lifelines. Lifelines examples given in this paper are essentially sketches that point towards a visual formalism that corresponds to transactional protocols.
INTRODUCTION

A fundamental difference in the apprehension of sculpture from the apprehension of two dimensional imagery begins with the difference in the perception of the work. Specifically, a two dimensional work is viewed primarily from a single station point. Generally one views a painting, drawing or photograph while standing or sitting. Whatever locomotion that was necessary to bring one within meaningful proximity to the work stops and apprehension (and perhaps contemplation and comprehension) of the image becomes the primary and dominant activity. The perceptual systems that are active are primarily the visual ones; head and eye, optic nerve, visual cortex etc. Ideally, all other physical activity quiets down and assumes a background mode function, and the greatest part of our attention is devoted to the image before us.

The fixed image provides a focus for our attention and activity and ideally provides us with the opportunity to make nothing else matter except the issue at hand, to effectively limit the intrusion of worldly events. The ability of a still image to set up a situation in which we can achieve this moment of introspective perception is of perhaps supreme value. This quality is one of the reasons
that the still image continues to maintain its importance in the face of motion pictures, television, computer animation, holography and the like.

If it is accurate that the still image gives us the moment of introspective perception, then perhaps it would be appropriate to characterize sculpture as that which provides the opportunity for contemplative proprioceptive perception. Proprioception is the sense of our own movements, the positions of our limbs, the state of our muscles etc.

As an object in space, the sculpture requires that we move it or move ourselves in order to apprehend the piece in its totality. If the sculpture compels us to move around it in order to see it, then in some sense it is also promoting at least a functional awareness of the space we have to move around in, (perception of space) as well as an awareness of our own movements and postures within the space (proprioception). Likewise, if a sculpture compels or even invites us to touch it then, in some sense, it is also inviting us to acknowledge our own sense of touch. The image we take with us will be one that we carry in our bodies as well as our minds.

It is this notion of "body image" which I have chosen to address in Waterworks. The dancer, the yogi and the martial artist have rich traditions from which to draw a wealth of body images, poetic expression, spiritual
transcendence and peace of mind. The images evoked through an encounter with a sculpture, be they body images or otherwise, are by definition, somewhat more ambiguous.

The artist sets up a situation, that is to say, the artist makes a presentation to which an entire class of responses, reactions, and interactions might be appropriate. This setting up of the ambiguous situation invites the viewer to participate in the creative process by including the viewer in the decision making process. Which of the variety of responses the viewer makes is determined by the interaction of the viewer and the sculpture. The decision is the viewers.

From Jacob Bronowsky's essay *The Imaginative Mind in Art* in reference to a poem by Dylan Thomas but making the point for art in general:

> Imagination simply means the human habit of making images inside one's head. Everyone of us reads the same poem, and yet each one of us makes his own poem. This is the nature of imagination: that everyone has to reimage, and to reimage for himself. Dylan Thomas certainly imagined this poem first, certainly created the poem. And yet if you want to understand the poem, you have to recreate it for yourself. This is a strange thought, but it is fundamental. No work of art has been created with such finality that you need contribute nothing to it. You must recreate the work for yourself... [Bronowsky]

Making decisions in response to materials and space is basically what a sculptor does. So in this sense the viewer does indeed share in the creative experience when
he or she responds to a sculpture. The quality of the experience is dependent upon the degree to which the viewer becomes involved with that response. Encouraging that response is part of the function of sculpture. The sculptor's individual expression determines the specific range, quality and context within which the viewer, or rather the participant-viewer is encouraged to respond.

This thesis is concerned with the notion that sculpture can function so as to promote creative interaction, i.e. affect the quality of the viewers experience. The sculptures that succeed in this endeavor are those that succeed in compelling the viewer to become involved with the response to or the exploration of space or materials or interaction.

Life and art become complements to each other, an impasse reached in one is often resolvable through an insight provided by the other. It is my intention to affirm the interdependence of art and life, of nature and our perceptions of her. I further intend to throw my lot in with those thinkers, scientists, artists and philosophers who are in the process of exploring and affirming the transactional or interdependent nature between human perception and conception. That we are a part of what we perceive, that what we perceive affects who we are and that what we do affects our environment. In short an ecological approach towards the development of
the human consciousness. The objective of this thesis is to present an example of art making as an exploration and an intrinsic element of this developmental process.
Chapter 1

MODES OF INQUIRY; An Artist’s Approach

Art helps me to understand my relationship to my environment, history and my self (self: referring to the universal and individual self).

The academic issues of context, perspective, proportion, balance, rhythm, color and proximity are issues that provide me with a cognitive system with which to comprehend what I perceive. The taking in hand of tools and stuff manifests theory into a substantive, tangible quality. The act of doing: technique and volition are crystalized in the art object. The completed art object is its own proof of success or failure. It is fact. The art object confirms or denies the validity of the effort put forth in its execution.

Art is that manifestation of human creativity that is the gestalt of concept - process - product.

When an emotion, idea or mood (i.e. concept) is experienced to the extent that it becomes part of an individual's personal history, the concept may then be said to have been integrated into that individual's collective experience. The interaction that takes place when that individual is able to express that concept in
his or her own terms is the very essence of the creative process. The cultivation of the creative process combined with the mastery of attendant technique is the essential characteristic of the artist.

Process has to do with the artist's relationship with his or her medium. Medium being both the material and the method in which it is worked. It is necessary to develop a feel for and or understanding of the subtleties and nuances required to coax the optimum performance and expression out of the chosen material. The image should be consistent with the medium, so that the techniques employed are consistent with or at least conscious of the characteristics of the material.

The art object is a product of the synthesis of the internal (concept integration), and external (process and technique) creative processes. The successful art object is a crystalization of concept and process.

The function of art in society is basically one of communication. The purpose of art is essentially one of enlightenment. Even though the motivations and reasons given by artists often have little to do with society or communication. The artist sets up a situation - a painting, sculpture, film, etc. from which to relate a mood, feeling or idea through direct and or metaphorical association. This setting up of the situation may be and often is after the fact. Often the artist does not
consciously set out to say something. It is part of the nature of art that the final statement may not become apparent (even to the artist) until after the piece has been completed.

When the viewer relates to an issue addressed by the art object, a special kind of communication takes place. Specifically, the concept is incorporated into the art object for its own sake and as a result of the transaction that took place between the artist and work while the work was in process.

Furthermore, the viewer is (ideally) responding to the work as a result of his or her own interaction with the art object free from intrusion by other personalities. The concept is ideally communicated without the intrusion of another ego. The communication that takes place between artist to art object and art object to viewer is an association somewhat akin to love. Love defined as the relinquishment of one's own ego to the extent that it may be replaced with concern for another person, idea, etc. When an emotion is elicited or thought stimulated as a result of contact with the art work, that interaction completes the cycle of the creative process and the artist fulfills his or her place in society as a celebrant of the human experience.

In Jewish tradition, a high form of charity takes place when the donor does not know to whom specifically
his donation is going and recipient does not know who is
his benefactor. I suggest that a high form of
enlightenment takes place when a concept is communicated
on the strength of its own worth and embraced for the same
reason. As the tradition goes, the highest form of
charity is providing someone with the opportunity to help
him or her self. Likewise the art that succeeds is that
which provides the viewer with the opportunity to gain his
or her own insights.

In the preface of his book Visual Thinking, Rudolf
Arnheim states,

"...that artistic activity is a form of
reasoning, in which perceiving and thinking are
indivisibly intertwined." Arnheim goes on to
suggest that "a slit between sense and thought" is
responsible for "various deficiency diseases in
modern man." [Arnheim]

It is an attempt to reintegrate the human persona that
fuels the creative process. This thesis is in effect a
consolidation of what I am able to express (in print)
about the relationship between people and space as I have
explored that relationship via an involvement in
environmental art.

My first half-conscious probe into the issue was to
conceive of a series of sensory isolation... something or
others. I don't remember exactly what I called them but
they were to be a series of sculptural objects that were
meant to facilitate some type of communication between (generally) two or three people while restricting one or more of the five senses. The idea I had in mind was that a group of people would spend some time with each other in each one of these situations until everybody had been through each of them with everyone else in the group. The culmination of the piece was to be a specially designed chamber, embryonic if you will, for the entire group to assemble and meet. This meeting would be the first class in an imaginary art school, the encounters in the sensory isolation communication modules functioning as orientation for the first class, with subsequent class meetings periodically interspersed into a predominantly studio schedule. I don't remember thinking much about curriculum at the time, in fact, I built only one of the preliminary modules.
It was a somewhat simple construction of plywood, 2x4s and plexiglass which I entitled visual communication exerciser.

