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EDITED BY
Ayse Banu Demir,
İzmir University of Economics, Türkiye

REVIEWED BY
Eqram Rahman,
Innovation Aestheitcs, United Kingdom

*CORRESPONDENCE
Bruno B. Andrade
bruno.andrade@fiocruz.br

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The aesthetic lens: embracing complexity through art in medicine and science

Bruno B. Andrade[1,2]*, Mariana Araújo-Pereira[1,2] and Helder I. Nakaya[3,4]

[1]Multinational Organization Network Sponsoring Translational and Epidemiological Research (MONSTER) Institute, Salvador, Brazil, [2]Laboratory of Clinical and Translational Research, Gonçalo Moniz Institute, Oswaldo Cruz Foundation, Salvador, Brazil, [3]School of Pharmaceutical Sciences, University of São Paulo, São Paulo, Brazil, [4]Hospital Israelita Albert Einstein, São Paulo, Brazil

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Introduction

In the evolving landscape of medicine and science, where precision, data, and technological advances are increasingly emphasized, the role of art and aesthetics has often been underappreciated. Yet, if we reflect on the process of discovery, clinical practice, and scientific investigation, we find that art and science are intrinsically linked, not as opposites but as complementary forces. The aesthetic experience—the shapes, colors, and sensations that art evokes—has profound implications for how we understand, interpret, and approach the world around us. In this piece, we argue that exposure to art and aesthetics is a fundamental component of shaping more holistic, creative, and insightful medical professionals and researchers.

Rationality meets sensation

Medicine and science have traditionally been domains ruled by rationality, objectivity, and precision (Price et al., 2009). Nevertheless, the very nature of our work often confronts us with ambiguity and the limits of these tools. Diseases do not always follow predictable patterns, and biology, particularly in the era of multi-omics, reveals layers of complexity that challenge linear thinking. Here, art offers a crucial bridge, allowing us to transcend rigid structures and embrace the inherent messiness of life (Root-Bernstein, 2001).

In art, especially in the abstraction and disruption of traditional forms, we encounter what seems chaotic or non-sensical. But this is where beauty lies—in the interplay between form and formlessness, in the balance between symmetry and disarray. Physicians and scientists alike can draw on these lessons. When confronted with a difficult diagnosis or puzzling data, the capacity to think beyond the binary, to see patterns where none were previously visible, becomes an asset (Barabási et al., 2011). This artistic sensibility trains the eye and the mind to remain open, adaptive, and curious in the face of complexity (Reilly et al., 2005).

There are several types of art: literature, drama, music, dance, and visual arts. The latter, in particular, has a significant impact on knowledge retention, learning, and scientific education (Tyler and Likova, 2012). When integrated into the development of scientific thinking, they help simplify complex concepts while maintaining the aesthetic and structural depth of scientific content (Simões and Sousa, 2024). Additionally, they foster attention to detail and encourages deep thinking about the subject. It is no surprise

that there is a movement to transform the science, technology, engineering, and mathematics (STEM) learning framework by incorporating the dimension of "Art," leading to STEAM (Zhang and Jia, 2024).

STEAM-based education has been implemented in different parts of the world and across various learning stages, from early childhood to high school, consistently demonstrating positive outcomes. Studies indicate that incorporating artistic elements into scientific disciplines fosters creativity (Ozkan and Umdu Topsakal, 2021; Zhang and Jia, 2024), strengthens scientific critical thinking (Ananda et al., 2023), and improves scientific literacy (Twiningsih and Elisanti, 2021). This multidisciplinary approach, which integrates scientific, mathematical, technological, and artistic principles, supports the development of individuals with stronger critical thinking and problem-solving abilities, which can have a surprisingly positive impact especially on those who wish to pursue the path of science and medicine.

