NEW CONTEXTS CONTRIBUTION FROM SCOTT AND BISIG: 09.02.07

Title of paper: 10.02.07

Active Discourses: Inside the Lab Context

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Keywords

Disciplinary hierarchies, know-how transfer, language, methodologies, art and science teams, ethics, value-free science, economics or culture, empirical knowledge, creativity and innovation, gender and representation, progress and information, capitalist ideology, poetic metaphors for society, knowledge, psychology.

Introduction

By now a number of projects between art and science have taken place and it has become apparent that in these contexts no ground rules exist. Our main premise in this paper is that two specific contexts: the scientific lab and the trans-disciplinary research consortium might provide artists with solid raw materials, pertinent debates and unique potentials in order to encourage critical analysis in the public realm and perhaps even affect social change. Two explicit examples will be used to illustrate this premise: the artists-in-lab project, an educational venture, which places artists in science labs to learn about science and bring their consequent interpretations out into the public and the e-skin consortium: a art/science team involving neuroscientists, artists and artificial intelligence experts. In direct relation to these projects, the authoress, (artist/organizer) and the author (a senior scientific researcher) have collected their experiences and identified nine pertinent questions, which might serve as guidelines for others who are also interested to pursue art and science collaborations. A) For the purposes of background information, we will briefly compare the aims, time frames and potential results of these projects. B) This paper will elaborate on some issues from the questions we have identified with relevant discussions and debates. The hope is that these resultant discussions may also help to develop strategies for the future, because they not only trace some fundamental problems in the collaborative practice of artists and scientists, but they attempt to outline a process for the encouragement of more fruitful art and science collaboration.

A: Our two art and science contexts

The ideology behind our first context, the artists-in-labs program[1] is based on the provision of many different immersive experiences inside various cultures of scientific research. This requires the artists to have actual "hands on" access inside the lab itself, as well as attend relevant lectures and conferences concerning topics in physics, engineering, computer sciences as well as life sciences. Artists are inspired to develop their content and their interpretations accordingly and to reflect upon the impact of technical and social issues of scientific inquiry on the public. However, the project also helped scientists to learn about current methodological, aesthetic and communication developments in the arts and to gain some insight into the world of contemporary art and new media. The overall aim of this context provision is to encourage further collaboration between both parties including an extension of discourse and an exchange of research practices and methodologies.

The second context is the e-skin consortium[2], which is based on a single thematic base: the electronic mimicry and audification of the sensory modalities of human skin for the visually impaired. Besides the authors of this paper, the main partners are the Artificial Intelligence Lab of the University of Zurich, the Institute of Neuroscience and the Wearable Computer Lab both at the Swiss Federal Institute of Technology and the Academy of Art and Design in Switzerland. In this context, the artistic inquiry is based on the fact that today our cultural events are dominated by visual information and hardly rely on the combined senses of touch and sound. Very few theatre, dance or art events exist in which visually impaired people can participate. On the engineering side, the focus is on the construction of ergonomic Human Computer Interfaces (HCI) that provide audio-tactile feedback and allow interaction with external audio-visual devices. The scientists are interested in audio tactile cognitive mapping in relation to navigation and interaction. They will explore how these electronic devices can augment cross-modal potentials of human sensory perception.

The overall aim of the contextual consortium is to implement our discoveries in "artificial" systems that should interact intelligently with people on "real" mediated platforms.

The most apparent differences between these two contexts are the time, funding and sharing of workloads. For example in the contextual experience of the artists-in-labs

[1] http://www.artistsinlabs.ch
[2] http://www.eskin.ch

project, nine months is now seen as the minimum duration for artists to learn some essentials about scientific research and to build interpretative prototypes. Funding support, which is provided by the Swiss Ministry of Culture, includes the artist's salary and covers workload and material costs for the science labs. In the example of the e-skin consortium, even after three years, the consortium is still changing and currently expanding into an international European Union collaboration. For the purposes of this paper, which focuses on contextual provision of pertinent social impact debates and the critical analysis of the relationships between disciplines and the public realm, the results of the artists-in-labs projects were very encouraging. Consortiums like e-skin are different contexts and in many ways constitute rockier roads. Even though the partners in this consortium may share similar goals, a number of factors like funding, success criteria and different levels of expertise and commitment complicate this trans-disciplinary collaboration. More comparisons between these contexts will become clear further on in this paper, when we reference them as evidence of our reactions to the nine questioned we have identified.

B Questions and related discourses

The first set of questions we have asked ourselves, addresses the problems and recommendations of trans-disciplinary practice itself, particularly the issues of education, hierarchies, know-how transfer and related methodologies. The second set is concerned with knowledge in relation to ethics, values, and sense of place. The third category is about creativity in relation to innovation, gender and representation. Finally, we wish to address the impact of art and science on society, including the concepts of understanding, progress, economics and metaphor. Without a doubt, these issues constitute huge subjects, which cannot possibly be explored in a single paper, but as many researchers in the combined fields of art and science would agree, large questions like these are often indicative of very new contextual beginnings.

1. Are disciplinary hierarchies so necessary for art and science researchers?

Naturally, we cannot compare all science disciplines with all art disciplines. Therefore, we decided to not focus on the very commercial aspects of each world, namely the gallery infrastructure where the mediums of painting and photography are sold nor the global companies that participate in science, although some of these aspects will be mentioned.

Rather our emphasis will be placed on some disciplines of scientific research in academic labs and on local media and related conceptual art activities. Special emphasis will include trans-disciplinary issues, which are relevant to society at large.

In Germanic countries, science (Wissenschaft) is often divided between basic science (the search for empirical knowledge) and applied science (the application of research to human needs). Our predominant concern is for contemporary artists who are interested in both of these research directions. We call these artists "art researchers" in this paper. These "art researchers" are interested in discovery, or very systematic methods of critical analysis, or human behaviour or empirical observations or a criticism of science/technology itself or a combination of these issues. Hopefully, this clarification will prevent that some of our statements are considered to be over generalized.

In relation to hierarchies, we have extracted three problems from our efforts to create interdisciplinary collaborations between art and science researchers. The first problem concerns the level of awareness about the values of trans-disciplinary practice between art and science. The second problem deals with the level of respect for one another that is often seriously lacking. The third problem addresses the obvious difficulty of combining technical and educational training in order to form a basis for true trans-disciplinary practice.

1.1 Raising awareness of the need to collaborate

Today, there are many reasons why researchers from the fields of art and science need to exchange knowledge and information among each other. Unfortunately, the generations in academic power, who are now over 50, are often influenced by the predominant cultural division of art and science, and therefore remain captive in career decisions that they once made at the age of 16. Very few of them are open enough to acquire a wider overview about research activities outside their own narrow field or to emphasize communication with the public who largely funds their research. In the arts, collaborations between disciplines are favoured but mostly confined to the areas of film, theatre or opera, where many people must work together. The disciplines of photography, painting, or sculpture often remain bastions of narrow power. Although the field of scientific research has a very evolved legacy of systematic practice, the concept of the "art researcher" is a relatively new scenario. While some disciplines like documentary film, or sculpture with new industrial materials might need an initial level of inquiry and gathering of pertinent data, most practice based art schools have not developed a legacy for society and research. This has some consequences when an art researcher is required to gather empirical evidence or conduct a critical survey, and tries to trace how these results affect society. Therefore, current art research facilitators need to look at scientific research for some guidance in this respect, not to necessarily copy their methodologies but perhaps to generate hybrid approaches, which may be more appropriate for the tasks at hand. At the very least, artists should learn to understand how empirical data is assessed and can contributes to knowledge and the establishment of common ground.

