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The Electric Retina An Interplay of Media Art and Neuroscience

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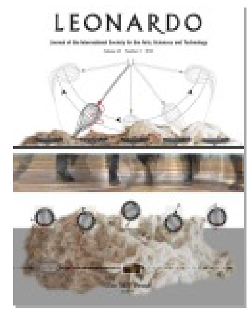

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ARTIST'S ARTICLE

The Electric Retina: An Interplay of Media Art and Neuroscience

Corinne Hodel and Stephan C.F. Neuhauss, with Artist's Statement by Jill Scott

ABSTRACT

The Electric Retina is an interactive sculpture built by the artist Jill Scott. This project is the result of her residency at the Institute of Zoology (Zurich) neurobiological laboratory and is an artistic interpretation of the lab's research on zebrafish vision. This trans-disciplinary collaboration has served to communicate scientific findings to the general public. Moreover, learning different styles and modes of communication required for interfacing with the general public and with the artist has been a worthwhile experience for the scientists involved.

Jill Scott's background is in media art; she constructs video artworks and interactive performances. She is also co-director of the Artists in Labs program, located in the Institute of Cultural Studies at the Zurich University of the Arts. This program enables Swiss artists to work as residents in specific Swiss scientific laboratories for several months, and as Scott wanted the experience herself, she applied to our lab as an extra resident, not funded by her organization. The intensity of her involvement required her to be part of our research group rather than a momentary visitor. This approach reflects the conception of the program itself and allows for a much more intensive knowledge transfer between artists and scientists, leading to new encounters at multiple levels. Here we describe Scott's residency in our neurobiology lab at the Zoological Institute of the University of Zurich from our point of view as participating scientists.

SCOTT'S RESIDENCY

In our laboratory, the focus of our research is the zebrafish retina. Zebrafish are small tropical fish that are used as model organisms in vertebrate biology around the world. This fish offers multiple advantages for visual research [1]. The larvae have to catch prey by the tender age of five days (post-fertilization), and acute vision at this early stage is indispensable for their survival. Therefore, the retina has to develop very quickly and is particularly accessible in five-day-old larvae. In the laboratory, blind larvae survive only if raised in a medium containing high concentrations of living food such as paramecia. In this paradisiacal condition, nutrition can be passively obtained simply by opening the mouth.

We are able to evoke an optokinetic response (OKR), that is, stereotyped eye movements, in a "movie theater" for fish by projecting moving stripes onto a screen that is watched by the larvae.

Presentation of a moving stimulus triggers eye movements that can be analyzed in real time using custom-designed software. In this way, we are able to test quantifiably the visual performance of larvae, even though they are only about 7 mm in length.

The velocity of eye movement gives us information about levels of visual impairment. For instance, the absence of eye movement (apart from spontaneous movements) after visual stimulation is a reliable indication of complete blindness. Zebrafish strains with impaired visual performance in the OKR movie theater can be further analyzed by electrophysiological analysis. The electric response of the retina to flashing light is measured with a tiny electrode, which sits on the cornea of the eye surface. Depending on the site of the defect in the visual pathway, the response will show typical characteristics indicative of the cellular localization of the defect. Histological sections of the zebrafish eye can be also viewed with a microscope, and this process reveals further details of abnormalities in the retina. As in the human eye, the zebrafish retina harbors light-sensitive photoreceptors and other neuronal cells that process the signal from the photoreceptor and send it to the optic nerve. In zebrafish, photoreceptors are arranged in a rigid pattern array over the retina.

When Jill Scott started her residency, she accompanied us during all stages of our research process. These hands-on demonstrations were supplemented by tutorials conveying basic concepts of neurobiology, ophthalmology and genetics. As an honorary member of our research group, she also took part in our weekly seminars and meetings. Finally, she worked alongside the scientists and performed her own experiments. This deep insight into our day-to-day activities was essential for creating a piece of art that could reflect and interpret our research in a robust manner.

This exchange turned out to be bidirectional, however, as lab members soon became involved in the artist's process. The ideas for the final artwork evolved through mutual interaction during several brainstorming sessions and other discussions. After a year, *The Electric Retina* was ready for its first public exhibition, at the BrainFair 2008 on the occasion of the 175th birthday of the University of Zurich.

