

Art - Science - Visualization Collaborations; Examining the Spectrum

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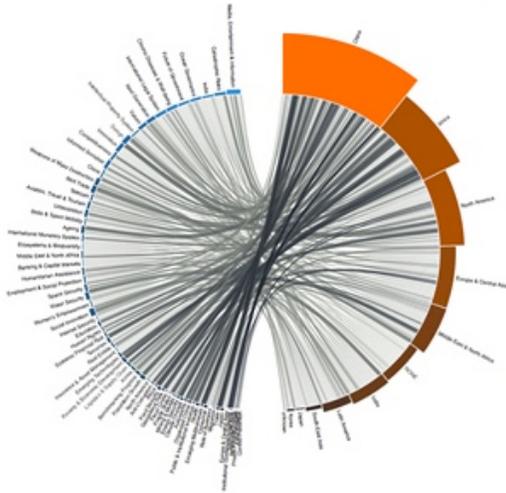


Fig.1., Jan Tulp, Global Council Interlinkage Visualization [1]



Fig.2., Nathalie Miebach, *In the Shadow of a Giant* (detail) [2]

Abstract—Collaborations between artists, scientists and visualization specialists cover a wide range of work. This paper examines the spectrum of collaborations between artists, visualization specialists and scientists. It looks at the broad range of outcomes, purposes, scope and forms. Knowing the range of possibilities as well as understanding the vocabulary and processes of the respective disciplines is important to facilitate future successful collaboration. Outcomes of the collaborative process range from artists using their design and color skills to improve visualization to scientists collaborating with artists on work designed to hang in a gallery. Visualization specialists and even some scientists speak of the surprising influence artists have had on their research. Art and visualization are both exploratory processes as well as communication avenues. Collaborations between visualization, art and science have the potential to communicate the science to a broader audience; increase scientists' ability to explore their research; and potentially find solutions to significant problems of our time. Having a common understanding and language will facilitate building successful productive teams.

Index Terms— Data Visualization, Scientific Visualization, Art-Science-Technology Collaborations, Art and Visualization, Art.

1 INTRODUCTION

The definition of art has been debated for centuries. Art-Sci-Tech is an alloy that is even less clearly defined. Given that collaborations between artists, visualization specialists and scientists cover a wide spectrum, this paper examines the balance and the breadth between art and visualization in order to help build a common understanding and facilitate successful future collaborations.

2 DEFINITIONS

Side-stepping discussions of what is and isn't art, info-vis, sci-vis and art differ because of the intent of the creator. The distinction is not in hierarchy, but in the primary purpose of the work. Information visualization and scientific visualization are tools for conveying complex information in a comprehensible form. Alternatively, art presents layers of visual connections,

analogies and metaphors, asking the viewer to complete the picture. Unlike visualization, its intent is to raise questions rather than provide answers. The distinction is in the primary intent. Understanding the components of Art-Sci-Tech collaborations gives us the ability to choose when, where and in what strength to apply the tools of each discipline. That said, all visualizations are a blend of disciplines. All lie in the spectrum between seeking answers and asking questions.

3 THE SPECTRUM

The work of Jan Tulp and Natalie Miebach represent two ends of this spectrum. On the left is an information visualization beautifully executed by Jan Tulp [fig. 1], who is trained in computer science as well as visual art. Its primary function is to allow access and to facilitate comprehension of large data sets. On the right is a sculpture by Nathalie Miebach [fig. 2], an artist who builds sculptures based on environmental data. While based on data, it is art, with all of the ambiguities inherent therein.

3.1 Jan Tulp – Artful Info Vis

Jan Tulp's visualization of the Global Agenda Councils Interlinkage [fig. 1] reveals an immense amount of data through the interactive elements of the visualization. The interactivity allows viewers to explore the relationships and clustering between the Councils while exposing areas where the density of the Councils' networks diminishes the value of those connections.

