Fröschl, M. (2025). A Reflection on Doors to Hidden Worlds. *Mutual Images*, 13, 74-82. https://doi.org/10.32926/2025.Froschl

ORIGINAL ARTICLE

A Reflection on Doors to Hidden Worlds

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ISSN 2496-1868

Abstract: The ever-expanding boundaries of visualization fuel discussions about objectivity and subjectivity in imaging techniques. This paper aims to introduce practical examples from the University of Applied Arts Vienna's Science Visualization Lab and spark discussions about the representation, presentation, and translation of humanity's scientific knowledge. Historically rooted in science communication through documentary films, the lab has expanded its creative field to engage recipients more directly. In recent years, the metaphorical 'fourth wall' has been broken down, introducing a wider range of artistic strategies to present essential and universally significant topics for humanity. With these strategies, the lab seeks to bring the world of science closer to various audiences. These visual and other sensory translations of scientific data open up debates in both art and science about the didactic, subjective, or objective nature of art-science presentations. The discussion about the context in which scientific data is presented to audiences is essential for research and development in visualising science.

Keywords: scientific; visualisation; visual effects; documentary films; animation

1. Introduction

The Science Visualization Lab at the University of Applied Arts Vienna practices the tradition of immersing audiences in scientific phenomena through visual and spatial means, as an active, exploratory, and sometimes embodied practice. Media art belongs to a broader genealogy of knowledge production and emerging new media might change how we approach the creation of socially responsible scientific knowledge (Grau, 2007:357). Immersive art-science is beyond abstract representation, it is supposed to be a multi-sensorial experience to increase tacit knowledge (Mancuso, 2011).

There are several contemporary examples of acquiring, and handling data from the "real" world, representing and presenting it in popular TV and web applications (Grau et al., 2015). The Lab embodies both trajectories: it develops visualizations that convey scientific phenomena using authentic scientific data while challenging audiences with perceptual or experiential engagement.

The roots of this visual immersive tradition stretch back centuries. Robert Hooke's *Micrographia* (1665) and Ernst Haeckel's *Kunstformen der Natur* (1904) brought otherwise invisible natural phenomena into perceptible, almost tactile forms, combining precision with aesthetic attention. In the 20th and 21st centuries, scientific documentary films and experimental science filmmaking extended this visual immersive impulse. Early experimental scientific films in France and Italy were technical innovations and artistic avant-garde at the same time (Bernabei, 2025:28).

Later productions such as Jacques Cousteau's *The Silent World* (1956), David Attenborough's BBC series—from *Life on Earth* (1979) to *The Private Life of Plants* (1995)—and National Geographic and IMAX documentaries also employed techniques such as time-lapse, macro- and micro-photography, and immersive soundscapes to allow audiences to inhabit environments otherwise inaccessible.

In this tradition of television for general audiences, the internationally broadcast *Universum* documentary productions *Limits of Perception – Grenzen der Wahrnehmung* (2001), *NatureTech – BIONIK – Das Genie der Natur* (2006), *TimeLimits – Grenzen der Zeit* (2008), *Limits of Light* (2011), and *Planet You – Wir sind Planeten* (2012) were produced. These works constituted the foundational basis for the subsequent establishment of the Science Visualization Lab and were presented at the inaugural edition of the *Figuring the Invisible* conference (Bellano, 2023), where they operated as case studies of immersive TV documentaries, offering concrete material for methodological and theoretical discussion.

Scientific illustrations continue to immerse audiences in the depiction of natural phenomena, as exemplified in works such as *Science Illustration* (Escardó and Wiedemann, 2021). Visual strategies in these illustrations enable complex information to be rendered legible, accessible, and compelling. These works underscore that visualization has not only accompanied but has actively constituted the production and communication of scientific knowledge across historical and contemporary contexts. Similarly, *Science from Sight to Insight* (Gross and Harmon, 2013) emphasizes that visualization has been central to making scientific knowledge intelligible and engaging. Additionally, for instance, Neuroaesthetic studies reinforce this continuity: Researchers (ie Ramachandran and Hirstein, 1999; Gallese and Guerra, 2019) demonstrate that both cinematic and installation-based visualizations engage perceptual, emotional, and empathetic faculties.

Another example shown at the conference's second edition, Peter Galison's science film making is an example for contemporary deepening of this tradition. In works such as *Black Holes: The Edge of All We Know* (2020), which explores the imaging of black holes, he combines live-action footage with animation to visualize abstract concepts and to render the complex, collaborative processes by which scientists construct images from data. His films emphasize points where physicists, experimenters, engineers, and artists interact.

