Art - Science - Visualization Collaborations:  
Examining the Spectrum  
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Fig. 1. Jan Tulp, Global Council Interlinkage visualization  
Fig. 2. Nathalie Miebach, In the Shadow of a Giant (detail)

Abstract— Collaborations between artists, visualization specialists and scientists produce a broad range of outcomes. They vary widely in purpose, scope and form. Being familiar with the range of possibilities as well as understanding the vocabulary and processes of the respective disciplines facilitates the process. The collaboration process ranges from artists assisting with color maps and design decisions to scientists collaborating with artists on work designed to hang in a gallery. The outcomes often extend beyond the original intent. Visualization specialist and scientists speak of the surprising impacts on their work. Art and visualization both are exploratory processes as well as communication avenues. Collaborations between the three fields show the potential for outcomes from increasing understanding of science to discovering solutions to significant problems of our time.

Index Terms—Design, Data Visualization, Art-Science-Tech Collaborations, Art, Visualization. NOTE: I tried to access the official list for the INDEX TERMS via the web and via the email as IEEE instructs but no no avail. Please feel free to revise.

1 INTRODUCTION

Collaborations between artists, visualization specialists and scientists cover a wide spectrum. Understanding the range and types of collaborations gives all parties a means through which to explore their options and possibilities. The two images above represent the range of blending the two fields. On the left is a beautifully executed visualization by Jan Tulp, [fig. 1] who is trained in computer science as well as visual art. On the right is a sculpture by Nathalie Miebach, [fig. 2] an artist who builds sculptures based on environmental data she collects.

Information and scientific visualizations are typically produced with computer graphic programs for display on monitors. Multi-media artists using visualization as the foundation of their work often adopted these technologies, while other artists have maintained tradition artistic materials. While the visualization professionals focus on communication, the artists are seeking to provide connection. Both groups are involved in examining and communicating data and science. The artist community speaks of the desire to depict the science in a language that also speaks to our humanity. It is this spectrum of visualizations, their uses and audiences that will be discussed here.

2 THE SPECTRUM

Collaborations come in as many forms as there are artists and visualization scientists. Most also involve the scientist whose research produced the data. Some scientists seek assistance with the design elements of their visualization, others want to collaborate on works of art. There is much interesting work being produced in collaborations in between those two poles. The outcomes are clearer visualizations, visualizations that communicate on an emotional as well as intellectual level. Unexpectedly, there are collaborations that are moving the arts as well as the sciences into new directions, opening up new fields of artistic practice and changing the direction of visualization science and the science behind the data. The value of these collaborations is being acknowledged by funding agencies across the disciplines. Examination of the common traits within these successful collaborations will provide a roadmap for those considering working across disciplines.

As the data sets grow and the variables become more complex, scientists are turning to artists to become part of their team. The reasons are many. The following is an introduction to the spectrum work, established best practices for maximizing the outcomes and the benefits coming from the field.

2.1 Expanding the Vocabulary of Visualization

Embracing artistic collaboration, Daniel Keefe and his team at the Interactive Visualization Lab, University of Minnesota, work with artists to expand the
vocabulary of data visualization. From the earliest stage of visualization process he and his team engage artists in the develop of the visualization construction. They are taking advantage of an expanded artistic language and the iterative design process to create new tools for creating clear, readily understood visualizations.

Keefe explains his motivation for working with artists this way: “Artist and scientist teams push technology in creative new directions, often resulting in exciting new modes of interacting with computers that can impact many domains across science, engineering, and medicine.” [1]

Figure 3 shows the artist’s rendering. Figure 4 is the resulting visualization.

The intent of this collaboration was to create means multiple of clearly visualizing the stresses in the rotation of patients with back injuries. It is an example of artistic practice aiding in the clarity of the visualization and forwarding the science. The funding source and need for specific results places this collaboration clearly on the science end of the spectrum.