THE PRODUCT: *THE ELECTRIC RETINA*

The artwork that resulted from Scott's residency in our laboratory is a sculpture symbolizing a part of the retina, with

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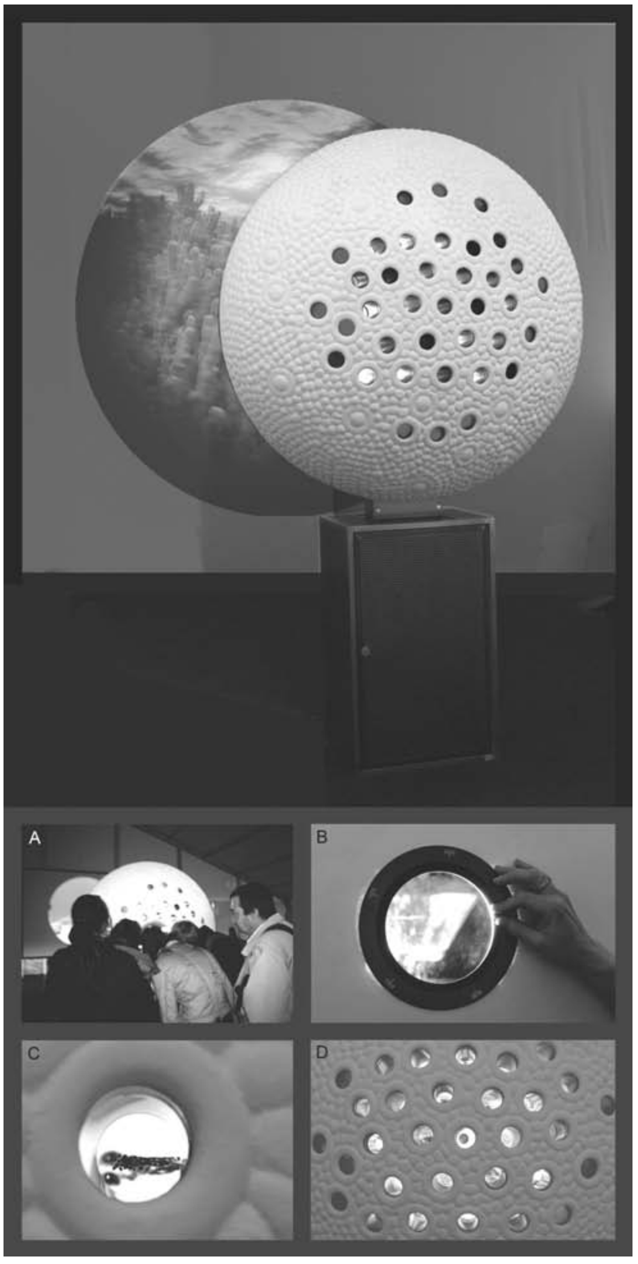


Fig. 1. Jill Scott, *The Electric Retina*, interactive sculpture, 200 × 120 × 80 cm, 2008, exhibited in a public space. For a short documentary about *The Electric Retina* see <www.vimeo.com/1387705>. (© Jillian Scott)

which the audience can interact (Fig. 1). The base of the sculpture is composed of a metal socket, which harbors technical components such as a media player, sound devices and touch sensors. The socket supports an appealing giant sphere with a diameter of 120 cm, which aroused the curiosity of the spectators (Fig. 1a). Here two white hemispheres coalesce into a round eyeball. At the front, the iris of the eye serves as a window guiding the light beam from the internal video projector onto a screen about 3 meters away from the sculpture. The audience can choose between five thematically different sets of movies by turning a lens on the front of the "iris" (Fig. 1b). Once the lens-carrying wheel is latched in a new position, the movie linked with this setting starts. The projected movies are the result of a post-edited underwater shoot off the coast of Australia. Subsequent image processing of the pictures by Jill Scott resulted in an artistic representation of this ocean environment seen from the perspectives of zebrafish afflicted with particular eye diseases. These diseases were chosen from animal models used in our research, as well as from common human visual afflictions. In the case of progressive diseases such as retinitis pigmentosa, the movie starts with an original scene that is gradually modified according to the course of the disease. Apart from these public movies seen by all spectators, there are private viewing holes or oculars that display representative macro images and animated sequences from studies actually made in our laboratory (Fig. 1c). These oculars represent the photoreceptors' pattern array spread irregularly over the back hemisphere (Fig. 1d). The images are displayed on a huge LCD screen inside the sculpture. The content of the oculars changes simultaneously with the projected movies as the large lens is rotated. In addition to the regular selection of movie sets, there is another, more subtle interface between sculpture and spectator. If no one interacts with the sculpture for several minutes, a sixth set of movies starts automatically. This attract loop is immediately interrupted when a spectator approaches the sculpture and touches the border of an ocular, starting one of the five other movie sets. A touch sensor underneath the surface connected to the media player mediates this elaborate human-machine interaction.