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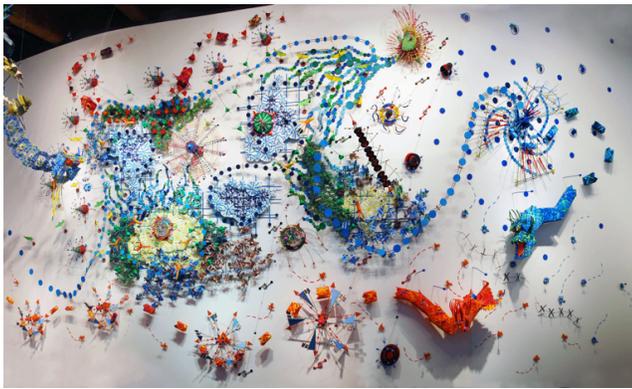


Fig.3., N. Miebach, *Changing Waters* [2]

3.2 Natalie Miebach - Art Materials, Artist Collected Data

Nathalie Miebach is a sculptor whose work is based on self-collected environmental data of marine environments. Staying true to the numbers, she creates sculptural glyphs to represent the variables and geographical data. The glyphs and interwoven elements create a sculptural work that is also a visualization of data. Her interest is in the role that visual aesthetics plays in the translation and understanding of scientific information [2].

“Changing Waters” [fig. 3] is based on meteorological and oceanic interactions within the Gulf of Maine. Using data from NOAA buoys, the work depicts data about the seasonal variations of marine life. The 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 [2]. The work is intentionally hand-constructed from everyday materials that give the science a human imprint.

3.3 Enhancing Visualization via the Artistic Process

Embracing artistic collaboration, Daniel Keefe, Assistant Professor of Computer Science, 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 the visualization process, Keefe and his team engage artists in constructing the components of the visualization. Keefe’s team is taking advantage of an expanded artistic language and the iterative design process to create new tools for creating clear, practical 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.”



Fig.4., D. Keefe, A sketch from artist’s thumbnail sketches [4].

In an example of artistic practice aiding in the clarity of the visualization, Figure 4 shows an artist’s rendering of areas of stress in patients with back injuries. In this project, the team’s goal was to allow physicians to see more easily the location of the patient’s pain or injury. The funding source and the need for specific results place this collaboration clearly on the scientific visualization end of the spectrum. Figure 5 is the resulting visualization, graphically linking the pain to the relevant vertebrae.

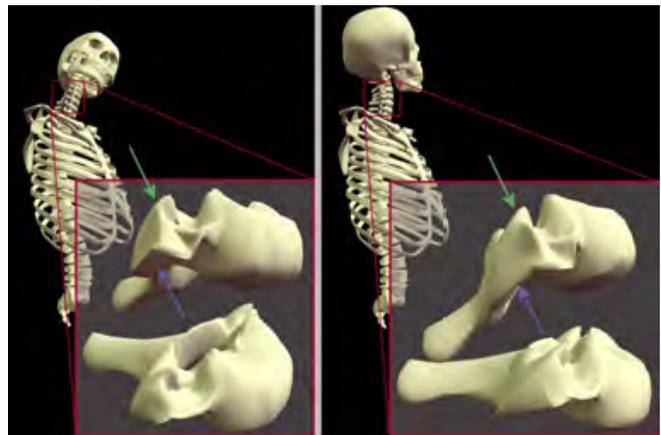


Fig.5., D. Keefe, The resulting visualization [3].

3.4 Mark Lombardi - Art First, Information Second

Mark Lombardi was a neo-conceptual artist whose work was on the vanguard of visualization. In his seminal work, he created a series of drawings that tracked the entwined complexity of connections within the global banking system in the 1980s. The drawings are based on information he collected from newspapers and his own research, exposing the connections of the world’s banking executives. Developed in the days before commonly used info vis software, his low-tech approach is clear, effective and poetically beautiful. The data is collected and then edited by the artist with artistic goals in mind. While the primary intent is political commentary exposing the interconnectivity of individuals driving the world economy [fig. 6], Lombardi’s BCCI series speaks to the economic imbalance and closed interconnected spheres of influence within the global banking system. In this nascent example of data visualization, it speaks to us through our hearts, our eyes and our intellects.

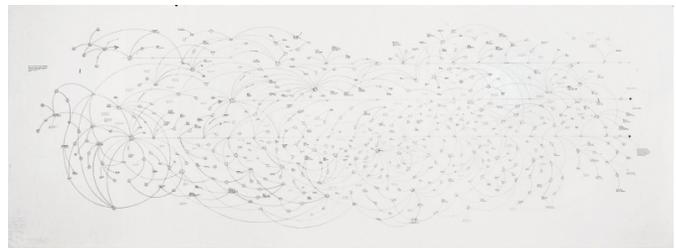


Fig. 6 Mark Lombardi, *BCCI-ICIC & FAB, 1972-91 (4th Version), 1996–2000* [5].