2.2 Artist’s Vis, Info Vis – Comparing the Tools

Side stepping discussions of what is and isn’t art, visualizations created by fine artist differs from info visualizations in that the intent is different. The distinction is not in hierarchy, but the primary purpose of the work. The primary goal of info visualization is direct commutation on a specific topic. Alternatively, fine art presents layers of visual connections, analogies and metaphor. With art, viewers add their own life experience to the mix, resulting in individual internal experiences. Its’ intent is to raise questions rather than provide answers. Information visualization and scientific visualization are tools for conveying complex information in a comprehensible form. That itself is an art and there are many info visualizations that take your breath away. The distinction is in the primary intent. Understanding the components gives us the ability to choose when, where and in what strength to apply the tools of each disciple. That said, all visualization are a blend of both disciples. All lie in the spectrum between seeking answers and asking questions.

2.2.1 Mark Lombardi

Mark Lombardi is a visual artist who began working on drawings that tracked the entwined connections and relationships within the global banking system, in the 1980’s. The drawings are based on information he collected from newspapers and his own research, uncovering the out-of-view connections in the world banking system. Developed in the days before commonly used info vis software, his approach is low-tech but very effective. The look similar to info vis but their intent is different. The “information” is artists collected and selected. It is as much political commentary rather than a scientifically complete data set. [Fig.5]

Lasting art depicts the concerns of its time while retaining relevance for generations to come. Lombardi’s work does just that. Speaking to the economic imbalance and the closed interconnected spheres of influence within the global banking system, the BCCI series provides stunning drawings that speak to our heart, eye and mind.

![Fig. 3. D. Keefe, from artist’s thumbnail sketches [1], Interactive Visualization Lab, Univ. of Minnesota](image1)

![Fig. 4. D. Keefe, resulting visualization [1] Interactive Visualization Lab, Univ. of Minnesota](image2)

![Fig. 5. Mark Lombardi, BCCI-ICIC & FAB, 1972-91 (4th Version), 1996–2000 [16]](image3)

![Fig. 6. Mark Lombardi, BCCI-ICIC & FAB, 1972-91 (4th Version), 1996–2000 (detail) 2000.250.1 [16](image4)

2.2.2 Jan Tulp

Jan Tulp’s visualization of the Global Agenda Council’s Interlinkage [fig. 1] is an interesting contrast to Lombardi’s BCCI-ICIC. Both are dealing with international financial networks. Tulps’ visualization reveals an immense amount of data through the interactive elements of the work. It is an interactive piece that allows viewers to explore the relationships and clustering between the Councils. It also exposes areas where the density of the council’s networks diminishes the value of those connections.

2.3 A Standing Team - Art and Visualization

The field of visualization is growing rapidly. There are now many practitioners well schooled in both data visualization and artistic practice. “Wind Map” is a stunning example. It simultaneously incorporates all of the requirements of a scientific visualization i.e., clarity and accuracy while maintaining the beauty, emotional impact and metaphoric qualities of art.
Viegas and Wattenberg’s description of the project details the blend of artistic and scientific intent. They state, “The map was created in the cold winter months when wind was much on our minds. It conveys the movement of the air in the most basic way: with visual motion. As an artwork that reflects the real world, its emotional meaning changes from day to day. On calm days it can be a soothing meditation on the environment; during hurricanes it can become ominous and frightening. Although we made the wind map as an artistic exploration, we’ve been surprised by the kinds of things people use it for: bird watchers have tracked migration patterns; bicyclists have planned their trips; and we’ve even seen conspiracy theorists use it to track mysterious chemicals in the air.” [6]

2.4 Twelve Minds

Like Viegas and Wattenberg, Ruth West, Associate Professor at the University of Northern Texas and the Director of xREZ lab, is an interdisciplinary artist-researcher working with emerging technologies. She has a depth of training and knowledge in art, science and visualization, specifically, new media, molecular genetics, information aesthetics, scientific visualization, as well as virtual / immersive environments.

In collaboration with twelve partners she spearheaded “ATLAS in silico”. [fig.7] It is a room size virtual environment where visitors can explore interpreted renderings of the Global Ocean Survey, a recent pioneering voyage of discovery circumnavigating the Earth’s oceans, providing a new picture of life on Earth.