The Science Visualization Lab mirrors and extends these strategies through immersive, interactive installations. For example, the Lab's projects often use 3D visualization, projection mapping, and Augmented Reality to make complex biological, or environmental phenomena tangible. Similar to Galison's animated sequences, the Lab visualizes processes rather than just outcomes, showing the collaborative dimensions of research and prioritize means for audiences to experience science in accurate metaphors.

In the book *Doors to Hidden Worlds—The Power of Visualization in Science, Media, and Art* (Fröschl and Vendl, 2023) a review of the first seven

years of the Science Visualization Lab was published. Therein, an expanded discussion on *Computer-Animated Scientific Visualizations* (Fröschl, 2019) was elaborated. The work on the topic of visual effects for documentary films, as well as the recent book presentation led to the invitation as one of the keynote speakers to the conference's second edition *Figuring the Invisible* and chairing a conference track with the title *Science Visualization from Theory to Fiction and Documentary* at the University of Padua. The metaphor to open doors to hidden worlds fit to the main topic of the conference: Visual effects and animations to make invisible elements visible to show them in documentary films. This is also one of the main objectives of the Science Visualization Lab. Starting in the late 1960ies, the founder of the lab, chemist, documentary director and producer Alfred Vendl experimented with *Doors to Reality* (Vendl, 2023) and soon discovered his passion for documentary shots that show something that cannot be seen with the naked eye. A side his career as university professor, he continuously funded new elaborate and expensive visual and special effect shots for his documentary film productions.

In 2016, the Science Visualization Lab was established to advance these initiatives, as the president of the University of Applied Arts Vienna at the time recognized the potential for innovative scholarly inquiry and international visibility for the university. The exploration of human perception through *computer-animated scientific visualizations* has proven valuable in bridging the gap between the arts and sciences.

The Science Visualization Lab has emerged as a hub for such interdisciplinary collaborations, employing advanced scientific imaging techniques in close collaboration with scientific imaging experts to make the microscopic and nanoscopic worlds through authentic visual effects accessible to the public. The visualization of multiple problems humankind faces today is the key to understanding and awareness, therefore the role of visualizations should not be underestimated in addressing global topics such as climate change, genetic engineering, and ecological sustainability. *Computer-animated scientific visualization* represents a hybrid discipline we can describe as a combination of emotional, sensory, subjective, objective, rational, and analytical approaches. Unlike traditional scientific visualizations that prioritize raw data representation, this method allows more creativity, but still with accurate data representation, aesthetic experimentation. The goal is not just to present information but to engage audiences emotionally and intellectually, encouraging even more than conventional scientific visualizations visual thinking.

The lab's methodology integrates authentic scientific imaging with artistic processes. Tools like scanning electron microscopy (SEM), computed tomography (CT), confocal laser scanning microscopy (CLSM), and light microscopy generate high-resolution datasets that are carefully processed into visual models. These visualizations, whether as standalone animation, as sequence in a documentary film or as a part of interactive art installations, serve as *visual doors* to worlds that are not visible for humans otherwise. The presentation at the conference included an overview of relevant projects that were created since the founding of the lab.

2. Project examples and methods of the Science Visualization Lab to make the invisible visible

Productions out of the history of the Science Visualization Lab were chosen as visual examples for making the invisible visible with computer animations and visual effects. The productions shown were excerpts of documentary films and exhibition documentation videos. Several projects

highlight the lab's innovative, increasingly immersive and experimental approach. One example is *CRISPR/Cas9-NHEJ: Action in the Nucleus* (2017), a project that visualizes the groundbreaking gene-editing technology CRISPR in colorful detail. Using color-coded animated representations, the project depicts the "dance" of molecular interactions during DNA editing in the nucleus of a cell. The project uses "jelly cloud-like" protein models and philosophical soundscapes to provoke thoughts on the ethical and scientific implications of genetic manipulation. Such facts make attentive recipients admire their own human bodies and the wonder of biological existence. The video was presented in a full-dome environment as a part of the *Future Room* (2017) installation by Ruth Schnell and on several occasions as standalone piece.