Perhaps art researchers and science researchers already share the fact that their respective discourse is connected to patrons and peers rather than to clients and consumers. One of the most interesting examples about the raising of awareness during the artists-in-labs project concerned assumptions about each other's professional career paths. Scientists assumed that their "publish or perish" lifestyle might not be appealing for art researchers to mimic. These same scientists were very surprised to discover that in order to survive the artists had to 'exhibit and connect to the audience or perish' and that conflicts were often played out in the exhibition space itself.

1.2 Lack of Respect

As Rich Gold, ex-mediator of the artist in residence program at Xerox Park in the USA, once suggested: "Engineering, science, art and design are different, the problem is to create a language to speak to each other with respect".[3] Gold concluded that the problems of collaboration lay not in the fact that these disciplines were different, but that there was a basic lack of respect for each other's accumulated knowledge and the associated means of expressing it. When Max Planck asserted that the scientist must work by using an ¨essentially artistic imagination¨, we think he was referring to the opening up of the scientific research process.[4]

Despite a (somewhat superficial) push for interdisciplinary programs, scientific research is still plagued by a prevalent tendency to ignore knowledge and opinions from outside fields. In science, hierarchies among research disciplines constitute one of the most problematic stumbling blocks for both interdisciplinary education and collaboration. These hierarchies have no real scientific justification and students are often actively prevented from crossing scientific hierarchies, either due to a lack of interdisciplinary curriculum's or by having their credits in other fields rejected. Animosities that stem from this type of education directly affect the practice of research. Art-science collaborations might help to reflect and overcome such hierarchies. In art-science collaborations, some aspects that help to

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[3] Rich Gold's comments can be found in Harrris, G. (1999). Art and Innovation: The Xerox Parc Artists-in-Residence Program Leonardo Books, MIT Press

[4] Plank, M. http://www-groups.dcs.st-and.ac.uk/~history/Mathematicians/Planck.html

maintain such animosities are not relevant such as the struggle for the same money, for visibility and for justification. Perhaps, if collaborations are partially hosted by art schools, unconstrained and informal social environment would be provided within which scientists feel freer to explain and reflect on their research in simpler words, outside the walls of their institutions. For these reasons it might even be easier for art and science researchers to collaborate rather than for one science lab to collaborate with another science lab.

Unfortunately, the mantle of science often seems to confer an unquestioned intellectual and moral superiority upon those who assume it. One of the most outspoken critics of art and science collaboration is Lewis Wolpert. He suggests, art cannot be taken seriously because it is "not constrained by reality", and that to try to bring the arts and sciences together is just "social snobbery as scientists are still envious of the status of the arts and the humanities". [9] We also wonder about the hierarchy that endows some artists with the moral and intellectual hauteur to look down on science as a career for "nerds". It is obvious that the respect between art and science researchers will not improve if collaborators are unprepared to learn about each other's processes and knowledge in their respective environments.

1.3 Educational environments required

For reasons outlined in sections 1.2 and 1.3, we recommend that more art and science initiatives be implemented in educational institutions. Such educational programs require collaborative co-teaching of seminars and workshops on an undergraduate level, co-supervision of (art / science) students' PhD theses, the development of shared tools and participation in research including planning, undertaking and interpretation of experiments. As a reaction to these needs, new departments are launched like those found at the University of Western Australia where Symbiotica conducts Masters Degrees in art and biology or like the Open University in Milton Keyes that offers combined design, engineering and innovation degrees.[5] Team teaching might hold the answer to the provision of pioneering approaches and perspectives which could reflect on the nature of innovation itself. As Erwin Schrödinger once said about innovation and teamwork, "the task is not so much to see what no one has yet seen but to think what nobody has yet thought about that which everybody sees".[6] It is our belief that trans-disciplinary education can definitely help to develop new insights as well as allow artists to contribute to

[5] See SymboticA at http://www.symbiotica.uwa.edu.au/ Art and Science Collaborative Research Laboratory. The Open University: http://design.open.ac.uk/aims/aims.html

[6] Schrödinger, E. http://nobelprize.org/physics/laureates/1933/schrodinger-bio.html

innovation. From our experience in the artists-in-labs project, when the artists met among each other they often compared how theoretical disputes are resolved within their respective scientific fields and how specific research goals are achieved. This allowed them to legitimately contribute to the discussions about scientific experiments in an informed and sensible fashion.

Another type of co-education worth mentioning is the role of thematic expeditions. This is one of the reasons why Dr. Lloyd Anderson, director of science at the National Endowment for Science, Technology and Art (NESTA)[7] in the UK, currently recommends funding for a substantial creation of time and space within which ethical and content based discussions can take place and ideas can flow between art and science researchers. NESTA hopes to promote new and transparent approaches and Anderson likens the creation of these contextual spaces to the creation of 'green corridors' in biology. In biology, these corridors are not isolated biotopes, but holistic fields and communities, which can promote diversity and exchange between species. The e-skin consortium is an attempt to create a similar corridor for the establishment of trans-disciplinary theory and practice based on a single theme: the human skin. On a practical level it concerns itself with the cultural problems of visually impaired people. This requires art researchers to be engaged in psychology (empirical studies) and to learn some basics in engineering.

2. How can we promote know-how transfer between art and science?

Our comments on know-how transfer fall into three categories: the concept of immersive contexts where mimicry encourages transfer, the need to learn terminologies for the art and science research debate and the potentials of know-how transfer in relation to the sharing of prototype development.

2.1 Participation through immersion and mimicry

Immersion is revered in both art and science as one of the most valuable ways to transfer knowledge from educational facilitator to student. According to Sandra Caravita, the lab context in any discipline is so fundamental for learning and for the exchange of information that education is problematic without it.[8] Immersion for artists in the science

[7] NESTA, Science, National Endowment for Science, Technology and Art. http://www.nesta.org.uk

[8] Caravita,S., Hallden O. (1995). Reframing the Problem of Conceptual Change, Learning and Instruction, 4. p.89; Caravita, S.(1995). Costruzione collaborativa di prodotti e tecnologie della comunicazione, TD7. p.6.

laboratory is an excellent starting point for new educational approaches to trans-disciplinary practice. Caravita also suggests that a scientist must actively build knowledge through the personal interpretation of her/his experience, but must share this experience not only with peers but also with 'outsiders'. We suggest that the artist can become this very valuable 'outsider'.