Exemplary Movie Set: Healing Disease with a Special Diet

Here, we describe the science underlying one movie set, based on research on the zebrafish strain *noir*, which suffers from a hereditary disease. As its name implies, sick offspring of this fish line have a darker appearance than healthy siblings. Black body pigmentation is often associated with blindness (Fig. 2). As pigment cells develop, zebrafish larvae start to adjust the degree of their body pigmentation to the background illumination by spreading or concentrating pigment granules within the cell. Thus, a light-adapted larva is brighter than a dark-adapted individual—unless it is unable to sense light and lives in perpetual internal darkness.

The defective protein underlying the disease in noir plays an important role in most cells, not only those involved in vision. It is part of a complex (pyruvate dehydrogenase) that boosts the synthesis of a key molecule (acetyl coenzyme A) involved in carbohydrate metabolism. As a result, in noir mutants a central metabolic pathway is blocked. Considering the biochemical pathway, supplying a fatty acid diet to the affected fish can circumvent this block. Indeed, noir can be almost completely cured of these symptoms simply by feeding on a mixture of fatty acids. The diet and its consequence are comparable to the nutrition of essential provitamins for humans. By nature, the human body is unable to synthesize certain vitamins; food containing those vitamins is thus indispensable for our health.

The Electric Retina highlighted our research on the noir fish. Looking more closely at the oculars, viewers can see photographs and animated pictures from the experiments made with noir. Simultaneously, the screen shows a blurry underwater landscape—modeled by computer—from the conjectured perspective of the visually impaired noir fish. As soon as the simulated fish starts to feed on floating morsels of food (symbolizing the supplied fatty acids), the blurry scenery is replaced by a clear image of the ocean.