It's not that I lost interest in the project. I felt that it was a good idea and that it would keep, possibly for a beginning project in the art school I was to enter the following September. In the meantime, there was so much to learn. At the time, I was a student at Miami Dade Junior College and was getting my first exposure to a full time art curriculum. Everything from figure drawing to photography, from printmaking to ceramics, from design to conceptual art was attractive to me. It all seemed fresh, new and yet somehow comfortable, and I wanted to try them all. I was just beginning my education as an artist.
It seems as though the theory of art was acquired for the most part rather informally. It was generally through impromptu conversation with teachers or visiting artists and most significantly with other students. It was also apparent that the majority of the formal education revolved around doing. Process, technique and critique. I think one distinction between art education and most academic and technical teaching is that in academia the focus is on finding a predetermined, correct answer to a structured question, where as my best art teachers basically said, "I'm not even going to ask you a question, rather I may or may not give you some things to think about, so that you can come up with your own questions".

Much of what seems to go on in art making has to do with a continual gesture, feedback and response process, so that "the answer" or "the question" is formulated through a dynamically responsive process. The significance of the gesture is perceived, and evaluated, often, I suspect, without a clear distinction between the perception and the evaluation. The following gesture usually confirms or repudiates the evaluation.

I am getting ahead of myself, the point being that I had become involved in activity that seemed to strike a resonant chord somewhere in my personality. When Ron Mitchell, one of my first instructors at Miami Dade, spoke of balance and rhythm in reference to the hand building of
a ceramic sculpture, I knew what he was talking about. Now I had never heard the term rhythm used in reference to anything but music and even in that it was an abstract reference to a formal time signature-notation. But when he admonished our beginning ceramics class to think about the structural elements of our pieces in terms of rhythm, harmony and balance, I felt as though I knew just what he meant. Now this may not seem to be a profound realization, but it is one my earliest recollections of hearing somebody refer to and name a phenomenon which I had "discovered" on my own but had not yet named. Rhythm, balance and harmony or perhaps timing, balance and harmony; timing, balance and resonance; the elusive essential qualities in successful works of art or successful life for that matter. As I write these recollections down I get the feeling that much of my motivation in pursuing a life in art making is a result of an attempt to reconcile the disparity between life and art through the pursuit of rhythm, balance and harmony. Art provides a microcosmic and or allegorical example of a process or structure or relationship that could be perceived in life. It works inversely as well, day to day experiences often providing lessons in patience, observation, sensitivity, persistence and timing necessary to realize a successful work of art.
Chapter 2

LANGUAGE

My major procrastination in writing or rather beginning to write this thesis revolved around the trouble of reconciling the making of art with intellectualization about art. From the beginning and in the end it is the work of art, the art object and experience of the art object and the making of the art object that justifies the art object. If the work of art "works", then one needn't say any more about it. Yet, at the same time the right words often open up new understanding, explain references previously not recognized and impart new meaning to relationships noticed but not acknowledged.

The sound of the waterfall
Has long since ceased
Yet with the mention
Of its name
We can hear it still

[KINTO]

The poet has written this haiku with two assumptions, first that the reader has in fact listened to the sound of a waterfall, and second that the reader knows the word waterfall. I suspect that in order to empathize with the experiential quality the poet alludes to, the reader
should have probably known the word waterfall at the time he or she was listening to the sound of the waterfall.

How do we deal with experiences for which we have no name? Do we bury them in a psychological matrix such as the subconscious as suggested by Freud? Or, as suggested by Ida Rolf are these experiences stored in our neuro-musculature? Are these experiences significant and what are the implications of not naming them? What are the ways in which we gain access to these experiences?

Does a word have any meaning other than what it refers to? Is this different for a noun or a verb than it is for an article? Is it different when words are combined, or does the sentence still only mean what it is about? Is the language of art different?

Is one of the functions of art to provide us with references to experiences too subtle, too private or too complex to be named? Does a great work of art provide us with both the experience and the reference? It is my contention that this is indeed the case, that art at its best is both epistemological and ontological in nature.

Rothko spoke of his paintings as a family and intended them to be displayed as a group, when viewed this way, it becomes apparent that Rothko had developed a language. Moving from painting to painting one sees that he had succeeded in expressing power and nuance with each new set of colors and spaces. This language while
consistent with itself is not dependent upon named references to other experiences in order to impart meaning, it provides its own experience.
Chapter 3
PERCEPTION

The color field paintings of Mark Rothko introduced me to the notion that transition was an expressible quality. The paintings showed me that powerful domains, in this case those of color and space, could be balanced as long as there was the appropriate attention paid to the transition between one domain and the next. Viewing Rothko's paintings allowed me to understand these concepts of power and subtlety by providing the opportunity to perceive (i.e., experience) power and subtlety.

When hung together in a room, Rothko's paintings re-enforce each other. The paintings or rather the effect of the paintings seem to fill the room so that the space is transformed by the cumulative reverberation of the paintings with each other. The space itself becomes special.

The controlled manipulation of the perception of a space; presence modulation, as a fine arts genre has evolved into a discipline in its own right. The works of Robert Irwin are exemplary in this regard.

When I married the painting to the environment, suddenly it had to deal with environment around it
Irwin's remark was in reference to a series of paintings he did on concave discs, that when viewed under the appropriate lighting conditions, succeeded in eliminating the distinction between the edge of the painting and the walls they were hung upon. Another artist, James Turrell, a contemporary and one time associate of Irwin's, has succeeded in eliminating the distinctions (at least in the visual domain) between surface and space. In Turrell's installations, it becomes impossible to discern that what appears to be a subtly painted surface, is in fact exquisitely diffuse light coming from a room behind an aperture; until one places one's hand into empty space!

In each of these cases the artist has presented (not represented) a unique expression of a quality of light or space or presence that is in and of itself both the reference and the referant. The work of art facilitates a genuine shareable experience. If there were an ideal state objective for the work around which this thesis is centered, it might be to achieve the capability of a language of shared experience.

J.J. Gibson suggests that the senses in a given perceptual system often offer overlapping stimulus
response to invariants in a given field of environmental energy. The perceptual system may use this overlapping of response to extract a higher order invariant; information. The organism in turn will often use overlaps of perceptual systems to extract higher orders of information from the environment. As in the case of location of a fire by smell. The olfactory system responds to volatile aerosols released by the fire, the haptic system orients the head to equalize the bilateral stimulation of the cutaneous system (air movement on the skin of the face or wetted finger) in order to determine wind direction. The composite of information indicating that a fire is "over there".

With out getting too deeply into the rich and controversial domain of knowledge representation, epistemology, ontology, philosophy of the mind and intelligence, artificial or otherwise, let us assume for a moment that an overlapping and integrated information

2 Besides the change in stimuli from place to place and from time to time, it can also be shown that certain higher order variables—stimulus energy, ratios, and proportions, for example—do not change. ... And it will be shown that these invariants of the energy flux at the receptors of an organism correspond to the permanent properties of the environment. They constitute, therefore, information about the permanent environment. [Gibson]
processing system is a good thing. Good in the sense that the greater the information bandwidth or the broader the spectrum of perception, the greater the opportunity to extract higher orders of information. Or to put it another way, the more we learn to refine our perceptual systems, the greater the opportunity we afford ourselves to comprehend the richness of our environment.

How do we go about designing a process to refine our perceptual capabilities?
Chapter 4

BODY LANGUAGE IN THE INFORMATION AGE

The notion of body language as it is intended in this chapter, revolves around the idea of learning to understand and interpret what our bodies may be telling us about ourselves and our environment. It may be that an entire range of what we now consider to be parapsychological phenomena; from premonitions (knowledge of an event before it occurs) to dowsing (the ability to locate water underground) will eventually yield to explanations such as that proposed by Tributsch regarding animals and earthquake prediction.

In Tributsch's theory the uptake of the neurotransmitter serotonin is disrupted by the presence of positively ionized aerosols. This disruption of serotonin uptake seems to produce an acute discomfort that the animals recognize as a precursor to violent seismic or meteorological activity. The presence of the charged particles, which are also in evidence in association with violent storms, are attributed in the case of earthquakes to the buildup of pressure on the piezo-electrically reactive quartzite in the earth's crust.