In their reports, many of the lab directors said that the artists were important objective and social catalysts for the scientists because they enjoyed hearing about their work. If the artist is lucky enough to accompany a scientific researcher on a specific experiment, then perhaps the operative involvement, the exploring of ideas and reality, and the placing of hypotheses into practice could be even affected by the artist's feedback. An essential part of this immersion is mimicry, a process that provides an essential insight into the life and mind of scientific inquiry. According to the English psychologist Susan Blackmore, mimetic actions are causal and often unintentionally adopted.[9] Generally, from our experience with the life sciences, the most beneficial way to start working with scientists is to assist them to collect the empirical evidence they need for their research. For example, in the artists-in-labs project at the Centre for Microscopy, artists were given a 'hands-on' education on tools like the Scanning Electron Microscope. The mastering of skills like these requires a very exact level of mimicry as part of the learning process. For example, in the context of the e-skin consortium, the phenomenon of mimicry plays an essential role in education (the acquiring of competencies to create embroidered circuitry) and also it uses the mimicry of biological phenomena to create the inspiration for further technological development. This is because the actual e-skin prototypes attempt to electronically mimic the perceptive modalities of the human skin (pressure, temperature, vibration and proprioception) which are constantly detecting and reacting to environmental realities.

2.2 Learning Terminologies for the Debate

While popular science journalism can serve as an initial access for art researchers to grasp scientific concepts, the reading of science textbooks and glossaries or the attending of lectures seems to be necessary for a higher level of communication between the art and science researchers. The importance of learning terminologies in order to facilitate know-how transfer became very obvious throughout the artists-in-labs project. At the Artificial Intelligence Lab, some communication problems occurred because the artist did not share the same definitions as the scientists. When art researchers learnt the actual scientific meanings of terms by attending related lectures, research presentations and

[9] Blackmore, S. (2000). The Meme Machine. Oxford University Press. p.52.

internal debates, they developed much more appropriate metaphors, which embedded the lab's robots and scientific research with a deeper meaning. One example of a confusing set of definitions concerns the word "embodiment". In philosophy, embodiment is a holistic term implying that the mind and spirit are equally integral parts for the working of a biological system and there is no separation of body and mind (anti-Descartes). In artificial intelligence, embodiment implies that an agent can only behave according to the interaction of its body with its environment. Behaviour is therefore the result of an interaction between a agent's body, it's mental capabilities, and its direct environment and never stems from purely cognitive capabilities. In the art world these definitions are hardly debated and most artists think that the word "embodied" simply means " technology which is incorporated into the human form"

In most cases, after several months of the artists-in-labs project, the artists' vocabulary had changed and grown considerably towards the scientific definitions, but more preparation would have certainly helped. Consequently, the most recent incarnation of the artists-in-labs project has extended the duration of the artists' residencies from five to nine months duration. The acquisition of new insights and terminologies was not restricted to the artists. The scientists have also learnt about contemporary art thanks to the presentations of the artist about their own art world contexts.

The e-skin consortium, which tries to combine cultural production, engineering and scientific research from different fields and with regard to shifting goals, suffered from far more difficulties with regard to terminology and respect than the artists-in-labs project. Some of difficulties involved in the definition of the actual goals of the project stemmed from the fact that potential partners were not used to the existence of different terminologies. This experience illustrates that collaborators need to appreciate the existence of entirely different backgrounds and semantics between art and science researchers. Scientists are well trained in being very explicit in their usage of terminologies but occasionally tend to accuse "outsiders" of ignorance whenever their usage of terminology differs. At the same time, scientists often have considerable difficulties in explaining terminologies to professionals from entirely different science disciplines. Terminologies may even refer to other terminologies within the same discipline, which further complicates their translation. This major problem in know-how transfer is reflected by the fact that a large number of books about both popular science and specialist science exist on the market, but there are hardly any books in between. Rolf Pfeifer's latest book

"How the Body Shapes the Way We Think"[10] is a notable exception in that it abstracts away technical implementation details but stays accurate about inherent conceptual ideas. Naturally, this is partially due to the subject, artificial intelligence has a bigger mass appeal than quantum physics. We think that more writers need to cover a middle ground that might appeal to both specialists and the general public. As we have suggested, the proper use of terminology is one of the main mechanisms for building respect for each other's competencies and promotes communication abilities on a team level. These abilities are of particular importance if the team partners need to build prototypes together.

2.3 Sharing prototypes or trans-disciplinary tool development

We have identified that the development of prototypes in teams and the sharing of tools is also an important step in encouraging know-how transfer between art and science researchers. Trans-disciplinary teams have to be carefully created and the selection of partners may not only be based on their individual skills and attitudes. The selection also needs to take the possibility into account that the partners' roles might shift during the collaboration. For example, the artist might become accepted as an integral part of the development team; or the artist might want to wait for the resulting products to emerge from the lab in order to use them for her/his final artwork. While the first case seems rare, the second one can be a very problematic alternative. Artists in the artists-in-labs project who expected the scientists to work for them were quickly disappointed. Often, when art-science research teams are working together, they differ in their ideas about the production process: art researchers have relatively short but iterative cycles of planning, building and observation. Scientists and engineers often need more time to realize the variety of potentials inherent in their research prototypes.

In science, the construction of prototypes and miniatures may serve to represent and communicate scientific concepts without focusing on the finer technical details. Artists on the other hand are very versed in finding the essential worth by building models, which can function as powerful tools for communication and representation. For example in the e-skin consortium, the media artists and scientists agreed that an artificial skin would be a model or miniature of real skin if it possessed a deformable surface and and embedded temperature, pressure and vibration sensors. Consequently the first e-skin prototypes consisted solely of surface texture samples and some working sensors.

[10] Pfeifer. R. (2007). How the Body Shapes the Way We Think. MIT-Press.

Perhaps the collaborative development of tools and kits could constitute a more suitable approach in the promotion of know-how transfer between art and science. Such kits can become an experimentation platform for people from very diverse backgrounds. Within the last forty years, art science teams have produced thousands of innovative audio and visual tools. For example, artists in research teams helped to develop many visualization tools such as Softimage[11] or on-line compositing platforms. Another popular example are robotic kits such as Lego Mindstorm[12] that are used not only by the initial primary target audience (kids) but also by scientists and artists in their own projects. Such kits can serve as implicit tools of know-how transfer by forming a common practical framework based on which conceptual and abstract ideas are turned into physical examples. The results obtained by employing these tools very much depend on the background and intentions of the user. For example, media and communication tools are increasingly shared by scientists and artists for illustration and as public demonstration platforms, but the results are often quite different. This aspect of sharing tools with different outcomes and intentions is an interesting issue to discuss further. What happens to the know-how transfer when a simulation tool envisioned by an artist, has turned out to be a test platform for scientists to use? Or visa versa? Regardless the differences between the actual methods and methodologies of production must also become a discussion point.

3. Can methods or methodologies be shared?

As science critic Sandra Harding has defined, the word 'method' refers to a pre-determined technique for the gathering of evidence, but the term 'methodology' describes a theory and evaluation of choices about how research does or should proceed. Currently, these two categories cause debates among art and science researchers. They suggest that sharing methods might be easier than swapping methodologies and that learning in consortium teams leads to new discussions about these issues.