Images and multichannel audio are created through a process that combines genetic information from microorganisms collected by the Global Ocean Survey with environmental and social data from the geographical locations in which the organisms were found. Participants explore relationships within data that span from the molecular to the global. [7]

2.5 Art which Collects and Illuminates Data

“Bion” [fig. 8] is the result of a collaboration between Adam Brown, a conceptual artist, and Andrew Fagg, a computer scientist working in bioengineering. It is an interactive art installation illuminating, literally, human–computer interaction. The installation is composed of hundreds of mass-produced, 3-dimensional glowing and chirping sculptural forms their creators call bions. As visitors enter the room, the bions recognize and responds to their presence and proximity. The bions communicate that information between themselves and the viewers through visual and auditory means. As time passes the response diminishes only to increase when new visitors arrive. It is as if the bions sense a new presence, tell the others and then relax once the new presence is determined not to be a threat. “Bion” makes reference to an individual element of primordial biological energy identified as orgone by the scientist Wilhelm Reich. Each bion, measuring approximately 4x3x2 ½ inches is a synthetic “life-form” fitted with an audio speaker, blue lights and multiple sensors. The bions are suspended by fine gage wire connected to panels that are attached to the ceiling. When installed the panels form clusters of bions arranged at different elevations. Each bion has the ability to communicate with the others and with viewers that enter the space. [8]

2.6 Artistic Materials, Artist Collected Data

Nathalie Mielbach is a sculptor whose work is based on self-collected and externally-collected environmental data of marine environments. Staying true to the numbers, she creates sculptural glyphs to represent the variable
and geographical data. The glyphs and woven elements create a hybrid sculptural visualization that functions both as sculpture and data visualization. Her interest is in the role visual aesthetics plays in the translation and understanding of scientific information. [15]

“Changing Waters” [fig.9] is based on meteorological and oceanic interactions within the Gulf of Maine. Using data from NOAA and GOMOSS buoys, the work depicts data about the seasonal variations of marine life.

The large-scale installation consists of a 33-foot-long wall containing plotted information through the geographic anchors of a map of the Gulf of Maine. Additional structures depict biological, chemical and geophysical relationships between marine ecosystems and weather patterns. There are also a series of large, hanging structures that depict specific biological, chemical or geophysical relationships between marine ecosystems and weather patterns. [15]

![Fig. 9. N. Miebach, “Changing Waters”](image)

The work is clearly hand constructed from everyday materials that like Lombardi’s drawings portray the science with a human imprint.

2.7 Multiple Outcomes

One solution to the balance within collaborations is to opt for multiple outcomes. This allows for the needs and interests of both parties to be accommodated.

Artists are often asked to assist with color maps or contextual frameworks. Below is one such example. Collaborating with Sean Williams of the Research Visualization Team at Los Alamos National Labs we tested out our interest in working together by developing a new color map on ocean eddy visualization. Williams, working with the oceanographic team and their data, developed a visualization tracking the ocean eddies worldwide. Understanding eddy patterns assists in the accuracy of climate change models because the eddies are a determining factor in ocean carbon absorption. Our goal was simply to enhance the distinctions within the visualization through adjustments in the color map.

Many artists shy away from this type of request. However, some of my most rewarding extended collaborations I have been evolved in started from small beginnings. As an artist working on environmental issues within the oceans, I was more than glad to work on the color mapping. In exchange, I received access to research and the visualization itself. With the visualization as the corner stone, I built a body of work about environmental changes occurring in the oceans.

![Fig. 10. S. Williams, Detail of ocean eddy visualization, Global Eddy Analysis and Visualization [3]](image)

3 PRACTICAL CONSIDERATIONS

For collaborations to succeed mutually beneficial goals and parameters need to be established. The first question to ask is what is the primary goal of the collaboration? Is it a visualization? A piece of art? A visual documentation of the science? Or is the plan to produce multiple outcomes? Some collaborators begin with a specific goal or desired product. Others decide on open-ended explorations. The category of intention is often driven by the source of funding and balance between parties. More often than not, the plans are to start on one pole or the other – art or science – but the outcomes end up somewhere in the middle or with multiple results.

Goals are a starting point. Along the way surprises develop. Craig Tweedie, Associate Professor of Environmental Science and Director of the Systems Ecology Lab at the University of Texas, El Paso, a long time collaborator, responded this way when asked why he had given me such extensive access to his sites and staff. “We have shared a great deal of our data and she has, through the combination of multimedia and digital media, been able to completely alter how we view the ecosystems we study and the types of data discovery we have pursued.”