It is not unreasonable to assume that there are
corresponding sensitivities in our own bodies that respond to a range of electro-chemical phenomena in the environment. In the case of adverse reaction to positive ions, this has already been demonstrated. It cannot be ruled out that there exists energy domains that we are sensitive to, that modern science has yet to describe. After all it was not until the current century that there existed an accurate description of the behavior of ions.

In his book *The Third Wave*, Alvin Toffler wrote on the "infosphere" as the domain which the third wave would manifest itself. In the first wave of agricultural age, human kind established a relationship with the lithosphere in that we developed the skills necessary to establish a culture, indeed a civilization based upon what could be reliably (somewhat) coaxed from the ground. By the end of the second wave, the industrial age had imposed a somewhat adolescent domination over large portions of the earth surface and the biosphere in general.

As we make the transition into the third wave early indications suggest that it will be characterized as the information age.

Like the adolescent approaching young adulthood, human civilization is beginning to perceive that in order to manage its responsibilities, it must learn to understand those responsibilities.
Understanding is based on knowledge and knowledge may be defined as the integration of information. In what appears to be a still somewhat less than mature approach, mainstream civilization has come to fixate on the accumulation of information as some sort of stockpiling or speculation in an historical commodities market. Information is becoming the currency in a socio-economic system in which knowledge has become a commodity. Knowledge however, while it may be the basis for understanding, is not synonymous with understanding. Understanding implies a context in which knowledge is applied and insight gained through the experience of that application. So while the power brokers are scrambling to corner the various knowledge markets and compound the interest in their information banks, it might well be worth devoting some attention to the contexts and applications of all this knowledge. Then, perhaps we may look forward to the "fourth wave" as the age of understanding.

There is a statement attributed to Leonardo DaVinci that claims, "All knowledge originates in our sensibilities". In a world in which knowledge is in the process of becoming a prime commodity, the market-place of ideas would do well to contemplate Leonardo's assertion.

As a part of the understanding necessary to assimilate the burgeoning amount of information our
civilization is accumulating, it is necessary for us to broaden the bandwidth of our natural information processing capabilities. If a picture is worth a thousand words, then perhaps we need to be communicating in pictures. Consider the potential of a visual language with a syntax as sophisticated, and a vocabulary as well understood as that of a spoken language. If we add to this visual language, sound, with its ability to express volumetric, tonal and temporal information, we compound the information accessible further still. But we have only mentioned two of at least five senses, is it possible that one day we might develop our pan-sensory perceptual capabilities to respond to the richness of multi-modal information that our environment affords us? It is the suggestion of this thesis that development of our minds and bodies as fully integrated perceptual and expressive systems is imperative if we as a civilization are to reach our potential.

The phrase *body language in the information age* is used to suggest that we may indeed endeavor to develop a sophisticated multi-sensory means of communication that will enable us to perceive and communicate a far richer expression of our world than most of us are presently capable of.

Bear in mind that the natural universe still provides the best examples of information gathering and processing.
Nature provides the paradigms of process and form that can best serve as models for our design. The focus of our technological development is most appropriately directed towards the understanding of the natural universe rather than the domination of it. From Helmut Tributsch's How Life Learned to Live:

People in general think of nature and physical technology as opposite and conflicting worlds. Many live only in the technical, others only in the natural world. Both groups advocate their own interests and convictions. Why should it not be possible to work toward technological progress that is in harmony with nature? The schizophrenia from which we suffer is rooted in our schooling. Our biology studies disregard the fascinating technology in nature. Our physics or technology pay just as little heed to the ingenious technical inventions in the animal and plant kingdoms. Would not an engineer familiar with the technological ideas of nature have more respect for nature? Would not a naturalist who realized that life requires technology have more understanding for technological progress? Knowledge that reconciles nature and physical technology could pave the way for the progress that is not a threat to man, but to his benefit. [Tributsch]

Spaces that promote creative interaction; sculpture as a vehicle for transforming a space into a space that promotes creative interaction.

By developing environmental sculpture that encourages exploration of movement through space while at the same time providing the opportunity for various feedback modalities, I expect that an awareness will develop that will give rise to a lexicon of somatosensory images. In
time this body image lexicon may expand into the rudiments of a human language of space.

Under the premise that art making is in fact a legitimate mode of inquiry, I will suggest that an environmental sculptor might lend some significant insight into the understanding of the real and potential qualities of people in space.
Chapter 5

WATERWORKS

Waterworks is the author's ongoing investigation of the human experience of space. Begun in 1972, Waterworks started out as an inquiry into the nature of form, by setting up a situation from which a space, defined by a minimal structure could be explored from the inside as well as out.

My intent is to develop configurations (forms) that optimize the interaction of the participant-viewers who swim through the piece. The sculpture consists of the configuration of mirrors combined with the movement of the participant-viewers through the configuration. The objective is to establish a multi sensory image from which the participant-viewer may better relate to the perception and experience of space and the perception and experience of self.

In January of 1973, when I installed the first of what was to become a series of underwater environmental sculptures, I was primarily interested in the ability of the water medium to provide direct physical access to virtually any part of a three dimensional form. Building the form underwater enabled me to freely explore the form
from a limitless set of vantage points. To me the key to
the work was in the actual experience of the exploration
and discovery of a three dimensional form. It seemed
appropriate that the viewer should get into the water to
share in that discovery. I have since completed over a
dozen subsequent installations and have observed somewhat
over one hundred participant-viewers interact with these
installations.

Although the issues of form and structure continue to
be the focus of my sculptural efforts, it is becoming
increasingly clear to me that an equally important aspect
of this work is the light it may shed on the development
of environments that promote and stimulate creative and
productive interaction.

As soon as the first installation was actualized, it
became clear that the experience of perceiving the form
was as significant an issue as the form itself. This
realization was to be my first object lesson that the
essential nature of Art is experiential.

Subsequent work has suggested a formal paradigm in
which the relationship between structure and process is
transactional. Further work indicated that a situation
that elicited a particular class of interaction might
suggest a form (image) that would evoke some intrinsic
reference to the issues raised by experience of the
interaction. This new form or image then becomes an
element in a language of images. This image language becomes the means to communicate the issues raised by the original experience that is at least one order of abstraction closer to the perception of that experience than a written language.

In a painting the artist attempts to establish an image with which to express a mood, feeling or concept. In building a sculpture underwater to be viewed underwater, I am attempting to establish a multi-sensory image to communicate the possibilities for expanded consciousness through the presentation of alternative ways of relating to space.

The ability of water to support bodies enables the participant-viewer to access virtually any part of a three dimensional form with a smooth, relatively effortless movement. The structure becomes a form to focus one's movement around. There is an interplay that develops between the initiation of movement through the form and the perception of that movement (perception is accentuated by the inclusion of mirrors in the structure.) Within this interplay lies one of the keys to the development of a mind/body spatial consciousness.
5.1 Early notes on Waterworks

1972

Exercises in spatial organization directed towards an awareness and orientation to non-planar-surface, non-gravity reality.

To be able to relate to the universe in its own terms, in terms of time and space and speed...; to be aware of these dimensions...; to relate to them and the universe through them.

My first meeting, my first experience, my first conscious step towards this awareness is with space. Space relative to itself not to surface, not to planes or lines but to space. Horizonless - no up or down - just all around.

This event is a movement towards an awareness which at this point seems to be the product of this art experience. The creative synthesis of this, what makes this art is when these questions become defined or posed to the viewer through or because of the experience of the piece or event. The experience remains an exercise until it is "viewed"; Only when it is experienced does the synthesis take place, that is when it becomes art.

By organizing space in a different environment I am confronted with different ways of seeing and reacting to things. At first things will be strange and unfamiliar
but the more I function in the different environment the more my perceptions will become accustomed to and familiar with the new reality and hopefully I will expand my experience to two physical realities as opposed to the one I am currently dealing with.

In viewing the piece as in creating it, a different environment presents an alternative situation or at least poses the question of the possibility of one.

By expanding experience to two physical realities I have conjectured that my mental experience will shift or expand as a result of the awareness of that other reality.