3.1 The sharing of methods

Although contemporary media artists may personally develop methods for the gathering of evidence, there are no pre-determined techniques for this procedure. Consequently, a traditional painter or sculptor might move through a computer science lab and gather evidence in an accumulative and rather unsystematic way. A media artist on the other

[11] http://www.softimage.com/
[12] http://mindstorms.lego.com/Overview/

hand might get involved in internet blogging and open source activities in order to converge their methods with those of the computer programmers. Artists who possess experience in working along side engineers and scientists usually adapt and systematize methods of collecting and analyzing information. In the artists-in-labs project, the programmers at the Artificial Intelligence Lab and the artists even agreed to rely on the same tools (wiki, versioning system, web site) and procedures to manage discussions and combine contributions to the simulation software development.

3.2 Swapping methodologies

The development and exchange of methodologies within and among disciplines is a very fundamental and interesting process, which heavily relies on trans-disciplinary discussions. Within the scientific community, there is an ongoing controversy about methodologies that has been sparked by findings about complex and chaotic systems and phenomena like self-organization. This debate focuses on the appropriateness and limitations of traditional analytical approaches in the empirical sciences compared to the incorporation of synthetic and holistic methodologies. This same debate has spread to the psychological and sociological realm. These controversies emphasize the fact that certain phenomena cannot be addressed by a reductionist approach but rather emerge through the interaction of all associated parts; also the observer's presence might actually affect the results of the experiment due to his or her subjective analysis. In fact entirely different organizational levels such as those found in biochemistry, cellular system, animals and societies, may emerge through similar principles from lower levels.

Artists are also questioning the use of methodologies, because these are often affected by what they are trying to build or who will experience it. Traditionally the artist's methodologies fall into the three categories of (1) assemblage, (2) elimination and (3) conceptualization. In contrast, the process or steps by which scientific discovery takes place are far more data driven and the innovative goals are often set in place from the start. Therefore, scientists often think that art methodologies are risky or a waste of time! If more holistic approaches are now emerging in both fields, then perhaps new levels of sharing methodologies between art and science researchers may evolve.

The cinematographic approach to documenting and re-interpreting information played a prominent role in the artists-in-labs project. For example, the artists in the Artificial Intelligence Lab have influenced the researchers' own documentation strategies. Many scientists now routinely film their robots at different development stages and create audiovisual documentations of experiments. These new documentation strategies are not only valuable for the scientists own research but constitute material suitable for trans-disciplinary communication. While artificial intelligence has grown to involve the methodology of accumulation, analysis and fabrication, new disciplines such as systems biology focus entirely on the search for holistic correlations instead of more traditional methodologies such as reduction, information gathering, incision, division, classification, codification and tagging. Meanwhile, art research heralds a conceptual approach, one, which reflects upon the process of imagining and ideas, postulation and supposition, impression and concoction while the process is taking place. Both science and art researchers nowadays posses a similar responsibility to reflect on and continuously question their methodologies. Both may require obsessive fascination, hard work and communication with their respective peer groups, but they are also both engaged in a healthy reassessment of not only their own methodologies but also other disciplines as well.

3.3 Learning methodologies inside consortium teams

These reassessments of processes become more apparent when art and science researchers work together in a consortium like e-skin. Combinations of cross-modal interaction, communication and comprehension in relation to tactility and sound are explored over time through consortium work. Here, research methodology combines basic and applied research, with constant user testing in workshops as a basis and inspiration for further developments. Together, art and science researchers use these workshops as test beds to find out how to increase the workshop participants' awareness of space, of each other and of their surroundings.

Throughout this research, the artists had to learn that user-oriented workshops should be incorporated as part of the methodological process and that assessments of them was a challenging enterprise even for science. In these workshops, sets of tasks were assigned to blind participants that focused on touch, tactile substitution as well as sound and movement/navigation. Not only needed the actual status and age of participants be taken into consideration, but also how the various impairments of the participants affected the results. With this in mind, user tests involving electro-touch sensitivity, pattern recognition, tactile substitution, improvisation and gesture-based communication, sound discrimination and navigation skills had to be newly designed and conducted. With the help of psychologists, results from the tests were then scientifically analyzed in order to assess the benefits. This methodology requires that both art and science researchers define clear goals and objectives such as: develop ergonomic technical solutions like flexible artificial skin materials in order to enhance the cross-modal experience of sound and tactility, increase communication with the mediated stage and its audiences and evaluate, adapt and improve navigation and orientation aids that are currently on the market. We claim that experiences like these are not only new for the artist but that they also may be interesting for any analysis of user interaction in media art projects.

4. What do the terms "radical" and "ethical" mean in art compared to science? Is there a concept of value-free Science?

The above questioning of methodologies in relation to the collection and analysis of data also has ethical connotations. On one level this discourse involves the ethics of practice and the relation to what is valued in science or art. On another level personal opinions and pressures from society influence any type of ethical reactions.

Traditionally, scientists' and artists' role models and public expectations of these roles have differed: artists were expected to be ethical and question common opinions and scientists were not supposed to have any opinions at all but rather deal with the evidence alone. Today, a sure way of ruining your scientific reputation is to ignore evidence because of a personal opinion. As soon as a scientist becomes an activist (even if his activism is purely based on evidence) he immediately raises suspicion among her/his peers. Also scientists often reject being grouped together under headings like global warming or genetic modified organisms issues. However, sometimes an over-whelming agreement about empirical data can verify a hypothesis and then scientific reason does favour a particular public opinion. This suspicion mechanism in science is very problematic and often prevents scientists from choosing an active role concerning issues of public interest.

In both the fields of science and those of art, practitioners are expected to know about and express respect towards something called "the state of art". For example, in the e-skin consortium, art researchers soon learnt that science possesses a code of ethical conduct that requires that a certain amount of credit must be given to other researchers in similar fields. In other words, important developments should always be referenced and credited accordingly. In this case, it is new for art researchers to learn this form of ethical analysis rather than to rely on a historical legacy handed to them from art critics. Science mostly requires honest reporting of results, meticulous control and repetition of observations, as well as the formulation and avocation of ideas, but it also requires each scientist to leave a legacy for others to follow. This shared ethic demands respect for each other and values peer assessment. The role of the artist researcher, as we have experienced in the artists-in-labs project, is to keep a diverse array of possible solutions alive, based on the current concepts, theories, principles and methods that are ethically debated among the various scientific peers and lab contexts.

As Elvin Fox Keller[13] suggests, the conventional accounts that scientists offer about their successes to each other are not value-free. In fact the very language, tacit presuppositions, expectations, and assumptions shared by natural scientific researchers are very value-laden". The scientist's quest for knowledge in itself reflects the existence of a value system. Furthermore, science exists and finances itself within a political and economic climate that is full of values. It cannot exist outside political priorities and capitalist interests. Therefore, questions like “should I collaborate with the military” are relatively free of peer pressure and depend on personal value systems. Here the art researchers environment is similar but they are even more interested in how to exemplify these very complex questions about the value of research in relation to personal ethics.