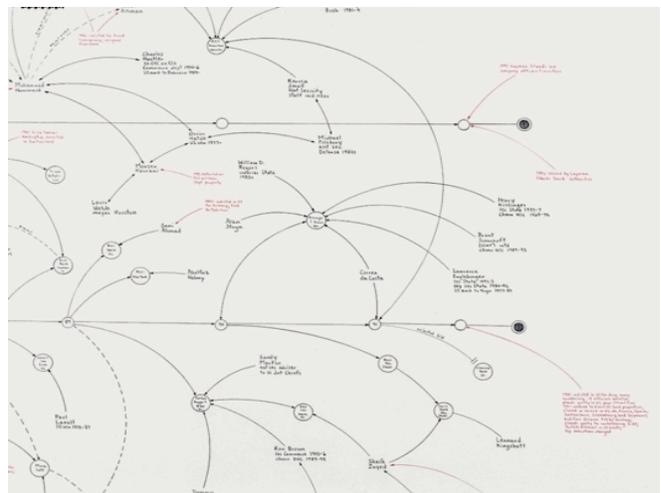


Fig.7., Mark Lombardi, *BCCI-ICIC & FAB, 1972-91 (4th Version), 1996–2000 (detail)* [5].

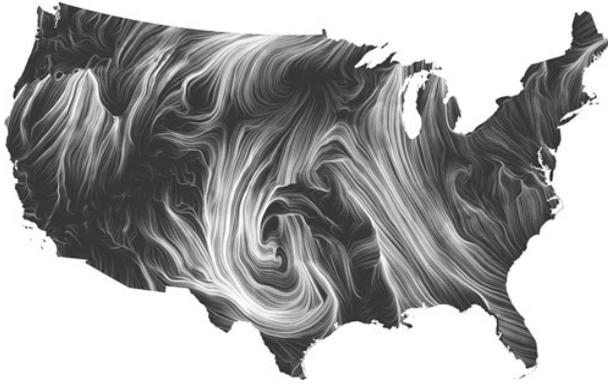


Fig.8., Viegas, M. Wattenberg, *Wind Map* [6].

3.5 Viegas and Wattenburg, Blended Intent

“Wind Map” [fig. 8] is the result of an established partnership between Fernanda Viegas and Martin Wattenburg. 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 Wattenburg’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].

3.6 Art Collecting and Illuminating Data

“Bion” [fig. 9] is a collaborative work created by Adam Brown, a conceptual artist, and Andrew Fagg, a computer scientist specializing in bioengineering. It is an interactive art installation illuminating human-computer interaction in a novel and macroscopic way. The installation is composed of hundreds of mass-produced, 3D glowing and chirping sculptural forms their creators call bions. “Bion” makes reference to an individual element of primordial biological energy identified as orgone by the scientist Wilhelm Reich. Each bion, measuring approximately $4 \times 3 \times 2\frac{1}{2}$ inches is a synthetic “life-form” fitted with an audio speaker, blue lights and multiple sensors. The Bions are suspended by fine gauge wire connected to panels that are attached to the ceiling. When installed the panels form clusters of bions arranged at different elevations [7].

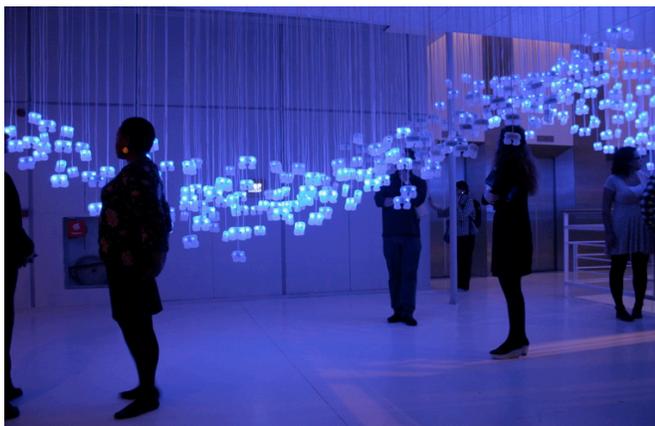


Fig. 9., A. Brown, A. Fagg, *Bion*. [7]

As visitors enter the room, the bions recognize and respond to their presence and proximity. The bions communicate that information between themselves and the viewers. 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.