5.2 Waterworks Film Narration

1974

Without planes, without a horizon, with a fluid density that overcomes gravity, the underwater world seems a fantasy. Nevertheless the underwater world is coexistent with our surface world of planar surfaces stretching out to horizon lines... all seemingly glued, bound together by gravity. These most basic postulates from which we develop our perceptual concept of environmental physical reality, cease to become an issue underwater. Underwater we must learn new ways to move, new ways to see, new ways to relate to the space all around us, as well as new ways to relate to our bodies and minds within that space.
Art as a communication form sets up a situation in which to relate a feeling, a mood or a concept to an audience through visual metaphors. By constructing a sculpture underwater, to be viewed underwater, the artist attempts to establish and communicate a full sensory metaphor from which to relate a series of feelings and moods. To view objects as you glide smoothly, almost without effort past them. One can truly relate to volume, depth, positive and negative space, once one has glided through the interior and exterior areas of a shape. The sculpture is an exercise in design and process within an altered environment.

It is a simple ecstasy, freedom of movement mind and body become one.

"When I work underwater I sculpt with my whole being, not just my hand or my head, but my hand and my head coming together as each gesture becomes a celebration of motion and form, a child's journey of exploring three dimensions, positive and negative space, sculpture from the inside outside in. The lines and buoys are a

---

3 When I wrote this narration, at the age of 21. I was pleased with the word as well as the concept of "metaphor". At this writing however I have decided that the notion of "image" as a presentation as opposed to a representation of or reference to a "feeling, mood or concept" is a more appropriate description of what art does.
reference point in space, a point to focus one's movement around, so that the sculpture is as much what is going on around, as it is the structure itself".

The sculpture is assembled on location so that the form is directly related to the immediate environment. The materials are portable and being of marine industry origin, are visually congruent as well as chemically non-reactive with the ocean ecosystem.

When the combination of images and sensations produce a new experience for the participant viewer, the piece is successful. For the viewer it becomes a total mind-body involvement in experiencing three dimensional form. For the sculptor it becomes a total mind-body involvement in creating three dimensional form.

5.3 Recent thoughts on Waterworks

- Water provides both the physical and metaphorical reference to the somesthetic awareness that these sculptures seek to engender.

- body images that evoke a corporeal memory of haptic, somesthetic development in the womb...

- re-awakening of somesthetic perception capabilities that respond to natural events, ...across space/time...

- allowing those who may be ungainly on land to experience feeling graceful
5.4 The sculpture

At the heart of all the theorizing, philosophizing and criticizing lies the practice of making sculpture. Making sculpture is the practice of making esthetic decisions about space and materials and carrying out those decisions. Waterworks is a system within which to carry out decisions about space in water. The system is composed of three subsystems; the structure, the water and the interaction of those in and around the structure.
The structural subsystem is comprised of a number of basic units which are themselves composed of four basic elements: anchors, floats, connective elements and focal elements. All the units are configured from some combination of basic elements and a structural subsystem may consist of one to n number of basic units.

Water, the universal solvent in this case becomes the fundamental catalyst in that it supports and facilitates access to the structure and in so doing, dictates the nature of interaction within and around the piece.
The class of interactions encouraged by Waterworks are predicated on the notion that our experience of form and space is enhanced by allowing the perceptual systems most directly concerned with the perception of form and space, the haptic, aural and visual systems to operate in concert with each other. Further more that the types of interaction should encourage development of perceptual learning associated with exploration of space and form by providing the conditions that promote increased awareness of the capabilities of the perceptual systems.

Table 1-2 The Influence of the Subsurface Environment on Sensory Capability

<table>
<thead>
<tr>
<th></th>
<th>Detection Range</th>
<th>Discrimination Precision</th>
<th>Localization Precision</th>
<th>Directionally</th>
<th>Change from dry to wet environment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vision</strong></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry</td>
<td>Good</td>
<td>Outstanding</td>
<td>Outstanding</td>
<td>Good</td>
<td>Poor</td>
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<tr>
<td>Wet</td>
<td>Fair to none</td>
<td>Good to none</td>
<td>Outstanding to none</td>
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<tr>
<td><strong>Audition</strong></td>
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<tr>
<td>Dry</td>
<td>Outstanding</td>
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<td>Wet</td>
<td>Outstanding</td>
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<td>Fair</td>
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<tr>
<td><strong>Somesthetic</strong></td>
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<tr>
<td>Dry</td>
<td>Poor</td>
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<td>Wet</td>
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<td>Fair</td>
<td>Fair</td>
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<tr>
<td><strong>Chemical</strong></td>
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<tr>
<td>Dry</td>
<td>Poor</td>
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<td>Wet</td>
<td>Poor to none</td>
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</tbody>
</table>

[ADO&BER]

To begin with, water makes the interaction distinct from any other interaction that we may become involved in. We float and or sink in it, we can't breathe it and it
touches us everywhere. For some, the last time they floated, immersed in fluid may have been in utero. In Waterworks, immersion is something we all share, and shared experience, especially one as primal as immersed floating, sets up a distinct rapport between the participant-viewers. Precisely what that rapport is, is the subject of continuing investigation.

The next major interactive consideration the viewer encounters with regard to the water is, to quote one participant "I can't breathe this stuff". Many of us have not paid much attention to our breathing since our first breath and probably even less attention to the space or time in between breaths. When viewing Waterworks, the viewing takes place under the surface and hence in between breaths so that our awareness of that particular space/time is accentuated. Again the significance of this accentuated awareness of our breathing is the topic of upcoming work.

If the water presents us with a different way of relating to our bodies in space, than it is the structure, the lines, the bouys, the mirrors that present us with a set of circumstances within which to explore and develop this relationship. The structure is a form to move around, to twist and turn, upside down, rightside up and every which way in between. The mirrors allow us to watch ourselves and each other as we play about, encouraging us
to perform and indulge ourselves in unabashed curiosity as to how we look as we play with new ways to move about unencumbered by gravity. I suspect that the mirrors encourage the notion of vicarious learning, ex. when a dancer watches another dancer perform a movement, and then performs the movement, ie. understanding through watching as opposed to explanation.

Each structural configuration seems to encourage a slightly different interaction. Some like the piece depicted on pp.59 seem optimal for two people, swimming around in concert with the helical shape seeing oneself and each other alternately. While the piece on pp.58 was able to accommodate over a dozen people at a time in a cacophony of exuberant activity, the sculpture on pp.60 suggested at least to me, quiet contemplation that worked without any body swimming around it. It appears as though within the particular character of interactions encouraged by these installation that a range of experiential qualities can be elicited.

There is a physicality inherent in sculpture making that carries over into sculpture viewing. Many of the decisions made in developing the Waterworks system seem to have had the effect of closing the distance or blurring the distinction between making sculpture and viewing it. The system has become a context in which to exercise esthetic decision making. The level of involvement
encouraged on the part of the viewer is close to that required on the part of the sculptor. The viewer and sculptor both explore the space and both are afforded the opportunity to begin to develop a body image lexicon based on a shared experience.
Chapter 6

DESIGN

Design; a problem with models. This chapter is essentially several pointers to questions about the design paradigms that have come to dominate the practice of design in industrial society. These paradigms, from design theory based on Euclidian geometry, to workplace management based on a 40 hour week to economic theory dedicated to growth, are all in need of serious review. This review is beyond the scope of this thesis, but some of the questions pointed to in this brief chapter are germane to both.

Form and function; the structure has an operational relationship to the process associated with it. I feel that this is probably a first order law of nature. I understand esthetics to be appropriateness, or perhaps moving towards absolute appropriateness: If a gesture satisfies itself within its context then it is appropriate; if that gesture fulfills itself and then transcends its immediate context, then this is what I understand an esthetic gesture to be.

The term design can be interchanged with the term order. To design something is to arrange it according to
some order. To order something is to arrange it in accordance to some design. Art and science may then be said to be engaged in either the development and or the discovery of designs. Traditionally, the scientist attempts to discover order in the natural universe and the artist attempts to esthetically express design or order. The extent to which either succeed is the extent to which the expression embodies some essential aspect of natural order.

Knowledge based expert systems, artificial intelligence, computerized solutions to mankind's problems: what might these solutions portend for humankind's development? That specialized portion of our society known as computer scientists and engineers are getting better and better at getting their machines to perform better. The performance specifications are awesome. These supercomputers, once given a model can make complex decisions and provide sophisticated solutions to complex problems. They can do it accurately, repeatably and convincingly.

But what are the models we are giving these machines? How good are the models and how well do we understand what we are modeling? These questions must be given serious consideration before we relegate any vital decision making to people, let alone machines!