3.1 Why Collaboration

The first question is usually why would visualization teams want an artist in their lab? Researchers who have done so repeatedly speak of the unexpected impact of the artist’s presence on their work.

Robert Root-Bernstein, Professor of Physiology at Michigan State University, is a long-standing advocate and researcher of art-science collaborations who has looked back to collect data. He has written extensively on art-science collaborations as one of the factors driving scientific progress. He explains, “Science and engineering are supposed to be objective, intellectual, analytical, and reproducible so that it is clear when an effective solution has been achieved to a problem. The arts, literature, and music, by contrast, are portrayed as being subjective, sensual, empathic, and unique, so that it is often unclear whether a specific problem is being addressed let alone whether a solution is achieved. It therefore comes as a considerable surprise to find that many scientists and engineers employ the arts as scientific tools, and that various artistic insights have actually preceded and made possible subsequent scientific discoveries and their practical applications.” [10] His research is detailed in “Sparks of Genius.”

Most collaborations begin as limited short-term expectations but many scientists report that they are still working with an artist years later. The reasoning, like art, is hard to pin down, but the number of collaborations which have expand into years and / or career-long bodies of work speaks for itself.
3.2 Chaos Theory and Acoustic Art Combine to Address Insect Infestations Contributing to Climate Change

One such example is the work David Dunn and Jim Crutchfield who have been collaborating for many years. David Dunn is a composer who focuses on the development of strategies and technologies for environmental sound monitoring in both aesthetic and scientific contexts. Jim Crutchfield, directs its Complexity Sciences Center, at the University of California, Davis, and promotes science interventions in non-scientific settings. Their combined diverse backgrounds lead to significant advances in understanding communication methods of insects. Connecting rapidly expanding insect populations, deforestation, global climate change, their research demonstrates the significant role that bioacoustics can play in disrupting the cycle. For example, they have discovered sound frequencies that turn the beetles cannibalistic. This knowledge opens the doors for a nontoxic bioacoustic mechanism for detection and control strategies, a significant advance to a growing problem. [2]

The chemical approach to controlling insect populations grew out of biology and chemistry collaborations. Crutchfield explains, “It is precisely this kind of intentional cooperation between disciplines—but now over a greater range of scales—that will most likely lead to new strategies for monitoring and defense against what seems to be a growing threat to the world’s forests and ultimately to humanity itself.” [3]

3.3 Selecting an Artist

It is all about the chemistry. Seasoned collaborators recommend a strikingly similar set of criteria - mutual respect, mutually agreed upon goals, clearly defined roles, clear communication, and most importantly, an interest and understanding of each other’s work. Rather than seeking someone with a demonstrated track record in a specific field or a familiar aesthetic, consider selecting someone who intrigues you, someone who you’d like to share a second cup of coffee. Is there interest in each other’s ideas? Is the communication clear? Is there mutual respect and curiosity?

3.4 Establishing Evaluation Markers

Collaborations are like experiments. You invest time and effort, evaluate the results, and decide whether to continue. Scientific-artistic collaborations are the same. A way to ease the process is to set up mutually agreed-upon evaluation points for the project. Artists need time to gain an understanding of the project and its science, as well as to develop their ideas. It is helpful to everyone if the scope of the project is clearly defined.

3.5 Assumptions

Collaborations bring together two different cultures. I am always surprised at the assumptions we all bring to the table on both sides. A basic understanding of each other’s constraints will smooth the process. Scientists are under tremendous pressure to keep their labs and experiments moving forward. Visualization specialists are fighting bugs, glitches and deadlines. Artists need time for contemplation and exploring multiple directions. Based on past experience, to artists I would suggest, presenting questions, needs and requests in an organized condensed fashion. To the engineers, understand what detours along the way are part of the process.

3.6 Language

Equally important is an awareness of the language used in each community. Surprisingly, it is not the scientific terminology that causes confusion but the common language used with our peers.

The vocabulary divide comes from both sides. Consider the following example. I was giving a lecture on color theory to a visualization team. Warm colors, cool colors, saturated, primary all were easily understood. A hand shot up when I began speaking about neutral color. The question, “What is a neutral color?” left me stumbling for a clear definition. It is such a fundamental concept in the arts, framing an explanation for a scientific audience gave me pause.