3.7 Twelve Minds

Ruth West, Ph.D., Associate Professor at the University of Northern Texas and Director of xREZ Lab, is an interdisciplinary artist and scientist working with emerging technologies. The depth of her training and knowledge in new media, molecular genetics, information aesthetics, scientific visualization, as well as virtual / immersive environments uniquely positions her to pursue large ambitious work involving many disciplines.

In collaboration with twelve partners she spearheaded “ATLAS, in silico” [fig. 10]. This interactive artwork is a room-sized virtual environment where visitors can explore interpreted renderings of the Global Ocean Survey. Images and multichannel audio are created through a process that combines genetic information from microorganisms collected by the Global Ocean Survey with environmental and population data from the geographical locations in which the organisms were found. Participants explore relationships within data that span from the molecular to the global [8].

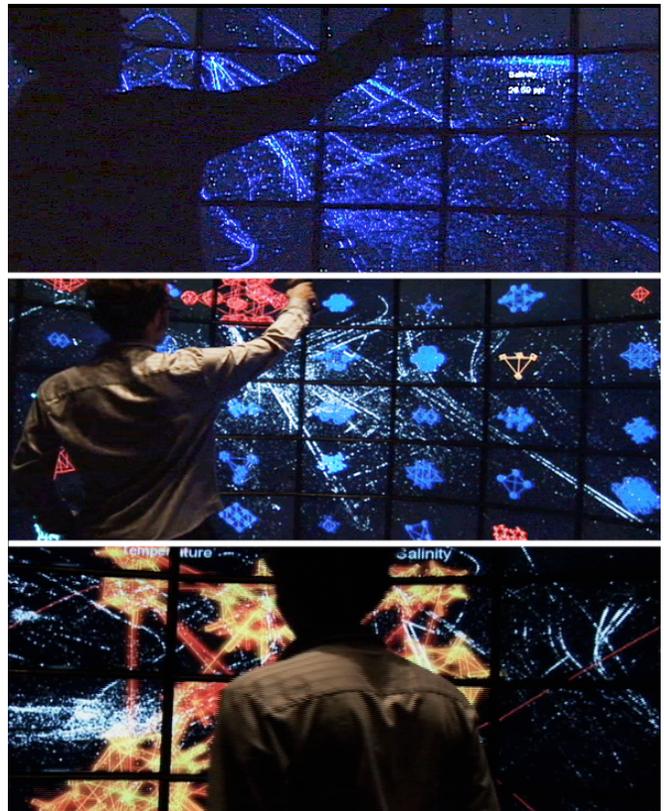


Fig. 10., R. West, *ATLAS, in silico*. [8]

3.8 Multiple Outcomes

One solution to the balance within visualization collaborations is to opt for multiple outcomes. Design projects with multiple outcomes make it easier to meet the needs of all participants. This is the approach that I personally have found most successful.

Collaborating with Sean Williams of the Research Visualization Team at Los Alamos National Labs, we developed a new color map [fig. 12] for their ocean eddy visualization. Williams, working with the oceanographic team and their data [fig. 11], developed a visualization tracking the ocean eddies worldwide. Understanding eddy patterns assists in the accuracy of climate change models because eddies are a determining factor in ocean carbon absorption. Our goal was to enhance the distinctions within the visualization through optimizations in the color map.

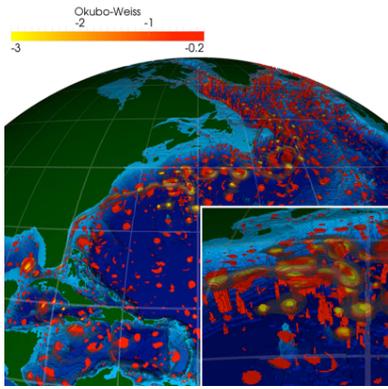


Fig.11., S. Williams, et al. Pre-visualization version of the ocean eddy research. [9]