It seems only reasonable to promote a design paradigm
which borrows from nature the fundamental principles of the intrinsic relationship between form, function and ecology. In short I advocate acknowledgment of an ecological esthetic and its incorporation into any serious design paradigm.
Chapter 7
WATERWORKS FIGURES
April, 1973 Harbour Island, Bahamas
May, 1973 Tufts University Pool, Cousins Gymnasium.
July, 1974  Smuggler's Cove Tortola, British Virgin Islands
April, 1983  MIT Alumni Pool Public performance & participatory event
sponsored in part by MIT Council for the Arts, Eventworks and CAVS
Chapter 8
LIFELINES

A crucial element of the composite of activities and concerns that encompass a contemporary definition of art is the issue of exploration. It is the exploratory aspect that factors perhaps most significantly when drawing the distinction between art and craft. While both the artist and artisan produce objects that demonstrate a facility for expressing an understanding of process and product; the artist must also express insight into the human experience of some aspect of the universe. This insight is gained through exploration. It is the combination of the clarity of the vision, in effect the quality of the exploration and the effectiveness of the expression of that vision that ultimately determines the success of a given work of art.

Traditionally the artist has been (in most cases) content to make observations and let the conclusions be drawn by history. In this century the scientist has taken the initiative to draw at least some conclusions from his or her own research. It may be that part of the reason science has become as prominent an influence on the direction of civilization as it has, is that scientists
have acted on conclusions drawn from their own observations. This influence is nowhere more evident then when we consider the development of humankind's tool making (and war making) capacity. It appears sadly and perhaps fatally that the evolution of human consciousness (at least on a societal level) has not kept pace.

I am of the opinion that part of the remedy for this situation, is to expand the exploration of the human experience in a renewed effort to better understand how and why we behave the way we do. Moreover, we must carefully begin to draw a set of conclusions based on a genuine and open ended understanding of humankind. Part of this renewed effort should be for artists to start drawing some conclusions of their own from some of the observations they have been making about the human experience, in such a way that would influence the evolution of human society so that society might responsibly manage it's technology and it's destiny.

The objective of this section is to outline a strategy for an investigation into the relationship between the formal and the interactive aspects of the Waterworks underwater environmental sculpture.
8.1 Abstract

Lifelines is the initialization of an artist's inquiry into the form of the movement of people in space. Initially this work will simply represent the paths of people moving through a variety of spaces by displaying a rendered trail or line based upon a sampling of the positions of the people in the space over time. The lines are interpolated from points corresponding to the position of the subject at the time of the sample, so that in effect the actual motion of the subject generates the line, hence the name Lifelines. Output displays generated by Lifelines will be referred to as Lifedrawings.

8.2 Pathways to Comprehension

On a practical level an interest in paths or trails might be traced back to the hunter-gatherer stage in human development when an interest and proficiency in the recognition of animal tracks was a significant factor in the survival of a group of hunter-gatherers.

The nature of that animal trail, the shape, size, depth, definition and frequency of the hoof, foot or paw prints that made up the trail, revealed much about the nature of the creature that left it. A good set of prints would reveal what kind of creature (e.g. herbivore or carnivore), how big, how heavy, how long ago it was since
it passed, the direction it was moving and how fast it was moving when it passed. All of which are significant issues when one is either trying to find a meal or trying to avoid becoming one.

What determined a good or readable set of prints were the characteristics of the environment through which the animal passed. A camel moving across loose sand in the high wind would be next to impossible to detect after several minutes where as the trail of a lion stalking antelope in moist clay along a river would be evident for days, providing there was no heavy rain in the interim. It is not unreasonable to speculate that there was a correlation between the conceptualization necessary to characterize an animal through the interpretation of the trail left by that animal, i.e. to develop a cognitive image, and that necessary to characterize an animal by painting pictures of it on cave walls, i.e. a visual image. Both of the images in this case are conceptualizations of a phenomenon (the perception of the animal) that are at least one step removed from the phenomenon itself, i.e. an abstraction, and that neither of these abstractions are necessarily dependent upon verbally or literally naming them. Both are dependent upon visual imagery. In the case of the tracker the recognition of the idea of animal is drawn from visual artifacts left by it. In the case of the cave painter the
expression of the idea of animal is accomplished through the use of visual artifacts in order to represent it. Conceivably the entire conceptual transmission of an abstraction of an event in nature may have taken place without a verbal lexicon. One possible implication being that the characterization of new phenomenon may be best initiated through visual representation.

The fields of biological anthropology, neuroanthropology and the neuro and behavioral sciences in general seem to be making significant head way into the understanding of the relationship between perception, conception and behavior (including communication) and will most likely provide the context for the further discussion of the issue of verbal vs. visual. For the purposes of this paper it is sufficient to accept that there is a correlation between images of an interaction and the nature of the subjects and events that comprised that interaction.

Just as a clear set of lion prints depended on a particular type of soil, like wise the quality of a pencil mark of given hardness depends on the roughness or tooth of the paper, just as the trace of an electromagnetic wave form on an oscilloscope depends upon the photo emitive quality of phosphors in a vacuum when struck by an electron beam. It is the trails left by the lion, pencil and electron beam that alert us to their presence and give
us insight into their nature. We have come to characterize functions by the shape of their trails: sineusoid, bell curve, linear.

Trails or secondary records of phenomena provide us with evidence and understanding of some of the salient features of those phenomena. In some cases (eg. neutrinos), trails are the only clue we have that the phenomenon exists. It is a wonderful achievement of human technology that we have been able to fashion instruments that create micro worlds that allow us to perceive phenomena in nature by allowing us to see the trails they have left. For the visual artist, much of the way of the world is understood through the language of vision, spatial, tonal and chromatic relationships. Images of interactions, trails, are one way in which the visual artist may come to a better understanding of the nature of interaction.

The microscope enables us to perceive micro-structure and process in nature, the telescope brings the macro-structure of the cosmos into view. With the advent of photography our ability to structure and manipulate time moved an order of magnitude from the realm of the abstract towards the domain of the perceivable.

The explosion of imaging technology that has come about as a result of our ability to manipulate the electro magnetic spectrum has diversified and intensified our
comprehension of the natural universe. From x-rays to radar to sonar to television and radio to ultrasound, thermography and nuclear magnetic resonance the transformation from structure (object) to process (modulation) to image has created a new metaphor for the contemplation of the nature of matter and energy and interaction.

If imaging technology has changed the way we perceive the universe then computing technology is in the process of changing the way in which we think about what we perceive. One definition of learning is that learning means being able to restate an idea or image in one's own terms. Although much of how we process and assimilate information remains hotly debated, the implication of this definition is that learning is dependent on being able to organize perceived information in some way so that it has meaning to the individual. Computers, by allowing us to organize information in virtually any way we choose provide us with the opportunity to give meaning to an extraordinary range of information, and to make that information accessible to an extraordinary range of individuals.

If human existence can be expressed as a function of human thought and human action, and if that thought can be expressed as a function of what we perceive and that there is a reciprocal relationship between how we perceive and
what we have perceived, then the implications of combining computing technology with imaging technology promises much for our understanding of the human experience of the universe.

8.3 Application

Lifelines is part of an approach to portraiture which seeks to express something of an individual or group character by presenting images that depict the subject's movement relative to him or herself, to others and to a given environment. The lifedrawing is a graphic characterization of the movement of a living thing through space. When viewed in context with images or other characterizations of the space and the subject, these lifedrawings may function as graphic references to a class of qualities that address something meaningful in the nature of the interaction between the subject and the environment. The field of environmental psychology is in the process of developing the language that speaks to and about the nature of interaction between people and space. Images can expand the scope of this language, and in doing so, broaden our understanding of ourselves and our environment. Appendix A contains a description of one approach to the incorporation of lifedrawings into an evaluation methodology from the field of environmental psychology. The combination of this hybrid approach may
lead to a better understanding of spaces that encourage creative interaction. The artist is concerned with producing images that express insight into some aspect of the human experience. The more profoundly the image expresses the insight the happier the artist, the more profound the insight, the happier the human. To be a happy human artist requires a dedication to image quality and a commitment to the quest for understanding. For the visual artist the visual image becomes the vehicle that facilitates that quest. The image is both the medium and the message. It becomes its own metaphor. Appendix B contains a description of some of the technology used to develop lifelines imagery. The images produced via the interface of computing and imaging technology are a product of complex interaction that reflect complex interactions. If by making and viewing and interacting with these images, we gain some insight into the nature of complex interaction, then perhaps we have reason to smile. If an image makes us smile, perhaps we have gained some insight.
8.4 LIFEDRAWING
Waterworks Swimmers
Waterworks Swimmers
Dolphin Tail
Graphic Design Suggested By Lifelines

SKY DISK
Chapter 9

CONCLUSIONS

What is an environment that promotes creative interaction? At the beginning of this paper I described creative interaction as a response to the environment with a well integrated sense of exploration, introspection and regard. Is this quality something that can be encouraged, evoked from an individual by a surrounding? Melvin Konner, known for, among other things, his work in behavioral anthropology and sociobiology, relates the following from the Fabric of Meaning chapter of his book The Tangled Wing:

From the earliest moments of embrionic development, cells crucially influence one another, are of use to one another and to the embrio. Genes may do much of the guiding from within, but cells are keenly responsive to other cells. These cues from other cells may be cell-surface markers or purely mechanical forces, caused by the genes or just by the geographic layout and the movements entailed in growth. Some of the most fundemental events of development, depend entirely on the juxtaposition of different tissues at critical moments.

