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ARTICLE

On the Aesthetics of Scientific Experimentation

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Abstract

We usually think of aesthetic experiences as belonging to our engagement with artistic products such as paintings, sculptures, literature, and music, or nature itself. But science can be a source of a wide range of aesthetic experiences, and scientific pursuits in their turn can be shaped by aesthetic judgements. In this piece, I explore how scientific experimentation, through the choice of design, production of results, performance, and creative agency, is both shaped by aesthetic judgements and a source of a broad range of aesthetic experiences. The piece reflects why the aesthetic dimension of scientific practice matters in the production of knowledge.

Keywords: aesthetic values; beauty; experiments; objectivity

When we think about aesthetic experiences, to our mind come examples of experiences we have had when engaging with art and nature. We usually associate the experience of beauty, awe, and wonder with the enjoyment of a certain kind of artefact, whether a sculpture, a painting, a piece of music, or an art installation. For most of us, our first aesthetic experiences did not take place in an art gallery, however. They took place in nature. Whether a beautiful sunset, hexagonal honeycomb structures, complex colourful fungi, or the wings of butterflies, we become acquainted with experiences of beauty, awe, and wonder way before we find ourselves at an art exhibition by simply engaging with nature. Once we start engaging with artistic artefacts, we further discover that, beyond valuing the properties of the object, we can find great beauty in the appreciation of the creativity and the imagination of the artist encapsulated in the artefact they have created. Over the past decade, much work has been done to expose that engaging with science and its history can parallel the aesthetic experiences we have of art and nature, and in fact, they are often hard to tell apart.[1] In this piece, I expose the aesthetically rich life of scientists, showing that it is not only the phenomena under study that can be found profoundly beautiful, but so can be the artefacts

[1] See Breitenbach 2013; Currie 2023; De Cruz 2004; Engler 1990, 2002; Holmes 1996, 2001; Hossenfelder 2018; Ivanova 2017a, b, 2020, 2023b, c, Ivanova and French 2020; Ivanova and Murphy 2023; Ivanova et al. 2024; Ivanova and Vaidyanathan 2026; Jacobi et al. 2022, 2023; Kivy 1991; Kosso 2002; Kozlov 2023a, b; Kuipers 2002; McAllister 1996; Montano 2014; Murphy 2023; Parsons 2023; Parsons and Reuger 2000; Stafford 1994; Todd 2008; Toon 2015; Turner 2019; Wragge-Morley 2020; Wylie 2021.

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scientists create, from the instruments and tools they use in their experiments, to the results and performances of those experiments. These aesthetic dimensions of experiments deeply enrich scientific practice and offer not only motivation for research but can also play a role in the pursuit of knowledge.

1. Design and significance

In 1851, Léon Foucault hangs a heavy brass ball attached to a rope from the ceiling of the Pantheon in Paris and swings it in motion. Underneath the pendulum, he places sand in which the ball leaves traces while swinging from left to right. To this day, we celebrate this as one of the most beautiful experiments in science. But why? Were we to witness this experiment, still open to the public, we would certainly find beauty in its visual features, not only because it is set up in one of the most beautiful buildings in Paris, but also because, in some way, it reminds us of an artwork, a kinetic sculpture with a mesmerising back and forth motion. But the visually pleasing features of the experiment are not solely responsible for the reputation of this experiment.[2] What makes Foucault's pendulum among the most beautiful experiments in science is what it accomplishes, its significance, and the ingredients needed to do so. With this experiment, Foucault demonstrates to the public a long-contested fact. It proved that the Earth indeed rotates around its axis, a profoundly significant contribution. How the experiment achieved this significant result, its design, was utterly simple, involving the most minimal of ingredients: a rope, some sand, a ball, and a tall enough building to allow for the pendulum to move back and forth. Over time, as the pendulum slowly moved back and forth, it left traces in the sand beneath it. Since the traces in the sand were not aligned with each other, Foucault had demonstrated the Earth's rotation beneath the pendulum. It is this relationship between the design of the experiment and its significance that presents a very different kind of beauty.[3] Rather than being something that strikes the senses, the beauty of Foucault's pendulum is to be found in our intellectual reflection and appreciation of what this experiment achieves, its significance, and how it does so. The visually pleasing features of the experiment are not to be considered irrelevant. They function as an invitation for engagement. But the beauty we uncover through understanding the design of the experiment and its results offers us a deeper experience and invites appreciation not only of the artefact itself—the experiment—but also of the creativity and ingenuity behind its design.

2. Creativity

After one of the most profound discoveries of the 20th century, the discovery of the structure of DNA, the scientific community had to address the question of DNA replication. James Watson and Francis Crick, who posited the double helix structure of DNA in their *Nature* article "Molecular Structure of Nucleic Acids," published in 1953, had already identified a possible replicating mechanism, but two further contenders were available. The three competing hypotheses, known as conservative, semi-conservative, and dispersive, posited different ideas on the replication of DNA. Identifying the correct replication mechanism became the goal of Matthew Meselson and Franklin Stahl, who, only five years after Crick and Watson's discovery, published the results of their famous experiment, confirming that DNA indeed replicates semi-conservatively. The experiment became celebrated as the most beautiful experiment in biology.[4] The experiment is celebrated for

[2] Ivanova 2021, 2023a.
[3] Ivanova 2023b, c.
[4] Holmes 2001; Ivanova 2023b.