Discussion

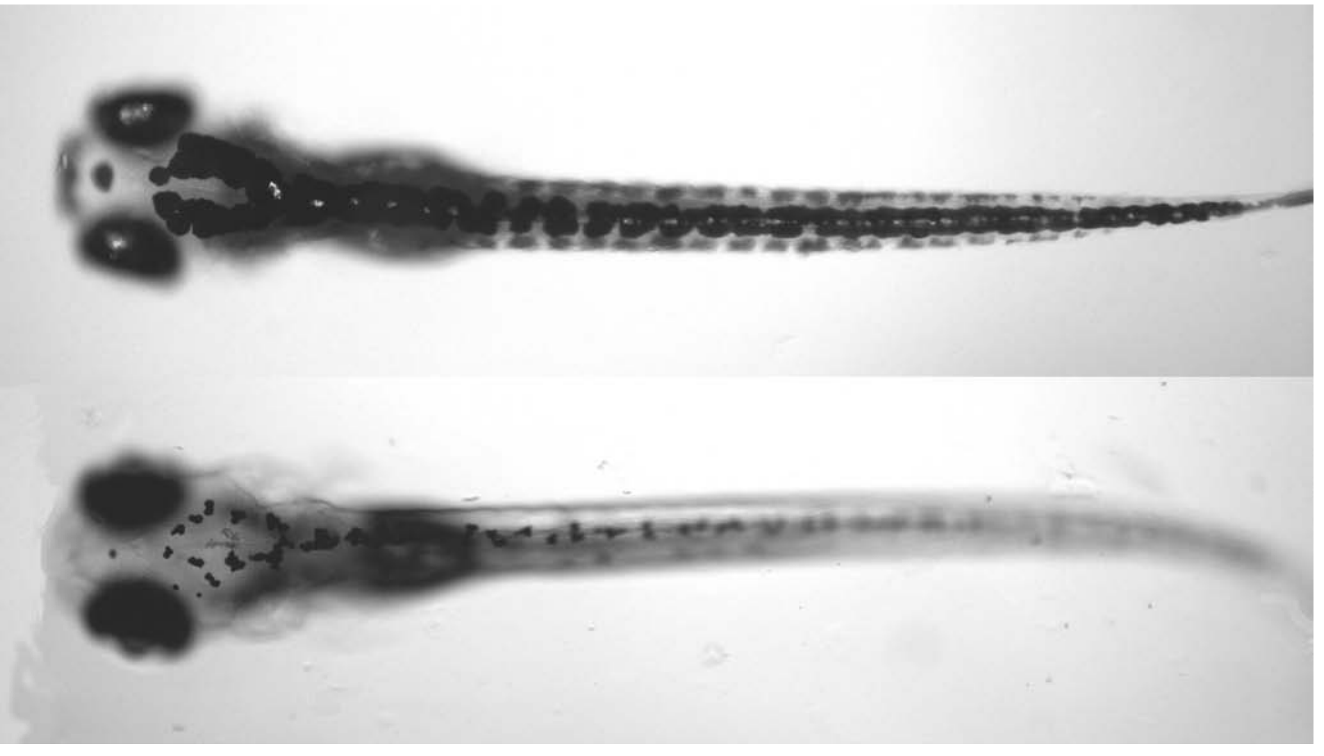
The Electric Retina in a Public Space

Beyond a doubt, an artwork is an unconventional form for transmitting scientific findings from the lab. A research project would normally culminate in an article published in a scientific journal. Along the way, scientists may present their results orally at talks or in front of posters at research conferences, but, obviously, such exchanges are restricted to a limited circle of experts. In contrast to these closed channels of communication, the exhibition of art is an experience open to the general public. Artists aspire to reach as many people as possible, and it may be argued that previous knowledge is not required for the audience to experience (and, one hopes, enjoy) a piece of art. Presenting scientific knowledge in the public domain as "art" opens an additional channel for interested outsiders to gain insight into scientific research. This kind of interaction is similar to an exhibition in a science museum; however, an artwork often aims not only to present the underlying research but also to provide an artistic interpretation. It is this "interpretation" that can foster increased dialogue between the scientific researcher and the general public. Discussions at the site of the exhibition of *The Electric Retina* at BrainFair Zurich 2008 and the festivities for the 175th anniversary of the University of Zurich constituted a two-sided experience for the audience. On the one hand, they encountered cutting-edge research on visual impairment by looking into the oculars. On the other hand, by watching the projected movies, they received a reflected perspective on the perceived effects of visual impairment. Such a confrontation spurred many interesting questions concerning experimental setup, animal testing or underlying mechanisms of eye diseases from the audience. Their questions were directly debated with the scientists involved in this research, who were also often present at the exhibition. The audience not only had the opportunity to get first-hand information from people directly involved in scientific research but, from our point of view, it was a novel experience to discuss our data thoroughly in this format. It helped to increase the awareness and interest of people without biological or medical backgrounds. In answering the audience's questions, we had to adapt our vocabulary and simplify complex occurrences so that the issues behind our research remained coherent. As Albert Einstein once suggested, things should be made as simple as possible but not simpler. This is still a proverbial task for scientists. We also gained insight into the main interest of the general public: how to recognize and treat medical and eyesight problems. Some people even needed to be redirected to eye doctors.

The Trans-Disciplinary Collaboration

The creation of an artwork such as *The Electric Retina* can be an intense trans-disciplinary collaboration. During the process of development and construction of the artwork, all participants can learn and profit from one another. When Jill Scott came to our lab, she knew only that we study the zebrafish eye by modifying the fish's genetics and testing its resultant behavior. She knew that this information was not sufficient to build a trans-disciplinary artwork. Consequently, she learned the basic principles of our research field in order to gain a deeper insight into our scientific subject. This process led to the adjustment of our combined vocabularies and helped Scott to

Fig. 2. Five-day-old zebrafish larvae. In contrast to the blind *noir* mutant (top panel) having a darker outer appearance, genetically unmodified wild-type larvae (bottom panel) are able to adapt body pigmentation to a bright background. (© Collette Maurer, Corinne Hodel and Stephan Neuhauss)



speak with us in our language. The artist has to understand the scientific terminology and the underlying concepts. For example, a biologist may use the term *evolution* exclusively in a Darwinian context, whereas an artist may use it instead as a synonym for development or maturation in general. Hence, for the artist, evolution may have a goal-directed component aiming at improvement. In a biological sense, evolution is a random process, and the directing force is selection by adaptation to a constantly changing environment. Thus, a long process of discussions and considerations should not be confused with a trivial simplification of a complex topic. As a temporary member of the research group, Scott gained increasing familiarity with the conceptual background of our research and became engaged in our discussions. Such in-depth insight is an indispensable requirement for building a meaningful artwork that includes scientific research.

From Inspiration to the Final Sculpture

When we showed Scott an image of the photoreceptor pattern array taken with a scanning electron microscope, she was immediately drawn to the regular tiling of these cells. This image became the start of her artistic inspiration; she was simply fascinated by its aesthetics, and we described its biological aspects, such as the ultra-structure of the cells and the implied structure-function relationships.