Another striking example and the internationally most successful project so far is *NOISE AQUARIUM* (2016) (Figure1) a collaboration with the head of the Art|Sci Center UCLA, Victoria Vesna. For the project, the author transformed tomographically scanned microscopic plankton into immersive, whale-sized computer-animated projections to illustrate the impact of noise and plastic pollution on marine life. Visitors interact in the installation, activating underwater noise and visualizing its effects on plankton. The visitors of the virtual reality interactive installation are invited to metaphorically balance the ecosystem with the impact of their own weight using a custom-made platform as an interaction device. The project's aim is to create a visceral response to the vicious circle to all these destructive techniques related to obtain fossil fuels and humanity's constant noise and plastic pollution of the environment. The project makes not only microscopic plankton species with fascinating shapes visible, but also the tendency to killing our own source of living.

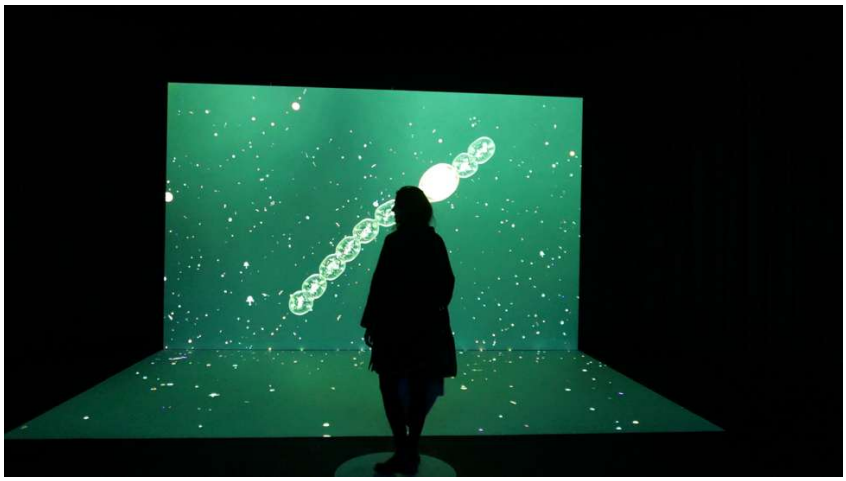

Figure 1. NOISE AQUARIUM in the Barbican Center London (2022). Photo by Martina R. Fröschl.

During the global pandemic of SARS-CoV-2, the project Virus Dice (2020) was created. It uses animations and an interactive board-gameplay performance to explain SARS-CoV-2, its infection pathway, and the probabilistic nature of health and disease. The dice metaphor emphasizes the role of chance and uncertainty, aiming to lower the entry threshold to deal with highly complex topics of biochemistry.

Another project that deals with ecological issues of us humans with our planet is Butterfly}Pieris{Effect (2022) (Figure 2. It highlights the life cycle of the Cabbage White Butterfly (Pieris brassicae) while advocating for biodiversity and that every species, even a pest species is a vital part of the planet's ecosystem. The project challenges the human-centric worldview, encouraging empathy and recognition of the interconnectedness of ecosystems. The art-sci installation tries to question the dichotomy of 'our' (human) gaze and 'their' (insect) point of view.

Figure 2. *Butterfly}Pieris{Effect* (2022) at NTU Singapore. Photo by Martina R. Fröschl.

The creative process and the openness for experimentation is not without challenges, every experiment has no clear outcome and therefore it might need more time, for processing and reflection. The polysemic reception of visualizations depends on the culture in which recipients grew up and are an often underestimated issue (D'Ignazio and Klein, 2020).

The field of cultural studies widely discusses the encoding and decoding of meaning (Ross, 2011), visualizations might be particularly encoded and decoded individually and interpreted subjectively.

Additionally, the environment and the location in which the computer animations and installations are presented have a huge influence on the general reception of the projects. Misinterpretation might happen, like in every form of presentation. However, this ambiguity might also be a strength, allowing various audiences to find personal meaning.

The lab's commitment to experimentation is evident in its openness to *happy accidents* such as rendering errors and glitches, which often reveal new artistic possibilities. These *happened pieces* are celebrated as documents of the creative process, demonstrating the interplay between technology and human creativity.

Looking ahead, the Science Visualization Lab seeks to deepen its interdisciplinary collaborations, blending artistic and scientific processes and skills to inspire curiosity and critical thinking. The lab emphasizes the importance of local and personal engagement, echoing Donna Haraway's call for situated knowledge, we should not think that objectivity is about disembodied detachment (Haraway, 1988).