Konner continues, citing research of Stanley Crain of the Albert Einstein College of Medicine:

...Crain and his colleages concluded: "thus
there is by now considerable evidence suggesting that specific interneuronal contacts are determined by genetic mechanisms during development, and that organized neural assemblies are formed in forward reference to their ultimate function. Yet for all the importance of internal structures in brain development, experience still affects neural connections. ... Mark Rosenzweig, Marian Diamond, Edward Bennet and others at the University of California at Berkely showed that impoverishing or enriching the environment of rats, even aged rats can affect the weight and thickness of the cerebral cortex, the ratio of supporting cells to nerve cells, the number and size of synapses, the amount of synaptic transmitter chemicals and their enzymes, the complexity of higher order branching of dendrites, and the number of spines crowded onto a unit length of dendrite.

He concludes the chapter by asserting:

...any analysis of the causes of human nature that tends to ignore either the genes or the environmental factors may be safely ignored. [Konner]

Until such time as artists include gene splicing in their repertoire of techniques, we must be content to limit our interaction with DNA to observation and understanding. As far as after the fact influences however, ie. environment, I feel that artists have and do offer significant insight into the nature of human nature, and are able to make a meaningful contribution to our understanding of it. For as far as the interactions between people and environment are concerned, artists are real players in the field, not simply observers or theoreticians. Artists set up situations that directly affect our relationship to our environment.
The James Turrell show at the Whitney Museum in June of 1980 is to my mind a good example. The Museum was very crowded with lots of people wearing the usual art goers faces, looks of interest or boredom, perplexity or curiosity. When I reached the fourth floor where the Turrell exhibit was installed I noticed something quite different on the faces of the people coming out of the exhibition. There was an air of excitement in the room and looks of delight on the faces of the people. People were walking out of the show with smiles on their faces.

In practice, what is it that determines an artist's decision to place a sculptural element in an environment "here" as opposed to "there"? On what criteria does an artist decide that a piece is finished or that it "works"? What is it that determines an "appropriate decision" apart from its self evidence? The essence of creativity lies in these questions; in the questions probably more than in any answer we may arrive at. Any answer that presumes to solve the preceding questions in any definitive fashion, has lost sight of the fact that the beginning of the solution lies in asking the questions in the first place. In a close to the end of the semester lecture to the strobe lab class he inherited from Harold "Doc" Edgerton, V.E."Charlie"Miller recounted the "key to fame and fortune according to Edgerton..."what if I...".

I suspect there will be at sometime in the not too
distant future a laboratory study that demonstrates a positive correlation between creative interaction and "...thickness of the cortex, the ratio of supporting cells to nerve cells, the number and size of synapses...ect." and probably a few other significant factors that combine to provide a neuro-physiological description of a meaningful existence.

I expect that a complete understanding of meaningful existence will encompass the entire range of human, in fact planetary experience. I also expect that an integrated artistic/scientific approach to this understanding will take the form of a dynamic and open ended way of learning as opposed to any static model that attempts to account for everything.

I believe that art should provide people with meaningful, ultimately enlightening experience. Art at its best allows people to learn, feel and relate. Art does not teach, it encourages us to learn.
Appendix A

Environmental Psychology Evaluation Methodology

The following is an outline of several research techniques developed and or described by Albert Mehrabian and James Russell in their text An Approach to Environmental Psychology [M&R]. Mehrabian & Russell have proposed a framework for studying the relationship between behavior and environment. The framework proposed by M&R is that environment which they characterize as sense modalities (e.g. color, temperature, light and sound levels etc.) and information rate (the characterizing of temporal and spacial relationships among the stimulus components of an environment) combined with personality, elicit primary emotional responses of pleasure, arousal and dominance which in turn influence if not determine behavioral responses which they classify under the Approach-Avoidance model. This model suggests a reformation of target responses as exploratory and (creative) performance.

The first component of this evaluation is the series of questionaires composed of 5 tests, including a 14 paremeter semantic differential questionaire to determine a subject's response to the spacial and temporal
characteristics or information rate of a given environment, known as: A GENERAL MEASURE OF INFORMATION RATE. THE SEMANTIC DIFFERENTIAL MEASURE OF CHARATERISTIC EMOTIONS is an 18 paremeter questionnaire used to determine the personality characteristics of the subject. This questionnaire may be administered with two different sets of instructions, one for determining the general emotional characteristics of a subject and another set of instructions for determining the immediate emotional state of the subject at the time the questionnaire is administered. A 40 statement evaluation in which the subject is asked to agree or disagree with each of the statements + or - four degrees either side of neutral as a MEASURE OF AROUSAL SEEKING TENDENCY. A VERBAL MEASURE OF APPROACH-AVOIDANCE consists of 8 questions prompting the subject's response on desire to stay, explore, work and affiliate in a given situation.

An additional evaluation known as THE PORTABLE ROD AND FRAME TEST, as described by Herman Witkin, The Body Percept [Wapner] will be used to establish each subject's propensity towards field dependent or field independent characteristics. Field dependence and field independence as determined by the rod and frame test as well as a variety of other experiments has been shown to correlate rather strongly with different cognitive styles. At its simplest or most basic level, field independent types tend
to differentiate more strongly than field dependent types between themselves and their environment (eg. field independent types do not seem to be prone to vertigo and generally tend towards more "analytic" problem solving).

The Waterworks evaluation is designed for 24 individuals: 12 men, 12 women, and a control group of similar proportions. The test group will be asked to take a preliminary battery of tests two or three days prior to the pool site observations. This battery will include: the Measure of Arousal Seeking Tendency, the Semantic Differential of Characteristic Emotions, the Portable Rod and Frame Test and the General Measure of Information Rate as applied to a selection of Standardized Verbally Described Situations, and the Semantic Differential Measure of Emotional State at the end of the testing.

The pool site will be set up as follows: the configuration of mirrors will be installed in the pool, along with a Lifeline facility consisting of a fixed video camera and recorder, a coordinate input device (such as a mouse) and an IVIS computer.

Each of the 24 subjects will enter the pool for five minutes each on four different occasions, once alone, once with one other person, once with two other people and once with five other people. Each pass through the sculpture will be mapped by Lifelines and stored as a file on the computer. Pertinent details, such as where, how and with
whom the subject entered the pool will be recorded on videotape. A different color-linestyle combination will be assigned to each individual so that distinctions can be made during composite overlay comparisons.

When an individual has completed all four entries he/she will be asked to briefly describe the experience (the description recorded on audio cassette) and then will be given a second battery of tests that will include: the Portable Rod and Frame test, the Semantic Differential Measure of Emotional state, the General Measure of Information Rate as applied to the pool experience, and the Verbal Measure of Approach-Avoidance.

The control group is given both batteries of tests concurrently with the test group without pool site experience.

Evaluation of test results and classification of Lifeline categories will provide a body of data from which correlations between movement, environment and personality may be examined. For example, changes in such factors as field dependence, arousal levels, approach-avoidance and information rate may be compared with self reports and a given category of Lifeline that may characterize a tendency towards affiliative behavior within a particular environmental-emotional circumstance. Until the occurrence is completely understood, it might be more useful to characterize it according to its Lifeline pattern than to
call it "the chlorine affiliation syndrome" since whether or not chlorine is the or even a significant factor remains undetermined. The lifeline is directly referential to the known factors in the occurrence (the information i.e. line is displayed as a function of the movement represented on the video tape). If initial categorization is based on de facto line characteristics, it may reduce the temptation to prematurely name an occurrence according to a more subjective classification.
Appendix B

Technology

Lifelines employs television and computer graphics as a means to graphically represent path as entity juxtaposed against a video representation of the object that produced the path in the environment in which the interaction (object-environment) took place. The complexity of the line (number of points per figure) is optional and the sequence may be displayed as recorded or with a selection of dynamic graphic enhancements accentuating the movement of the figure through the space. Television provides the context from within which to establish a frame of reference. It is the medium that replicates the familiar (an arrangement of photons in space that we recognize as a scene) and transforms it into an arrangement of electrons in time which can then be manipulated to reproduce, enhance, distort or store the virtual image of that scene.