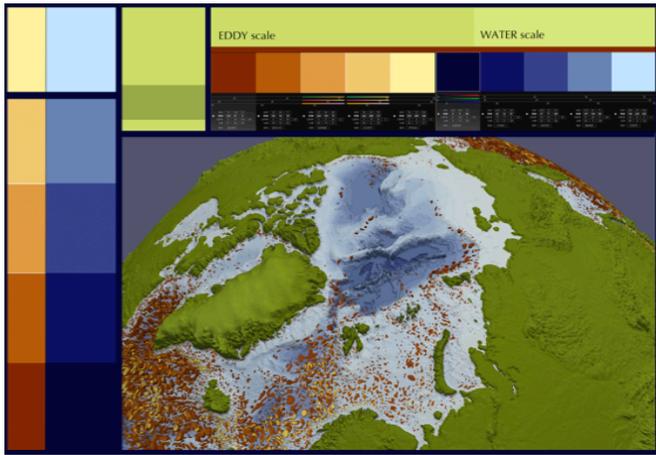


Fig.12., S. Williams and F. Samsel, This is the same visualization after color and design adjustments.

As an artist with past experience with oceanic environmental issues, this visualization project resonated with me. In exchange for my help with the color mapping, I received access to the research and the visualization itself. With the data and the visualization as launching points, I built a body of artistic work focusing on environmental changes occurring in the oceans.

By combining the scientific process and the artistic vocabulary, both aspects of a project are enhanced and better communication enabled. This can only have positive ramifications for public understanding and appreciation of both science and art.

4 WHY COLLABORATE?

I am regularly asked, “Why would a scientist want to collaborate with an artist?” 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 of mine, 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.”

While artists impacting science does occur, there is little research studying direct benefits to science from short-term single outcome collaborations. However, there is evidence supporting the benefits of intermingling of the arts and sciences.

4.1 SEAD: White Papers

Once such research effort was by The SEAD White Paper Working Group. The SEAD: White Papers were produced from a call for papers regarding art-science collaborations. The Working Group was chaired by Roger F. Malina, ATEC, UT Dallas and co-chaired by Carol Strohecker, Center for Design Innovation, University of North Carolina system. There were 55 selected

white papers and meta-analyses, looking at the methodology and benefits of interdisciplinary collaborations. The project was funded as part of the SEAD Network [10].

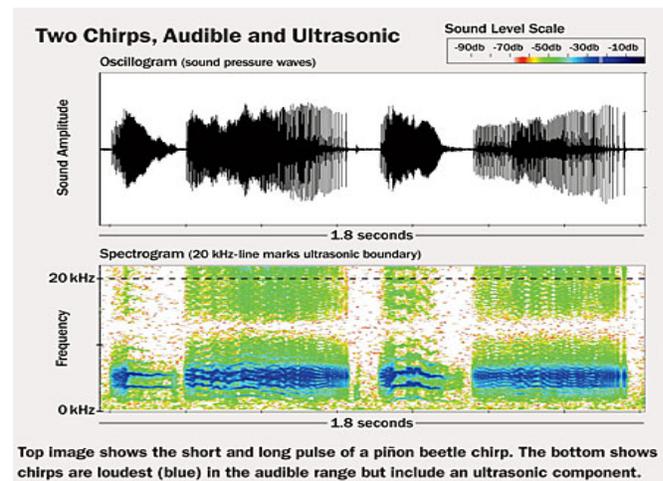
Two longtime advocates, Robert Root-Bernstein, Professor of Physiology at Michigan State University, and Jonathan Zilberg, Associate Research Scholar, University of Illinois at Urbana-Champaign, and Research Associate, Department of Transtechnology, University of Plymouth, offer contrasting views.

Root-Bernstein has been researching and advocating art-science collaborations throughout his career. His data and research point to art-science collaborations as one of the factors driving scientific progress. “The ways in which artists and scientists discover and invent problems, experiment with them, and generate and test possible solutions is universal.” [11]. 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”, written with Michele Root-Bernstein, and documents much of their research in the field.

In contrast, Zilberg has come to the conclusion multidisciplinary collaborations do not advance basic science although they do have other significant benefits. His *Meta-analyses of the SEAD White Papers* [12] concludes, “Art does not directly advance basic science, as reluctant as we might be to accept this conclusion. Yet this does not undermine the fact that cross-disciplinary work can and does contribute to scientific creativity and science education. They demonstrably enable enhanced public engagement, improve science education and add value in expanding the reach and relevance of each discipline to another, as well as internally across specializations within disciplines.” He agrees with Root-Bernstein, “It should be taken as axiomatic in the science community, and in the public at large, that a scientist has a vastly higher chance of making major contributions to the advancement of science and becoming a Nobel laureate if she or he is a practicing artist, particularly a musician.” (Root-Bernstein et. al. 2008) [12].