On the web-site for the Earth Charter[14], one can find a famous quote by Aldo Leopold from 1949: "All ethics rest upon a single premise: that the individual is a member of a community of interdependent parts.". By this he means that each individual voice counts as part of a potential strategy to present a more holistic viewpoint to the general public. In this category the most important discussion centres on bio-ethics and we feel this to be the most tacit example of a discourse, which needs further discussion. Even today, both the majority of the public and the majority of artists are uninformed about the topic. In our experience, the sharing of bio-ethics debates with scientists tends to help art researchers to produce more scientifically robust knowledge for the general public. This pathway does not solicit illustration; rather it encourages informed reactions based on fairly deep understandings about the scientific debate at hand. This debate not only extends the discussion about holism but it could shift the future reception of environmental and biotechnological research. While some debates have been organized by Science Cafés in Scandinavia, Paris and the USA[15] and also by the Welcome Trust in London[16], whose main focus is medicine and art, the public needs to be engaged in the controversies that

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[13] Fox Keller,E. (2000). The Century of the Gene, Harvard University Press.

[14] http://www.earthcharter.org

[15] Science Cafés or Cafe Scientifique. http://www.cafescientifique.org

[16] Welcome Trust. http://psci-com.ac.uk:80/events/public.html

can help scientists to become more accountable for their own research initiatives. We would suggest that more artists attend these events, instead of confining themselves to their own mono-disciplinary discussions. This factor would assure art researchers a larger role to play and perhaps even claim an unique voice for them. In this light we would consider art researchers as main players to transfer scientific research, which is ethically suspect to the public.

Firstly, artists pride themselves of their own freedom of speech and they are not frightened to say what they think. Secondly, they are concerned with artistry. The artistry in art comes not only from deciding what to say but also how to say it. Artists are often searching for that 'one' image, which might have the power to make an ethical comment really clear. These skills of finding unique visual metaphors for the public are learnt by trial and error with feedback from art educators and audiences. Thirdly, the corridors of communication from science to the public about ethics are shaky. In many science disciplines it often stifled by conformity or middle of the road pressure from science peers. One can find “critical” resistance from within science labs, but the pressure to conform to the stoic methodologies of science often requires the scientists to dampen their radicalism. In the Life Sciences, researchers should always be seen as standing in the middle of an informed ethical debate. Fourthly, some artists discovered that some scientists in the artists-in-labs project, thought that objective discovery in relation to peer pressure was a more important factor to take into account, rather than ethics. These four points are important factors to consider in relation to the public understanding of science.

For eco-activist artists, the quests for sustainable systems are issues that they share with many biologists. Some of these artists may assist local communities in a move towards sustainable developments, while others look for ways to raise public awareness and help manage local resources. If there were more practical and provoking contributions to the ethical debate by artists (particularly without the interference of religious morals), then some new strategies might be found.

5. Can consideration of place, community or culture affect scientific search for empirical knowledge?

In relation to this question, there are many facets and we can only hope to open up some parts of the discourse about situated knowledge. Also, place, culture and the situated aspects of knowledge cannot be discussed without the consideration of economics, an area that we will not address very deeply here. Knowledge is considered to be "situated" by art researchers, when the process of discovery takes into consideration the surrounding cultural and contextual fields as well as the direct access to the local community or public. Today, in most science institutions, the specialist's concept of know-how transfer is becoming more controversial, as scientists realize that researchers need leaders who have more of an overview of the public understanding of science. Most scientists define scientific investigation as a set of methodologies for evaluating empirical knowledge. However empirical knowledge can also be embedded in language, culture or traditions. This approach requires that the development of models to explain what is observed might also be influenced by other research factors, which are dependent on place or economics or culture. Usually art does not evaluate empirical knowledge but it does rely very much on 'situated knowledge', because it is a reflection, interpretation and appreciation of a local cultural community. The art market relies heavily on the fact that certain artists are related to or representative of a communal part of society. For example artists from the Black community or the Jewish community are often shown together or perhaps representatives of a national sensibility are featured. These preferences might be combined with the beauty of the object and its meaning. Alongside with expert marketing from certain galleries, the resultant work can provide a suitable substitute for other investments by the rich and allows them to appear more sophisticated. The art researcher is more concerned with actual developments of local sensibilities or the effects of cultural hybridity on conceptual evolution.

Science researchers seem to be mostly concerned with the exchange of empirical evidence among themselves. Therefore, science labs tend to function as a network of islands that are isolated from the actual societies in which they are located. This is due to the fact that the economies of science are based on international competition and knowledge is situated across an international zone where research is verified before it reaches the public. Scientific knowledge prizes itself in being seen as non-situated and universal. An experiment must show the same results regardless of the experimenter's cultural situation. Aspects that are important in the arts such as race, ethnicity or hybridity and life style are often only important to clinical researchers. The social sciences are considered to be closer to the arts, because these sciences attempt to make their "situatedness" and their "objectivity" fundamentally compatible. However, if we look at the motivation of a scientist, the availability of material and money to conduct research and the possibility of publication then scientific research is highly situated. Every scientist's motivation is grounded in her/his biography and therefore ultimately in her/his society and history of education. In fact, the local social status of a research lab may also affect a scientist's preferences in her/his research, For example Zurich is well known for neuroscience, and people may be more attracted to this field because they live in Zurich. It seems that any valuable exchange of knowledge between art and science researchers can only succeed if both groups take each other's situatedness into account. Being aware about the local background of others can easily shift one's potentials and alternatives.

6 Do art and science share similar attitudes towards creativity and innovation? Do differences in these definitions have any impact on gender and representation?

6.1 Creativity

In Science the term "creativity" seems to have many definitions. These range from thinking about creativity as a cognitive process, which requires careful study in neuroscience, to an actual "state of mind" in clinical psychology, to simply the capability to come up with an approach which is new and useful for the research at hand in computer science. We cannot think of many university science courses with similar levels of creative thinking and communication skills than one can find in art and design schools. Art training begins with a combination of abstract or controversial thematic topics and basic skill assignments in an attempt to inspire creative thinking. Many scientists and engineers question whether a similar level of creative training should enter into the process of applied scientific research. They often suggest that artists should wait until the research results can be published and/or applied before any design is commissioned to them. For example, the engineers in our program told us that designers mostly enter the picture after the production is completed and ready for the public. However, there is a growing variety of responses about this question, depending on the individual project and the type of scientific research involved.

Often well-established science fields tend to encourage a form of creativity, which is linked to innovation. This constitutes a gradual and quantifiable improvement of existing technology/knowledge instigating an evolutionary process rather than a revolutionary one. This attitude severely limits the diversity of personal interests and ideas in favour of a profound training embedding inside a well-known approach. The most intense debates about creativity and innovation in science are in relation to the public. Can creativity and innovation be protected or not? Do creativity and innovation benefit from protection or sharing? While the concept of science is very much based on the idea of free and unlimited information and knowledge exchange or relational creativity, but whenever commercial interests are involved, things drastically change. Unfortunately, this original and democratic view of relational creativity is often endangered by recent trends in encouraging the foundation of spin-off companies by scientists. Thus attitudes towards an open or closed version of creativity differ between publicly and privately funded scientific researchers. While scientists that partake in publicly funded research programs are usually very positive about making their innovations available to the public, innovations generated from privately funded organizations is usually protected with limited publication rights, but promoted with much higher levels of publicity. Therefore, local communities often receive a distorted view about innovation and creativity in various research programs.