In the first implementation study for Lifelines, the scene was recorded on 3/4" video tape and then was transferred from video tape to writeable optical video disk facilitated through the use of the digital frame store capability of a time base correcter (TBC). (One drawback of the 3/4" Umatic video cassette format is that
it's helical scan and tape transport configuration does not permit a stable video signal to be generated from a single frame. Signal stability is dependent upon both the helical scanning motion of the tape playback heads and the lateral motion of the tape moving past the drum (at a speed of 95.3 mm p/sec.) that carries the heads.)

Because in this first implementation (which from here on will be referred to as mark1) depended on the video image to supply all the information necessary to generate the Lifelines, it was deemed desirable to exercise as much control over that image as possible. The write once disk became the medium of choice because of its ability to store a sequence of video as a series of discrete individually addressable and readable frames. The TBC will read and digitize a composite video signal in real time and stabilize time base or synchronization instability in the video signal. The Phaser model TBC used in this case had the capability to digitize and store in a buffer one full frame (525 lines) of video and read that buffer out at real time video rate of 60 fields per second. The picture may then be displayed either as a full interlaced frame or as a 262 1/2 line field.

The next state of development for the mark1 version of Lifelines was the development of computer graphic software tool. This program is used to collect, store and display points on the figure(s) in the video image on a
frame by frame basis. As each frame is referenced and displayed on a video monitor at the graphics workstation, a cursor is displayed over the video image. The cursor corresponds to the position of a "puck" on a digitizing tablet. The position of the puck is interpreted by a micro processor which converts the position into a bit string recognized by the computer program as X and Y coordinates. Coordinates from each frame are read into a data structure. The structure stores the coordinates for each frame in such a way so that they may be written out to the display routine. The display routine uses the same coordinates to display the line segment that corresponds with a given frame of video.

A brief look at a sample structure should clarify the data storage and referencing procedure. A structure would be declared as follows:

```
disable 1 linedata,
  2 total_number_of_frames fixed,
  2 total_number_of_figures_per_frame (4),
    3 color_of_each_figure (12) fixed,
  2 frame_number (100),
    3 figure (4),
    4 head_size fixed,
    4 points (12),
      5 x fixed,
      5 y fixed;
```

The highest level of the structure is the name of the area in computer memory to be allocated for the storage of
data, in this case "linedata" and its level is "1". Level "1" contains no data. It is simply a name used to identify this particular block of storage. On level "2" we find three elements, the first of which, "total_number_of_frames", representing the total number of frames to be stored in the data structure will contain one fixed integer number corresponding to a value supplied through the main program. The second of the level 2 elements, "total_number_of_figures", can be thought of as a four (4) element, two dimensional array, each of the four elements capable of assuming any one of (12) values stored by the second dimension of the array designated by a third (3) level element, "color_of_each_figure". The last of the second (2) level elements is called "frame_number" and may be thought of as a 100 element multi-dimensional array, that is each of the 100 elements or frames has associated with it up to four elements called "figure" level (3), each of which has a fixed integer value called "head_size" level (4), and up to twelve (12) elements called "points", each of the twelve "points" corresponding to two fixed integer values called "x" and "y", level (5).

When the display program, which will display a dot pattern of a given size and color at a given location is ready to use the values corresponding to size, color and location, for example, the right knee on figure 2, in
frame 54, the reference that calls for that value would look something like this:

\[ X = \text{linedata.frame.number}(54).\text{figure}(2).\text{point}(8).x \]

where 8 is an element in the array of "points" corresponding to the right knee position). Likewise the value corresponding to the color for that same point would be referenced as;

\[ \text{color} = \text{linedata.total.num.of.figs.color.of.each.fig}(3); \]

three(3) corresponding to location of a shade of yellow in a color map. In both cases the only element in the reference call that contains any data is the last (i.e. "x" in the first example and "color_of_each_figure" in the second).

Values are taken from the graphics tablet, and prompting statements, eg.

\[ \text{call ask ("what color would you like", color);} \]

displayed on the terminal and assigned to the appropriate element in the data structure, as y values are assigned from the data structure to the appropriate statements in the display procedure.

In the markl version of Lifelines a program running on a 32 bit mini computer controls what may be thought of as two separate data bases (the video images on the write
once and the data that runs the program). A separate communications microcomputer known as the MICOM is necessary to handle communication between the workstation, the mini computer and the write once machine. The images from the write once and the frame buffer of the mini computer (which produces the graphic overlay) must be routed through a separate video switcher in order to display the video and graphics as a composite image.

B.1 Packaging a Picture

It may be apparent by now that the total amount of data when considered on a frame by frame basis is not very much, in the example given 12 points of two three digit numbers each, a single three digit number corresponding to headsize or z and a single digit corresponding to a color slot, a total of 208 bits per frame. As mentioned previously, a single frame of NTSC (National Television Standard Code) video consists of 525 lines of signal information. These 525 lines are displayed as two interlaced fields consisting of 262 1/2 lines each, the first 21 lines of each of these fields do not contain picture information and are not displayed. These 21 lines are known as the vertical blanking interval or VBI and gives the television or video monitor time to reposition its electron beam back at the top of its scanning pattern.
The VBI contains signal information used by the receiver to ensure picture quality, these signals include:

- equalizing pulses to synchronize video information between fields 1 and 2,
- vertical synch pulses,
- a second set of equalizing pulses to ensure field frequency regularity,
- vertical interval test signals or VITS which are used to evaluate various parameters of a broadcast system's performance such as frequency gain characteristics, differential gain and phase, envelope delay, frequency response, chrominance/luminance response among others,
- the vertical internal reference signal and a source identification signal indicating the origin of the signal, date, time, etc.

Equalizing and sync pulses take up the first 9 of these 21 lines. The vertical interval test signal takes up lines 17 and 18. The Vertical Interval Reference is on line 19 and source identification signal generally winds up on line 20. Line 21 is currently being used by several of the networks to encode a string of digital information that can be decoded on reception and displayed as text on the screen for the hearing impaired.

Negotiations have been underway between the various commercial interests and the US government regulating
agencies as to which of the variety of encoding protocol standards to adopt for the broadcast of graphic and textual information in the remaining electronic real estate of the vertical blanking interval. One standard that was recently adopted by The American National Standards Institute ANSI as well as the Canadian Standards Association is the North American Presentation-Level Protocol Syntax or NAPLPS. The ability to pack or encode a variety of types of information in a broadcast or a recorded video signal points the way towards an efficient and elegant technique for the dissemination of composite computer graphics-video images.

Using the example of the Waterworks evaluation, all of the recorded video, recorded audio of the participants self reports, lifeline coordinate and display information and test result data could be either mastered onto a video disk and/or broadcast or cablecast over a university or a research channel. A large number of researchers would then have access to an interactive replication of a behavioral study in which independently reachable conclusions from the original study condition would be possible.
Appendix C

Waterworkers Comments

Peter Mui
Ricardo Guillermo
Steven Edson

I used to swim frequently even before my interaction with Waterworks, but I considered it something I did for exercise; I enjoyed it in the same way that those languishing souls plodding along the banks of the Charles River enjoy jogging. I was trying to make myself healthier, and water was my Nautilus equipment. It restrained my movement, intimidated me, cast doubt on my physical and psychological well being, and that was what I wanted!

In preparation for the Waterworks performance, I learned to free-dive, and developed a new awareness of the water's depth - that it was more than the 3 feet of fluid close to the air that I churned through as part of my daily regime.

It was uncomfortable, physically and mentally, to let go of the air and envelop myself completely in the water. The air was my life-sustainer, and its inaccessibility made my need for it more acute. The water seemed to
oppose me as well, with the pain in my sinus cavities increasing with the depth. My dives were limited at first to shallow surface dives, then "daring" plunged to the bottom of the pool, where I immediately kicked off for the surface again, gasping for air upon arrival. I was determined to overcome my aversions, partially because I had committed myself to participating in the performance, partially because I wanted to challenge my physical and mental boundaries. There was another element, however, that element of being primordially aware of my fluid origin, both as an individual and as a species. As at the seashore, with the waves crashing and racing up to my feet, flirting with me, the water beckoned, even in the unlikely surroundings of the MIT pool.