Therefore, interested artists and researchers of all disciplines are invited to collaborate with the lab. For instance, the collaborative project *Boundaries of Visualization* (2023) (Figure 3) was started within this format including artist and biochemist Mehrta Shirzadian, and computer scientist and artist Peter Mindek. The project discusses advanced imaging techniques in molecular biology, emphasizing how conventional methods produce unclear results without enhanced lighting and data analysis. The project uses data from the innovative MINFLUX microscopy method to create a musical and 3D visualization of protein distributions related to Alzheimer's and Parkinson's diseases in mitochondria. Mitochondria are highlighted for their unique origin through symbiogenesis, where they were absorbed by single-celled organisms to enable complex life. This concept challenges traditional evolutionary models of competition and is creatively explored through collaborative visualizations of human skin.

Figure 3. *Boundaries of Visualization* at Schmiede Hallein 2023 by Mehrta Shirzadian, Peter Mindek, and Martina R. Fröschl. Photo by Martina R. Fröschl

The participation in conferences is a crucial part in starting new topics or new projects in the Science Visualization Lab. The topics and collaboration possibilities are probably almost unlimited. By fostering empathy, embracing ambiguity, and visualizing complexity, the lab hopes to inspire action on global challenges while cultivating a deeper appreciation for the invisible worlds that sustain life.

We might not predict the future but there might be visionary ideas, often formulated long before their time, that should guide humanity. In an era where science often struggles to communicate its value to a skeptical public, the work of the Science Visualization Lab represents a vital bridge, turning abstract data into tangible, emotional, and inspiring experiences.

3. Discussion

Imaging techniques and scientific communication are inherently tied to the tension between objectivity and subjectivity. This interplay influences not only the creation and interpretation of scientific imagery but also the broader context in which scientific knowledge is represented, presented, and translated for general and professional audiences. As art and science converge in these efforts, debates arise concerning the objective nature of these presentations.

Scientific imaging aims to provide accurate, objective representations of phenomena. However, the tools and processes used often involve subjective decisions. For instance, choices regarding color schemes, data thresholds, and image enhancements introduce interpretative layers. These subjective elements are necessary for making abstract or complex data comprehensible but can lead to misconceptions if not carefully managed (Tufte, 1997:24). This carefulness as part of integrity is essential to both scientific and artistic research.

The translation of scientific knowledge into accessible formats involves representational strategies that resonate with a variety of audiences. Traditional methods often favor didactic approaches, presenting facts in an authoritative manner, especially in TV documentary films. However, the increasing use of immersive technologies, such as virtual and augmented reality, challenges these norms, enabling audiences to experience phenomena more directly (Drucker, 2021:13).

In this context, interdisciplinarity emerges as a crucial factor. For example, collaborative efforts between scientists and artists can result in hybrid works that capture both empirical precision and humanistic insight. Such projects redefine how science communicates its narratives, emphasizing emotional and experiential dimensions (Wilson, 2010).

In artistic presentations, the "fourth wall" refers to the implicit barrier between the audience and the creators. Breaking this wall transforms passive observation into active participation, encouraging a more personal connection with the content (Schlütz et al., 2020).

Immersion, to "step inside" scientific phenomena, might democratize knowledge but also challenge perceptions of science as detached or inaccessible. Artistic strategies, such as metaphor and narrative, further enhance these experiences, translating abstract concepts into relatable terms. Art installations as well as TV documentaries can help these democratization approaches.

Proponents of a didactic approach assert that maintaining objectivity is essential for credibility, particularly in a post-truth era where misinformation is an issue. Conversely, advocates for subjective or hybrid methods argue that emotional engagement is critical for motivating action and fostering empathy, especially on complex, large-scale problems (Nisbet, 2009).

The context in which scientific data is presented might significantly shape its impact. A medical imaging study displayed in a clinical journal serves a markedly different purpose than the same data exhibited in a public art installation. Context influences the choice of visual language, the intended narrative, and the expected audience response.

Such initiatives highlight the role of storytelling in scientific communication, demonstrating how context-sensitive approaches can make complex data more accessible and meaningful, especially in embracing pluralism the most complete knowledge comes from synthesizing multiple perspectives, with priority given to local, indigenous, and experiential ways of knowing (D'Ignazio and Klein, 2020).

The interplay of objectivity and subjectivity in imaging and communication challenges traditional paradigms in both science and art. As the metaphorical "fourth wall" dissolves, art-science collaborations adopt innovative strategies to represent humanity's scientific endeavors, sparking debate over their didactic, subjective, or objective nature. Ultimately, the presentation of scientific knowledge must balance precision with

accessibility, tailoring its approach to diverse audiences and contexts to maximize its impact.

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