6.2 Innovative approaches by art and science researchers

Innovative approaches may vary, but local, social, cultural and environmental factors as well as information and development in relation to users do play important roles. Applied sciences like engineering and industrial or product design focuses on product-oriented efficiencies. We are more concerned with the attitudes of basic science researchers or those of media artists in this paper, here innovation is tightly associated with user interaction. Many media artists are inventing experimental forms of interaction that go beyond linear user engagements. Users serve as test beds for interface developments along the way. Some companies, foundations and funding boards find this working approach problematic. They require proposals for innovative products or applications to be completely worked out in advance despite the fact that many innovative projects and applications have been the unpredictable result of highly experimental collaborations. In the e-skin consortium, there was some confusion about innovation in relation to process and outcome. The art researcher's attitude was to invent a novel type of interface that combines prototypical sensors, actuators and software. This would be a truly experimental device consisting of several untested components. The engineer's attitude toward innovation was to develop and thoroughly test each component individually and serially before combining them into an interface. The scientist's attitude was to devise a set of important research questions beforehand and subsequently design experimental interfaces to address these questions. In the artists-in-labs project, the science labs that focused on computing, engineering and artificial intelligence tended to define innovation as the successful implementation of creative ideas within a productive framework, but actually there were many differences in concrete approach. At CSEM, innovation focused on how micro and nano technologies could be made into products for markets like telecommunications, mechatronics, medical and healthcare. In the Artificial Intelligence Lab innovation was about how new ideas about embodiment and intelligent behaviour could be applied to the realization of robotic agents and materials. In the GlobIS Group, innovation involved the development of new tools and platforms for collaborative information environments. In the Planetarium, innovation was about the educational approaches toward physics and astronomy and how these interpretations translate into computer animation. However, while the impact of most of these attitudes on society is hardly an issue in any of these science labs, the media art researcher is very focused on such public impacts on both a theoretical and practical level.

6.3 Women and creativity in science and art

We assume that some of the above limitations and attitudes in science could render these disciplines very unattractive for many people and women in particular. Certainly, new creative approaches are sorely needed to entice women to become more interested in these particular areas of science. Last year, our artists-in-labs project team conducted a gender survey with Arts Catalyst[17] in London and The Art and Genomics Centre in Amsterdam[18]. Differing attitudes towards creativity seem to be the cause of an enormous gender imbalance in many Northern European countries especially in computer and engineering departments. As statistics prove, women are under represented not only in engineering but also generally in most fields of science[19]. In relation to the science and gender discourse, the science writers in the US are leaders in this field. For example, in Evelyn Fox Keller's book 'The Century of the Gene'[20], she proclaimed that the few women who are engaged in genetic research always provide a much "more creative social approach". [14] The science question in feminism has also been raised very thoroughly by Sandra Harding[21]. Harding clearly states: "Perhaps we should turn to our novelists and our artists for a better grasp of what we need, because they are professionally less conditioned than we (scientists) to respond point by point to a culture's defences of ways of being in the world.". Donna J. Haraway[22] claims that artists who acquire solid information about science bring very sensitive issues to the public for scrutiny. Currently

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17 Arts Catalyst, London. http://www.artscatalyst.org/index.html

18 The Art and Genomics Centre, Amsterdam. http://www.artsgenomics.org

19 For an extensive survey about the stastics of representation see the EU report by The Helsinki Group on Women and Science. http://www.cordis.lu/improving/women/helsinki.htm

20 ibid:keller(2000)

21 Harding, S. (1986). The Science question in Feminism. Ithaca, New York: Cornell University Press.

22 Haraway, D. J. (1996). Modest_Witness@Second_Millennium.FemaleMan(c)_Meets_OncomouseTM. New York: Routledge

we are in the process of forming “ARTSACTIVE”, a worldwide Art and Science Network[23], which will explore solutions to the issue of shared creativity by training more artists in science. Perhaps, we can also harness the potentials of trans-disciplinary practice to involve women in a more creative approach to science. If for example, mature women artists were trained in scientific fields, could they produce mediated art and design works that emphasise the creative potentials of scientific inquiry? These works could also be distributed to secondary schools, where alternative role models are sorely lacking. Women, who abound in the arts, may bring an interesting controversy with them, one that cognitive scientists are already questioning: Is creativity only relational or does it grow with trans-disciplinary influence? Women seem to prefer the psychological definition of creativity, which suggests that this process is a state of mind[24]. Once Jacob Bronowski[25] suggested that the act of discovery in both art and science were similar. The "discoveries of science, the works of art, are explorations - more, are explosions of a hidden likeness. The discoverer or the artist presents in them two aspects of nature and fuses them into one. This is the act of creation, in which an original act is born, and it is the same act in original science and original art". Both similar and different attitudes towards the concepts of creativity and discovery need further discussion.

7. How do artists relate to terms like " technical progress" and "information society"? Does capitalist ideology help science and their related businesses or does it hinder production or deter progress generally?

Our approach to this rather difficult question is mostly personal, based mainly on our particular political stands in relation to our experience with the aforementioned two art and science contexts. As we cannot attempt to cover such a variety of attitudes on a global level, we will simply attempt to open up the discourse.

"Progress" has always been a very controversial word for both art and science researchers. Currently, art researchers are very interested in exploring the relationship between politics and science, and their educational establishments to a large degree condone this. Alternatively, the attitudes of scientific researchers towards "progress" are

[23] The first meting of this network organization entitled ARTSACTIVE took place in Jan 2006 in Cassis, France.
[24] For example, David Bohm thinks that creativity is a state of mind: Bohm, D. (1987). Science, Order and Creativity, New York.
[25] Bronowski, J. (1965).Science and Human Values. Harper and Row, New York, 1958. http://www.drbronowski.com

personally contained, whereas official science institutions often refrain from revealing their real opinions, particularly because they might damage their political or commercial status. "Technological progress" is even a more problematic term because often this subject is discussed without the sensitivities of political, cultural or even economic criteria. While quantitative improvements like performance, energy consumption and bandwidth may be important for engineers, the impact of these improvements on society including issues such as accessibility, privacy, and interdependence is often not considered to be part of the research scope. This separation of technical cause and social effect is very convenient for the promotion of capitalist ideology because it allows engineers to conveniently hide their political or social agendas. As we know from the artists-in-labs project experience, art researchers and science researchers often privately shared sceptical opinions about capitalism, because their research tends to promote diversity whereas capitalist interests tend to promote concentration and reduction. For example in case of the e-skin consortium, most commercial enterprises consider interfaces for the visually impaired in cultural environments to be uninteresting investments, due to the small market size, while the researchers themselves find the subject fascinating. The list of incompatibilities between research and capitalist interests continues: scientific goals are long term and capitalist goals are short term; science and art favour unpredictability, capitalism favours predictability; science is based on both positive and negative results but capitalism dislikes negative results. These topics highlight the problematic aspects of developing a scientific inquiry or an artwork that is entirely dependent upon commercial funding. Capitalism promises to contribute to technological progress if at least three of the following conditions are met: the existence of competition, unmet large-scale demand and critical consumer reactions. It should be clear from these criteria, that art and science research activities would benefit from more alternative approaches, not only with regard to "technological progress" but also to "information".