3.7 Medium

Artists use a range of medium, visual and otherwise. Artists are exploring sound and movement as visualization mediums as well as non-traditional medium.

3.7.1 Music Notes as Data Points

Daniel Crawford, a cello-playing undergraduate at the University of Minnesota, came up with a new way to describe both the trend and variations characterizing our warming climate. He composed, “Song of Our Warming Planet”, in which the notes represent annual temperature readings from 1880 to 2012 as charted by NASA’s Goddard Institute for Space Studies. [17]

3.7.2 Data Cuisine

“Kippis” Susanna Jaschko and Moritz Stefaner lead a workshop, “Open Data Cooking Workshop”, using of food and the properties of specific foods as a visualization medium. Participants explored ways to represent local data through the inherent qualities of food such as color, form, texture, smell, taste and the associations correlated with specific foods. A particularly captivating piece is “Kippis”, map of Finland depicts the differences in alcohol consumption across regions. Each region is symbolized with typical food from the area. The amount of wine, beer, and spirits consumed (compared to the average) is shown in the fill height of three glasses per region. [9]

Translating food into data visualization needs to take into account the associations and connotations of the specific foods just as the associations and connotations of specific colors impact our reading of information visualization.

Fig. 12 D. Dunn, J. Crutchfield, Sound scales [3]

Fig. 13 Open Data Cooking Workshop, “Kippis”, Finnish for cheers. [9]
people look at publicly available data and deal with it in a non-standardized way. I believe that art and design processes like the collective research we are talking about, enable us to see our society from a very different angle than the one that is presented to us by science, politics, history or mass media."  [9]

3.7.3 Surprise and Humor

“Messa di Voce” (Italian for “placing the voice”) is a multi-media performance in which the sound from the performers are translated into images on the screen. It is a whimsical work exploring pattern and sound. The images created by the sound offer an interesting look at the possibilities for sound visualization, which could be adapted to information or scientific visualization. [13] http://vimeo.com/2892576. The collaborators on this project were Golan Levin, Jaap Blonk, Joan La Barbara, Zach Lieberman.

4 Connecting Science to Our Everyday Lives

John Kingdon speaks to the value of intuition and the need to connect science to our everyday lives. “Art is above all a science and science is the context of life today, it is the hydra conditioning our environment both physically and through perception, informing every sense with allusions, the complexity of which can best be grasped intuitively. Our experience is felt rather than analyzed as in science, rather is it reorganized into forms and colors that effect a meaning…. The wondering dialectic mind of science expressing a poetry of growth and structure and life.”  [11]

Multi-disciplinary collaborations facilitate our human need for connection, to others, to the world, and to understanding. The complexity and breadth of knowledge today requires that we connect and collaboration with those outside of our spheres. The scientist benefits from intuitive thinking, the artist from linear thinking, and the visualization specialists are needed to connect the complexity.

5 Conclusion

For many scientists the materials, prototypes, and unrelated objects of an artist’s studio is a cacophony. Exposing their labs to the influences of a stereotypical artist’s environment would give anyone pause. Alloting time to facilitate that chaotic mysterious process requires convincing. From the artist’s perspective, the usual request of helping to create a visual worthy of a journal cover is meet with similar enthusiasm.

Discussing the spectrum of collaborative processes and alternatives provides a starting point for envisioning possible outcomes. It allows scientists to set boundaries around their commitment. It removes unknowns from the cost of entry. Most collaborators discover unexpected benefits of from the initial experiences. Those experiences pave the way to more substantial work.

Marjorie Blumenthal and Ken Goldberg offer this thought: “Bridging the two cultures is a grand challenge. There is a fundamental asymmetry and complementarity between them: the word Science comes from the Greek “to cut.” The word Art comes from the Latin “to join.” The results can be extremely productive by expanding public interest and engagement with both sectors, bringing new topics to new audiences, and educating and inspiring the next generation to transcend existing boundaries to discover and create the future of innovations.”[12] Visualization is the glue that that connects the cuts and holds the joints.

Acknowledgments

Francesca Samsel would like to thank the Texas Advanced Computing Center for the assistance of their staff and generous use of their facilities.

References


Fig. 14 Antony Gromley, Isa [18]