The mirrors of Waterworks served as the catalyst to bring me closer to the water environment. James Thurber said that the subject that interests man the most is man himself, and if I needed additional encouragement to challenge the water, it manifests itself in the desire to interact with this being I had lived intimately with for 21 years and apparently knew little about.

Suspended in water, my body could contort itself in ways I hadn't experienced, and I could reflect upon those contortions in the mirrors. The erect posture I was familiar with through my interactions with mirrors on land could be replaced with the ridiculous to the sublime. As
I overcame my aversion to the water, I found I could launch myself past the mirrors, keeping a frozen position. At first, these launches were aerodynamic, giving my body a sleek, aesthetically elongated repose. Later, they took on moving variations; I curled up in a ball and rolled, or with outstretched limbs did underwater cartwheels.

My interaction with the water, while still recreational, became more effortless and playful. Early on, I no doubt derived solace from the mirrors; in being able to observe myself interacting with the alien environment, in being able to assure myself that the emotional and physiological distress I was experiencing was having no outward effect. As I gained confidence, they became a tool with which I could experiment with myself in interaction with a new and unfamiliar medium.

Waterworks allowed me to obtain an increased confidence in, and awareness of, the water and myself.

Peter Mui 4/21/85
On Waterworks Ricardo Guillermo

Thoughts: Entering Waterworks released a flood of thoughts and thoughts are what remain. I have no visual image or record of the experience other than my recollections. Other than my involvement, a few acquaintances were made which I hope will endure.

We came from different fields: our fascination with water was the bond which joined us. From the field of architecture I have developed an orientation towards a future when we as a civilization will return to the sea to dwell. In preparation for this outcome I have worked for the past sixteen years and yielded a sourcebook for further research and a proposal for a new field of inquiry, "Aquatecture". My thesis "Aquatecture: Paradigms of design and sea born structures" can be found at the Roach Library of MIT and libraries of other fine institutions or through Aquatecture Press of Cambridge, Massachusetts.

Words: Our first meeting, anxious to work, we were informed of the Waterworks theory: elevation of consciousness can come through interaction and self awareness in an uncommon medium. An environment composed of reflection, buoyancy, and density would be formed. Mirrors, floats and blocks with ropes as a medium for the transferral of forces developed by each were used to define a matrix. Movement through the space was timed to
the breath hold period and we were free from the planar existence of terra firma and the social convention of constant extraversion. We would swim underwater, alone, in groups or pairs and observe ourselves in the mirrors for feedback of our process. The spatial matrix was formed and transformed perceptionally by our corporeal image and physical movement. This in turn influenced subsequent movements and perceptions and for a brief period an evolution of sorts occurred.

Trust: It was a demonstration, an embodiment of an idea. I did not find enlightenment. It was a trial. I still trust the theory is valid, it has not been disproved.

Brainstorms: I wanted coherence and order as opposed to randomness. My thoughts sought to organize, divide, define, merge the space and performance. Water in its course infallibly follows specific laws, yet it returns to a state of dispersal and dissolution, so I'm not so sure of the validity of my efforts to formalize a rigid choreography or boundary definition within the environment that was created. A system of notation, timing and spatial definition was hastily drawn up. Some ideas were adopted, others transformed. I found a limit to expression in the process as sure as the shore forms a limit to the sea. It was not my work, it was a collaboration.
Actions: A very private event proceeded the public one. (We sat in a circle) and showered together and remained still, sightless and soundless for some moments. It was a communion and rekindling of the spirit which had brought us together.

Suddenly we were amidst family, friends, musicians, technicians, and a public most of whom we did not know, a breath hold from our performance. Our groupings were set as was our path, but what we did in breath hold, in descent and accent, was respond to our moment's feelings.

Interactions: It was over too quickly and then donning flippers and aqualungs I became a guardian lurking in the corners of the pool lest an unwary explorer need help underwater.

Wave after wave of afficianados swam in for a closer look at the installation. I found joy in their interactions and took pride in the collective work the team had done.

Language: People behave very differently underwater. Economy and honesty, communications are difficult. It doesn't stop us from trying to communicate, but it takes something of greater importance to summon the effort required. We need a language of subtle gestures for use underwater.

Recollections: I appreciate the holistic scope of Uri's work, the broad gesture of it's simplicity and fit
of the minute details he has devised to structure his materials. Suspended in breath hold, bouyed in space, intent on accomplishing a simple act, installing the sculpture was most fun, through the preparations, performance, and subsequent trial installations.

I was handed rectangular mirrors edged and bounded with red rubber, a gromet hole in each corner. Then this marine yellow rope attached to a cinder block on one end and a float on the other. The task was to suspend the mirrors from the rope in a more or less precise configuration. In the lapse of the breath, very small tasks are indeed quite difficult. The time it took to make the joint was prolonged. Some may see this as a disadvantage equating less time with a better joint design. This may be true, but in any case one or two joints would be your limit in a breath hold. What is more important is the joy found in the act of connecting, joining, gathering together the parts. The act of joining the rope to the mirrors gave a great sense of achievement. In one breath, striving against inertia to bring the mirror to the rope, then the loop of rope through the gromet and finally the actual knot which joins, or the peg inserted in the loop for a friction fitting. That moment of saying, "Yes it is done, I may ascend, I may inspire", was very satisfying. The procedure of installation maintained these breath long periods of anticipation prior
to completing the joint. The simple type of joint which could just barely be accomplished, helped to prolong the anticipation and led to a greater sense of achievement when it was done.

Purpose: This is all I want to do is put things together and to see life grow. Is it not ironic with our experience and skill in design and construction, we must turn to underwater to find a site in which to build!
Through my participation in Waterworks, I was able to view and experience the swimming environment in a very new perspective. Mr. Levi's ideas just scratch the surface of vast possibilities that are available for human interaction with the swimming pool and water environment. In a very simple but maybe appropriate analogy of what the beach ball did for the beach. Waterworks enabled me to expand my ability to interact with an "old" environment in a new way. I was taught how to swim at the age of 2 years, and spent much time in the summer months playing, diving and splashing in pools. During my high school years I spent many arduous hours of exhaustive workouts practicing speed and endurance training for a highly competitive swim team. For me the pool has always been connected in a very limited relationship. To swim with sound/music maybe even language tapes, flowing through my ears while swimming and exploring the water environment of lights and mirrors helped me to realize the variations that are available, that could be applied to an old idea. What was once the luxury of an upper class and available to few, now in the modern age of mass production blow-up, portable pools where people can cool off or possibly exercise in, now with Mr. Levi's concepts, a revolution in how and what people do in their water environments can develop.

Steven Edson
REFERENCES

[ADO&BER 74] John Adolfson & Thomas Berghage.  
Perception And Performance Under Water.  

[Arnheim 74] Rudolf Arhiem.  
Visual Thinking.  

[Bronowsky 78] Jacob Bronowsky.  
The Visionary Eye.  
Essays in the Arts, Literature, and Science.

The Lure of the Dolphin.  

On Knowing: Essays for the Left Hand.  

[Churchland 82] Churchland, Paul M.  
Matter and Consciousness.  
The Massachusetts Institute of Technology, 1982.

The Senses Considered as Perceptual Systems.  
Psychology.

The Language of Vision.  
Paul Theobold, 1944.

[Kinto ??] Kinto.  
Haiku.  
from a haiku on exhibition at the Freer Gallery of The National Museum.

The Tangled Wing.  
Biological Constraints on the Human Spirit.
An Approach to Environmental Psychology.  
The Massachusetts Institute of Technology, 1974.

[Tofler 80] Alvin Tofler.  
The Third Wave.  
Morrow, 1980.

[Tributsch 82] Tributsch, Helmut.  
How Life Learned to Live.  
The Massachusetts Institute of Technology, 1982. 
Adaptation in Nature.

[Tributsch82 82] Tributsch, Helmut.  
When the Snakes Awake.  
The Massachusetts Institute of Technology, 1982. 
Animals and Earthquake Prediction.

[UWHB 76] Shilling, Werts & Schandelmeier.  
The Underwater Handbook.  

[Wapner 65] Seymore Wapner & Heinz Werner, editors.  
The Body Percept.  

Seeing is Forgetting the Name of the Thing One Sees.  
A Life of Contemporary Artist Robert Irwin.