As Richard Lowenberg suggests, we need to discuss more about the fact that our current society is "answer-rich but question-poor, where people place importance on a premium on facts and can get access to them fast and furiously"[26]. He also states that if the flow of information can determine the course of social evolution then information should be used to collaborate on more environmentally, economically, politically and culturally sustaining directions. In agreement, we suggest that there is a need for more public debates about information and the concepts of progress. If access to information is seen as 'progress',

[26] Lowenberg, R. Executive Director of the Davis Community Network in the US. http://www.dcn.org/dcn/exdir/ and also: Davis Community Network.rl@dcn.org

then surely the local environmental infrastructure should also benefit and some consequent improvements would be evident. Indeed, it seems that in cities like Bangalore, the capitalist policies behind science and business sometimes can really deter progress.

8. If artists share more poetic metaphors with scientists, will the results be more suitable for televisual literate societies?

This section presents some comparisons that reflect upon how different approaches to communication help or hinder the understanding of research. From our experience one of the main differences between art and science researchers is in their use of metaphors. This concerns the value of visual poetic metaphors compared to a more literal use of metaphors. Often scientific researchers have not had any formal training in the development of visual metaphors, and educators in these fields tend to use language metaphors because they feel that they minimize ambiguity and seem to be understood by most people. However, language in itself can be very ambiguous and full of clichés and triviality. As Swiss psychologist Burton Melnick[27] recently wrote about gender sensitive metaphors, one of the most problematic categories of science is the dividing concept of the sciences into either 'hard' or 'soft'. These label physics, computer science and mathematics as 'hard' sciences, and psychology, sociology and the arts as 'soft' or human sciences. This metaphor is partially responsible for the fact that many scientists consider the humanities to be full of soft, wobbly or airy attitudes. In the artists-in-labs project some scientists seemed to be surprised and often commented that the artists had amazing organisational skills combined with reliability and precision. Melnick concludes that it is extremely difficult to dissolve these stereotypes but it is brave to try. Old metaphors can cause conservative judgements and really affect the levels of respect. This is an issue that needs to be taken into account in relation to the future of art science collaboration.

Today, many scientists are very ambiguous about the value of metaphors. This problem has not only plagued the public understanding of science but many scientists themselves. A literal interpretation of a metaphor can lead to a wrong understanding of the subject at hand. Some examples include; a visual metaphor of an atom as a solar system consisting of a sun (the nucleus) and it's planets (the electrons) or how biological evolution corresponds to the metaphor of climbing a mountain in a three dimensional fitness

[27] Melnick, B. Cold Hard World \ Warm Soft Mommy: Gender and Metaphors of Hardness, Softness, Coldness, and Warmth. http://www.clas.ufl.edu/ipsa/journal/1999_melnick01.shtml

landscape[28,29]. This lack of training and consequent miss-representation in visual metaphors seems ridiculous when some of the most complex and beautiful metaphors can be found in science. We propose that art researchers, particularly media artists who possess formal training in designing poetic metaphors and communication with the general public, could have a very valuable role in contributing to the development of more exciting and also more appropriate scientific metaphors. Instead of using metaphors based on generalizations and language, the contemporary poetic metaphor is more based on thought or on conceptual associations. As Lakoff suggests[30], artists and writers learn that there are many conceptual types of visual poetic metaphors. There are structural metaphors related to the concept of dimension, whose dimensional associations may change with differing cultures Another type of metaphor is about orientation and occurs when structures are experienced in terms of spatial orientation. A third might be ontological metaphors, which occur when our experiences are related to abstract phenomena or in terms of concrete textures, forces or objects. It would be interesting to see what would happen if scientists were to start to explore more poetic metaphors. We believe that such metaphors might excel over more traditional metaphors with regard to comprehension in a modern society.

For example, in relation to metaphors, understanding the terminology in physics is very important. When PSI scientists explained how their cosmic-ray detector could detect and measure muon particles[31], they used the metaphor of a dinner plate to describe how approximately sixty muons cover its surface every second. Eating is an every day activity and in this case one can imagine that muons are constantly landing on one's food. The artist in residence took the same phenomena and applied it to a sound composition, where the particles trigger sound samples from a sound library with various pre-recorded samples from the PSI environment. It is our experience that the location of appropriate visual and poetic metaphors may help the scientists relate their own research to other researchers work. In another example, the artist at the Artificial Intelligence Lab used a metaphor for the researchers as isolated Galapagos Islands, and this made the scientists ponder deeply about the degree of collaboration and sharing of ideas between them.

Language may have augmentative value but now we live in an audio-visual culture. Film, sound and media can often offer potentials for the many angles of a scientific debate to

[28] http://www.findarticles.com/p/articles/mi_m2843/is_5_29/ai_n15734306

[29] http://www.morphostasis.org.uk/metaphors.htm. See also Theodore Brown: Making Truth, Metaphor in Science. University of Illinois Press. 2003

[30] Lakoff, G. (1993). The Contemporary Theory of Metaphor. http://www.ac.wwu.edu/%7Emarket/semiotic/lkof_met.html

[31] For a detailed explanation on Muons see: http://www.cosmicrays.org

be understood. Could these angles contribute to a highly skilled, critical and reflective artwork, which might gain more respect from science? How do art researchers deal with the learning curve of their own scientific knowledge and could a more common trans-disciplinary language evolve from conducting workshops in this regard? The aim of both these quests is to communicate more deeply with the public. We would like to suggest that our current mediated and literate public might be interested to replace the older language stereotypes, which are based on archetypical metaphors for more conceptual visual poetic metaphors.

9. How does the public benefit from art embedded with scientifically robust knowledge? Could psychological evaluation help art and science to communicate more clearly to the public?

9.1 Scientifically robust knowledge

As Donna Haraway suggests, if science is really neutral then artistic interpretations might also reflect about how cultural factors and public response might feed back the other way and have an influence on the research itself. Therefore, here in our final question we wish to reflect on the issue of the public being properly pre-exposed to the role of scientific research and resultant proofs. In other words, can art be a catalyst for science to reach the public or should it maintain a purely interpretative role?