4.2 The Case for Long-term Collaboration

Collaborations between David Dunn and Jim Crutchfield span two decades. 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, Ph.D., directs the Complexity Sciences Center at the University of California, Davis, and promotes science interventions in non-scientific settings. Their combined diverse backgrounds led to significant advances in understanding the communication methods of insects, specifically pinon beetles, responsible for devastating vast areas of forest [fig. 13].



Top image shows the short and long pulse of a piñon beetle chirp. The bottom shows chirps are loudest (blue) in the audible range but include an ultrasonic component.

Fig.13., D. Dunn, J. Crutchfield, Diagrams of pinon beetle chirps [13].

Connecting rapidly expanding insect populations, deforestation and global climate change, their research demonstrates the significant role that bioacoustics can play in disrupting the cycle. They discovered sound frequencies that turn pinon beetles cannibalistic, providing a nontoxic, bioacoustic mechanism for detection and control strategies - a significant advance to a rapidly growing problem [14].

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." [14].

5 ALTERNATIVE MEDIA

Artists use a range of media, visual and otherwise. There are ongoing explorations in sound and movement as a media for visualization. Other artists are using non-traditional media such as food and trash.

5.1 Music Notes as Data Points

Daniel Crawford, a cellist and undergraduate at the University of Minnesota, created 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 [15].

5.2 Data Cuisine

Susanna Jaschko, Ph.D., and Moritz Stefaner, led a workshop, "Open Data Cooking Workshop," using 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 we correlate with specific foods. A particularly captivating piece is "Kippis" [fig. 14], a map of Finland which depicts the differences in alcohol consumption across regions. Each region is symbolized by 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 [15]. Translating food into data visualization, the work takes 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.

This project was unusual not just in medium but also in purpose. Jaschko explains, "Most importantly, I was looking for an interesting way to make people look at publicly available data and deal with it in a non-standardized way. 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." [15].



Fig.14., Open Data Cooking Workshop, "Kippis." Kippis is Finnish for cheers [16].

6 CONNECTING SCIENCE TO OUR EVERYDAY LIVES

Multi-disciplinary collaborations facilitate our human need for connection to

others, to the world, and to our own understanding. The complexity and breadth of knowledge today requires that we connect and collaborate with those outside of our spheres. The scientist benefits from intuitive thinking and the artist from a scientific approach. The visualization specialists connect and clarify the complexity.

John Kingdon, Professor Emeritus of Political Science, University of Michigan, 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." He continues, "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 is expressing a poetry of growth and structure and life." [17].

7 CONCLUSION

Marjorie Blumenthal and Ken Goldberg, authors of one of the SEAD: White Papers, 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." [18].

Antony Gromley's "Isa" [fig.15] is a profound piece of art, a sculpture speaking to and visualizing our human emotions. The wire-mesh construct in "Isa" reflects the computational wire-mesh topography that is the basis for the visualization process. The lines between art and science blur as we blend intellectual and intuitive understanding through visualization.

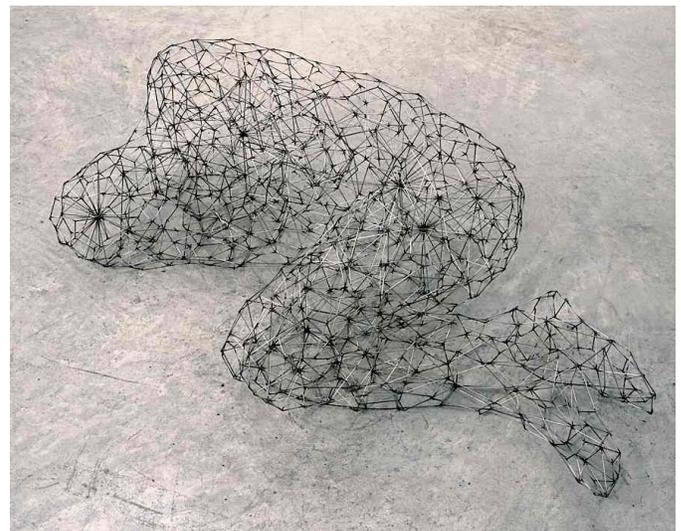


Fig.15., Antony Gromley, *Isa* [19].

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