Thus, this picture was the starting point for the external appearance of the sculpture, and we began to discuss how to associate our research with the artwork. Scott wondered how a zebrafish suffering from a certain eye disease would experience its immediate environment. While we often address the same question when we measure visual behavior in our OKR movie theater, we use a different angle. Our main interest is to define the exact limits of sensory processing, derived from correlation of the response of the larva to stimulus properties. Scott was interested in how the appearance of the natural environment, be it that of a human or of a fish, shifts because of the relevant eye disease. She asked herself to what degree a sick fish has to forgo the orientation and beauty of its own underwater world. While we as scientists focus on computational analysis of the response to an unnatural stimulus, shifts in the aesthesis of our planet stood as the central problem for the artist. These different points of view are inherited from being situated inside either an artistic or a scientific culture; therefore the exchange has a cross-pollinating effect. This awareness has helped us to reflect on aspects of our science that we have neglected, and artistic interaction may help to establish more fruitful communication with the general public in the future. Although both fields are human-specific enterprises, to see them merging at least at the edges is a truly satisfying experience.

Acknowledgments

We would like to thank all participating lab members (Oliver Biehlmaier, Ursina Gurzeler, Marion Haug, Miriam Henze, Ying-Yu Huang, Tiziana Jametti, Thomas Labhart, Colette Maurer, Kaspar Müller, Sabine Renninger and Markus Tschopp), who not only were an integral part of the whole project but also participated with great enthusiasm at the public events. We further acknowledge financial support for Corinne Hodel from the Neuroscience Center Zurich (ZNZ).

Comment from the Artist, Jill Scott

Since 1975, I have been a media artist, working on our ideological and historical perception of the human body or on the human body's sensory perception of its immediate environment. In the last five years, I have concentrated on neurobiology and cognition because I wanted to follow this particular scientific research in order to gain a deeper understanding of cross-modal perception. This quest has resulted in a set of "Neuromedia" artworks that attempt to augment interactive potentials of the viewer. At first I was resident in the Artificial Intelligence Laboratory at the University of Zurich (2002–2006), where I worked on a wearable computing project based on combined tactile and sound perception for the visually impaired (e-skin). From related workshops with visually impaired users, I became interested in the neurobiology research at the Stephan Neuhauss Group in Neurobiology in the Institute of Zoology University of Zurich. I joined the lab in 2007 as a resident to learn about the retinal and optical functions of the brain in relation to genetic behavior. Through this "learning curve" experience, I have become interested in art's potential as an interpretative catalyst for neuroscientific research, not only because the public needs to understand more about the complexities of human perception but because artists need to design more informed human computer interfaces (HCI). Many artists are interested in this research [2–5], but access to a deeper level of analysis can only warrant more scientifically robust inspiration. Furthermore, the residency in neurobiology was particularly exciting because the scientists actually wanted to work alongside me on the content of the proposed project: *The Electric Retina*. Our shared aspiration became to blend retinal research with interactive media art in order to realize some more artistic metaphorical associations that might help to demystify the complexity of visual perception research for the general public. The object has a responsive tactile surface, evoking connections between tactile and visual perception for the viewer. This interaction with the sculpture was achieved in two ways: first, proximity sensors were embedded into the rims of the ocular cones, which allowed the viewer to shift the animations through the act of "looking closely"; the second interaction occurred on the opposite side of the sculpture, where the viewer could shift an enlarged microscopic lens to trigger new movies. This lens matched the size and scale of the photoreceptors' surface, which stands 210 cm high and gives viewers the impression that they are standing behind the optic nerve looking back out through the photoreceptors to the surrounding environment.

The resultant project not only reflected the researchers' work at the lab but represented my own personal experience of learning about visual perception and the relation between the lab's research and clinical analysis. It was during my research at this lab that I discovered that I suffer from Low Pressure Glaucoma (in my case, a genetic disease of the optic nerve), which is difficult to diagnose because of the dominant behavioral tendency to visually compensate for the deficiency with the healthier eye. Therefore, the project finally included my own visual disease alongside the research in the lab, where the focus is to search for cures for many other human diseases by gaining genetic control of visual system development and function by analysis of zebrafish mutants. My artistic development came directly from the process of the residency as, on the one hand, I was engaged with practical scientific research, and, on the other hand, I discussed the effect of these impairments on vision with a research ophthalmologist.