Our aim here is to address these questions by discussing the actual corridors of exchange. We hope that matched pairs of art science researchers that collaborate on very particular problems will promote the production of artworks that are based on scientifically robust knowledge and that also take the intelligence of the audience into account. This is a very different approach to commissioned illustrations of for example physical or biological principles with the hope of enhancing the general public's comprehension and understanding of these sciences. Our concept not only encourages artists to become more serious researchers, but it is in accordance with Sandra Caravita's idea that knowledge building "receives promotion from the cultural environment and the social interactions that accompany the learner's explorations"[32]. But how accurate does an artwork have to be about scientific content? One interpretational approach, which is very much rejected by science researchers, is the use of "shock value" (i.e. Stelarc[33]) . In these cases, scientists see those artists as uninformed and problematic not only because

[32] ibid:Caravita(1995).
[33] Stelarc. http://www.stelarc.va.com.au/

they misrepresent the situation, but also because they are reminiscent of tabloid style journalism. This damages the image of scientific research. Instead, they preferred artists with more considered goals who were excited about the specific research being undertaken in the lab itself. They also preferred artists who had some prior experience in bringing results to the public. Science also has it radicals or mavericks like Marvin Minsky[34] and Hans Morawec[35] or Eric Drexler[36], who have a reputation of creating problematic fiction to shock the public in order to illustrate their points, but these scientists are not really taken seriously within our AIL research labs. Thus the concept of "shock value" is another arena for more discussion in the public realm.

We claim that the artist has to first be exposed to the every day activities of a particular scientific inquiry before they can interpret the results for the public. Historically, more informed interpretations have already had a valuable role to play if they were backed up by solid claims from the science community. (E.g. Hans Haacke’s work “Rhinewater Purification Plant” which conducted grey water reclamation in 1969[37]; or Harrison’s “Sustainable Food Source” 1972[38]). It seems that informed interpretations can help to explore art as a catalyst to improve public relations for scientists. Furthermore art researchers' interpretations of ethical and social issues within scientific research may also help to generate a new level of discussion within the scienctific community itself.

9.2 Psychological or sociological evaluation

Many academically inclined art researchers are beginning to use ethnographical studies and workshops to analyze social questions and to combine the results into something called "proof of practice". This combination might also further legitimize the studies of art researcher on a scientific level. For example, in the e-skin consortium, art researchers have learnt to test participants responses by using social science methodologies learnt from the Department of Psychology in Basel. Here science researchers are helping art researchers to empirically assess the navigation, information and communication potentials of the users in relation to their particular senses of tactility, proprioception, hearing and cognitive mapping. This testing can accurately identify inherent problems and

[34] Minsky, M. (1986). The Society of Mind. Simon and Schuster, New York.
[35] Moravec, H. (1988). Mind Children: the Future of Robot and Human Intelligence, Harvard University Press, Cambridge, Massachusetts.
[36] Drexler, E. (1986). The Engines of Creation: The Coming Era of Nanotechnology, Doubleday, New York.
[37] Hans Hacke 1969 Rhine water Purification Plant. http://greenmuseum.org/c/ecovention/rhine.html

[38] Information about the work of the harrisons can be found at in the Green museum web.site. http://greenmuseum.org/content/artist_index/artist_id-81.html

inconsistencies in order to help build the e-skin interface. In return, the media artist can benefit from the output of recording these tests and edit them into something digestible for the general public. Thus information in combination with perception might empower the public with a deeper level of shared awareness, intimacy and emotion. If one of the main aims in combining art research with the gathering of empirical knowledge is to "humanize science" for the general public, then perhaps these strategies are worth pursuing.

This requires a type of public communication strategy, which employs the same criteria and filters in presenting research results to the general public that sociologists and psychologists use to verify their own data. The public must be made to feel comfortable about the consideration of new ideas in order to overcome external factors or resistances and to deal with the unpleasant consequences of giving up what is currently held to be true. This requires a less protective construction of belief systems and more informed debates or constructive insights into the evolution of thought. Perhaps the results can lead to new social applications, which may even be able to be shown inside the environment of the scientific lab themselves. What is central, indeed crucial, is that researchers in both art and science fields still retain a commitment towards the public and their subjects of study.

Conclusion

The above questions constitute a starting point for further dialogue between art and science researchers; ones that can perhaps shift the public attitudes towards both fields of study. Certainly, these questions reinforce the need for more practical experiments in education as well as a re-thinking about trans-disciplinary collaboration. If science educators are looking for more sensitive and poetic metaphors and communication skills, then art can help. For contemporary artists 'real' information is not taboo and they particularly like more socially conscious scientists. Most of the directors of our artists-in-labs project group told me they had made friends with other contemporary artists in the past whose original approaches had impressed them.

These discourses might seem difficult to implement, but as we have illustrated by using our actual experiences within the two contexts of artists-in-labs project and the e-skin consortium, it seems possible to promote these ideas in the life, physics, computer, and engineering sciences and also in the arts and humanities. The general public is mostly uninformed about scientific debates in these fields. We claim that trans-disciplinary approaches may provide art researchers with solid raw materials, pertinent debates and unique potentials in order to encourage critical analysis in the public realm and perhaps even affect social change. We also claim that art researchers should learn more about science so that they can produce more highly skilled and reflective artworks, ones that might not only gain more respect from science but also be more relevant for future debates in the public realm. Scientific research has such a large impact on the future of humanity that it would seem irresponsible to not consider these potentials.

Acknowledgements

Parts and references in this essay also appear in the following book
Scott. J. 2006, *Artists-in-labs Processes of Inquiry*. Springer Press. Vienna New York and in also the accompanying 2-5 Hour film documentary DVD of this book edited by Marille Hahne.

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Biography

Jill Scott

Jill Scott was born in 1952, in Melbourne, Australia. Recent publications include: *Artists-in-labs Processes of Inquiry:* 2006 Springer/Vienna/New York, and *Coded Characters* Hatje Cantz 2002, Ed. Marille Hahne. Her education includes: PhD, University of Wales (UK) MA USF, San Francisco, Degree in Education and Degree in Art and Design. Currently she is Professor for Research in the Institute Cultural Studies in Art, Media and Design at the Hochschule für Gestaltung und Kunst (HGKZ-University of Applied Arts) in Zurich. Switzerland and Vice Director of the Z-Node at the University of Plymouth, UK. She has exhibited many video artworks, conceptual performances and interactive environments in USA, Japan, Australia and Europe since 1975. Her most recent artwork concerns the relation between retinal neuro-morphology and media sculpture, and she is also developing a new media documentary film about environmental science for the planetarium dome.

Daniel Bisig

Daniel Bisig was born in 1968 in Zürich, Switzerland. In 1994, he received a Master's degree in Natural Sciences at the Swiss Federal Institute of Technology. In 1998, he received a PhD in Protein Crystallography at the same university. In 1999, he finished training in web-design with a diploma at the EB-Wolfbach, Zurich. In between 1999 and 2001, he was teaching web-design at the EB-Wolfbach and worked as designer and programmer at the web-company Ditoy. In 2001, he joined the Artificial Intelligence Laboratory at the University of Zurich as a senior researcher. He has also been working as a research associate at the Department of Art and Design, University of Applied Sciences, Aargau in 2003 and at the Institute Cultural Studies, University of Art and Design, Zurich in 2004. Since 2006, he has an additional research position at the Institute for Computer Music and Sound Technology in Zurich. Since 1996, he has been active as an artist in the fields of computer animation, experimental video and software art. He's most recent works include BioSonics, an interactive Artificial Life installation, Ostrawa, an experimental video film and MediaFlies, a flocking based video and audio remixing tool.