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producing important, clear, and decisive results that gave it the status of a crucial experiment in science, decisively selecting one among three competing hypotheses. As stated above, producing significant results is only half the story; the elegant results were also achieved by designing a highly elegant, original, and beautiful design. Like Foucault's pendulum, the aesthetic value of this experiment lies in the relationship between its design and its results. Beyond valuing this dimension, in appreciating the design, we also appreciate the original and creative ways in which Meselson and Stahl decided to label DNA in the experiment. Using density gradient centrifugation to study the weight of the different strands of DNA, Meselson and Stahl deviated from standard techniques used at the time for DNA labelling, creating a rather original design.[5]

We praise artists for their imagination and creativity, employing different techniques and styles to convey meaning and evoke in us different emotions. But the creative thinking and use of the imagination in science are also central elements in the process of production and objects of our appreciation. As historian of science Gerard Holton writes when discussing the ingenious experiments designed to detect ether drift in the 19th century, "nobody before Michelson was able to imagine and construct an apparatus to measure the second-order effect of the presumed ether drift. The interferometer was a lovely thing". To measure the presumed effects, Albert Michelson and Edward Morley created a highly elegant and simple configuration to measure the presumed effect. To implement the design, they needed an instrument capable of high-precision measurement. Michelson's interferometer is to this day one of the most important scientific instruments that has been used in countless discoveries since its invention. While the experiment itself did not deliver on its aims, Michelson's creativity and imagination in setting up this experiment and creating the required instruments have certainly remained valued and appreciated.[6]

Being creatively involved, having a sense of creative agency over the design of a scientific product or performance of tasks, has been identified as a central source of work satisfaction and reason for doing science in a recent study. Ivanova et al. show that aesthetic experiences in the lab matter centrally to scientists' motivation for pursuing science and their overall satisfaction at work.[7] Feeling creatively involved in the lab, whether it is by crafting elegant experiments, clear and well-presented results, or having a sense of creative freedom performing experiments, was all identified as a source of work satisfaction. The study shows that lacking opportunities to be creative was seen as drudge and unrewarding work, while being creative and encountering surprising results were seen as the ultimate source of aesthetic pleasure. Surprising results were not only seen as a source of awe and wonder, but also an opportunity for exercising creativity in imagination. The participants in the study consistently stressed the importance of feeling creative agency and identified their own involvement in shaping a scientific process with their own aesthetic sensibility as highly rewarding and important.

3. Performance

Like artistic performances, scientific experiments have often been performed to audience. In the early days of the Royal Society, natural philosophers utilised newly invented instruments, such as the air pump, to study conditions that were previously impossible. While debates on the legitimacy of experimentation as a way of discovering nature's secrets were taking place, the aesthetic dimension of this practice contributed significantly for

[5] Ivanova 2023b.
[6] Ivanova 2023c.
[7] Ivanova et al. 2024.

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experiments to become integral part of the scientific method.[8] The experiment became a public spectacle with the experimenter like a performer demonstrating the intriguing phenomena made possible with the new tools of the day.[9] In his experimental notes, Joseph Priestley reflects on his experiments with electric currents, stating that they offered "the most delightful spectacle." Sharing these experiences of awe, delight, and pleasure that experimentation evoked became central to experimental practice. While today scientific experiments rarely constitute public spectacles in the same way, the tradition to invite the public into the lab continues even if it takes new forms. At the University of Queensland, which hosts the longest-running experiment to date, visitors can experience the spectacle of Thomas Parnell's beautiful exploratory experiment. Set up in 1927, the experiment demonstrates the behaviour of highly viscous liquids that appear solid, with droplets falling through the glass funnel over a period of a decade or more. This experiment is closely related to the 17th- and 18th-century experiments, including a simple setup, visually pleasing features, and its public nature, being set up outside a lecture theatre. The experiment immediately invites engagement and evokes in the viewer fascination and desire to understand the studied phenomenon, as well as to appreciate the elegance of the experimental design and its import. While contemporary experiments tend to be big, involving large communities across different labs and sophisticated technology, they continue to evoke aesthetic appreciation. In high-energy physics, where particle experiments lack the sense of immediateness and involve heavy data analysis, one can still find beauty in the design of modern experiments, in which we can find surprising elegance behind complex structures and configurations.[10] The sheer size of these experiments and the data they produce itself can evoke aesthetic experiences like awe and sublime.

The aesthetic responses we have to experiments can be diverse; they can be a product of appreciating the creative thinking behind the experimental design, or they can be due to our appreciation of the aptness of the experimental design, or how elegantly or beautifully it was set up to obtain its results. The experimental results themselves can be beautiful, and the experiment can engage with beautiful phenomena and utilise aesthetically pleasing instruments. Appreciating such setups can be paralleled to the aesthetic experience artworks evoke in us. We have demonstrated that the aesthetic dimension of experiments has played an important role in the pursuit of knowledge—from helping to legitimise experimentation as part of the scientific method in the first place, to motivating the exploration of phenomena, to guiding scientists in aptly designing experiments and presenting their results, and to acting as a primary motivator and reward for scientific work.

Milena Ivanova is a philosopher of science and lecturer at the University of Cambridge. She is based at the University of Cambridge Professional and Continuing Education, the Leverhulme Centre for the Future of Intelligence, and Newnham College. She is the author of *Duhem and Holism* (Cambridge University Press) and the co-editor of *The Aesthetics of Science: Beauty, Imagination and Understanding* and *The Aesthetics of Scientific Experiments*. Ivanova received the American Philosophical Association Op Ed Prize for her article "The Beautiful Experiment" and the APA Routledge Taylor and Francis Award for her article "What Is a Beautiful Experiment?".

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[8] Wragge-Morley 2020.
[9] Ivanova and Murphy 2023.
[10] Ivanova 2023b.

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