After Stephan Neuhauss invited me to talk at the Swiss Eye Week Conference (2008), I realized that a media artist's mediation between researchers and eye doctors could have a very important communicative role. Only by being immersed in the lab did I realize that the visual behavior of mutants represents the mutant perspective. I was fascinated by this and tried to translate this to a human perspective. Furthermore, the researchers were friendlier and more open to debate about the public appreciation of science than I thought they would be—particularly Stephan Neuhauss and his Ph.D. researcher Corinne Hodel, who both thought about the impact of the group's research on society and viewed new creative approaches as a gift.

Of course, sometimes I still felt like an outsider. Still, I really enjoyed brainstorming with the researchers about the relevance of research to problems in the developing world or about the ethical analysis of experimentation. Also, as all our other Artists in Labs residents agree, it is indeed impressive to witness the high level of team effort and mutual credit in any science lab. I particularly liked learning how to use their machines and imaging techniques, which I now regard as a set of new media for the media artist in the future. However, by far the most rewarding experience for me was to be included in the scientists' brainstorming sessions, particularly those about how to design experiments for new measurement potentials in their own scientific research. I can imagine that more artists and designers could become serious participants in teams performing scientific experiments at earlier stages of their development. From our experience in the Artist in Labs program, having placed 28 artist residencies in 21 science research centers, there is no doubt that scientists can learn a great deal about communication from artists. In addition to the sharing of ideas in the development of public projects like *The Electric Retina*, this exchange, in my view, is the point where the creative potentials of media art and science may actually meet on a more practical level in the future.

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Unedited references as provided by the authors.

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CALL FOR PAPERS

ArtScience: The Essential Connection

Guest Editor: Robert Root-Bernstein

What is the value of artistic practices, techniques, inventions, aesthetics and knowledge for the working scientist? What is the value of scientific practices, techniques, inventions, aesthetics and knowledge for the artist? When does art become science and science, art? Or are these categories useless at their boundaries and intersections?

Can an individual excel at both science and art, or is even a passing familiarity with one sufficient to influence the other significantly? Do the arts ever contribute significantly to scientific progress? Where will current scientific innovations lead the arts in the next few decades?

Submissions exploring these questions can be from artistic scientists who find their art avocation valuable; from scientist-artist collaborators who can demonstrate a scientific or artistic innovation; from scientifically literate artists who draw problems, materials, techniques or processes from the sciences; or from historians of art or science looking at past examples of such interactions.

Interested authors are invited to send proposals, queries and/or manuscripts to the Leonardo editorial office: Leonardo, 211 Sutter St., Suite 501, San Francisco, CA 94108, U.S.A. E-mail: <isast@leonardo.info>.

ANNOUNCEMENT

ZER01 SYMPOSIUM

GLOBAL WARNING—Artists, Scientists and Environmental Activism

Held in conjunction with the 3rd 01SJ Biennial
September 16–17, San Jose City Hall Council Chambers

The GLOBAL WARNING Symposium is organized by ZER01: The Art and Technology Network, City of San Jose Public Art Program and CADRE Laboratory for New Media at San Jose State University in collaboration with LEONARDO/The International Society for the Arts, Sciences and Technology, and with additional support from the Montalvo Arts Center.

The two-day symposium examines the interconnectedness of ideas and actions and the current relationships between art-making, science and ecology. A group of distinguished artists, scientists and policy-makers will present and examine case studies of collaborative environmental projects. A session highlighting environmental policy and an overview of activist environmental art will provide context for scientist-artist dialogues engaging active audience participation. Three teams selected to develop designs for the Climate Clock—a landmark public art project that incorporates Silicon Valley's measurement, data management and communications technologies to aid the understanding of climate change—will present their work. Public policy, urban planning, sustainable design and civic cultural/economic development strategies serve as platforms for a look at how public art can stimulate community dialogue about these issues of critical importance.

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The 01SJ Biennial is a multidisciplinary, international contemporary art festival that focuses on the intersection between art, technology and digital culture. The 3rd 01SJ Biennial will take place September 16–19, 2010 in venues throughout downtown San Jose, CA.

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The theme of the 3rd 01SJ Biennial, "Build Your Own World," is predicated on the notion that as artists, designers, engineers, architects, corporations and citizens we have the tools to (re)build the world—in both large and small ways. It is about how powerful ideas and innovative individuals from around the world can make a difference and come together to build a unique, citywide platform for creative solutions and public engagement. It is about the inspiration needed to build a world we want to live in and are able to live with.

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