The aesthetic in medical training: sensitivity to complexity

Medical training, historically rigid in its focus on anatomical knowledge and clinical protocols, should evolve to include art as a central pillar. It is not enough to produce competent technicians; we must develop physicians and scientists who are deeply sensitive to the nuances of human biology and behavior (Bardes et al., 2001). Art teaches us to appreciate ambiguity, to be comfortable with uncertainty, and to recognize that every case, every patient, is a complex interplay of variables (Frank, 2005).

By incorporating aesthetics into medical curricula, we can encourage students to see beyond the superficial—to embrace the layers of complexity that define both the human body and the diseases that affect it. Art, through its exploration of form, color, and texture, mirrors the intricacies of biology. Just as an artist might work with disruptive colors or asymmetry to provoke thought and evoke emotion, a physician must be attuned to the subtle disruptions in a patient's clinical presentation (Shapiro and Rucker, 2004).

Beyond honing observation skills, art fosters a deeper sense of empathy. By engaging with art, medical professionals are trained to view the human experience through multiple lenses, broadening their emotional range (Dolev et al., 2001). This is critical in-patient care, where understanding the lived experience of illness is as important as the clinical diagnosis.

The role of aesthetics in learning and scientific understanding

Although beauty and aesthetics may seem subjective, research suggests they follow identifiable patterns rather than being entirely personal constructs. Neuroaesthetics, a field within cognitive neuroscience, explores the biological foundations of aesthetic experiences, offering insights that can be applied to science education (Chatterjee and Vartanian, 2014). While debates persist, several findings point to the significant role aesthetics play in learning and cognitive development, particularly in children.

Aesthetic experiences influence attention and engagement: when individuals perceive something as beautiful, they tend to focus more intently and exhibit greater curiosity (Jakobson and Wickman, 2008). Conversely, encountering something perceived as unattractive or unsettling can generate an aversive response that hinders learning. This "pleasant" beauty may be linked to color schemes commonly found in nature and to structured, recognizable shapes, which are often preferred across different populations (Nascimento et al., 2021). The familiarity and order these elements contribute to a perception of harmony, reinforcing cognitive comfort.

Interestingly, aesthetic appreciation extends beyond traditional artistic domains. A study involving mathematicians demonstrated that viewing elegant mathematical formulas activated brain regions associated with emotional responses to beauty. Notably, even non-mathematicians found certain equations aesthetically pleasing despite lacking the knowledge to interpret them (Zeki et al., 2014). This suggests that aesthetic perception is closely tied to an innate sensitivity to symmetry and organization, rather than merely to prior understanding.

Complexity as opportunity, not obstacle

In today's scientific research, particularly in the realm of multi-omics, the vast amount of data available can feel overwhelming (Barabási et al., 2011). The temptation is often to simplify, to reduce complexity in an attempt to make predictions more manageable. However, biology resists such reductionism. It is inherently complex, imperfect, and sometimes unpredictable (Price et al., 2009). The relationship between genes, environment, and disease is not linear but dynamic, with countless variables interacting in ways we are only beginning to understand, while also demonstrating ever-increasing complexity in the interplay of different molecules, systems, and phenomena (Figure 1).

But what is complexity, and how can art help us better understand the biological world? While something complicated may involve many interconnected parts, it typically follows a structured set of rules that, given enough time and effort, can be broken down and understood. A mechanical watch, for example, is complicated—its gears and springs interact in precise ways, each with a defined and necessary function within a predictable system. At first glance, it might seem complex, but a watchmaker certainly would not think so. And even someone without prior knowledge, given enough time and access to a manual, could eventually grasp its mechanics—even if it took some time to get used to the elements, terms, and functioning of the machinery.

However, the human body—and biological processes as a whole—does not have an instruction manual. Or at least not one so detailed and defined that it allows us to understand how each small particle matters and interacts in the system, and that is why it is a complex field. Complexity arises when the interactions between elements create unpredictable behaviors, patterns, and feedback loops. We probably don't understand or even know in their entirety all the components of biological systems, which makes it difficult to explain them completely. And that is complex!

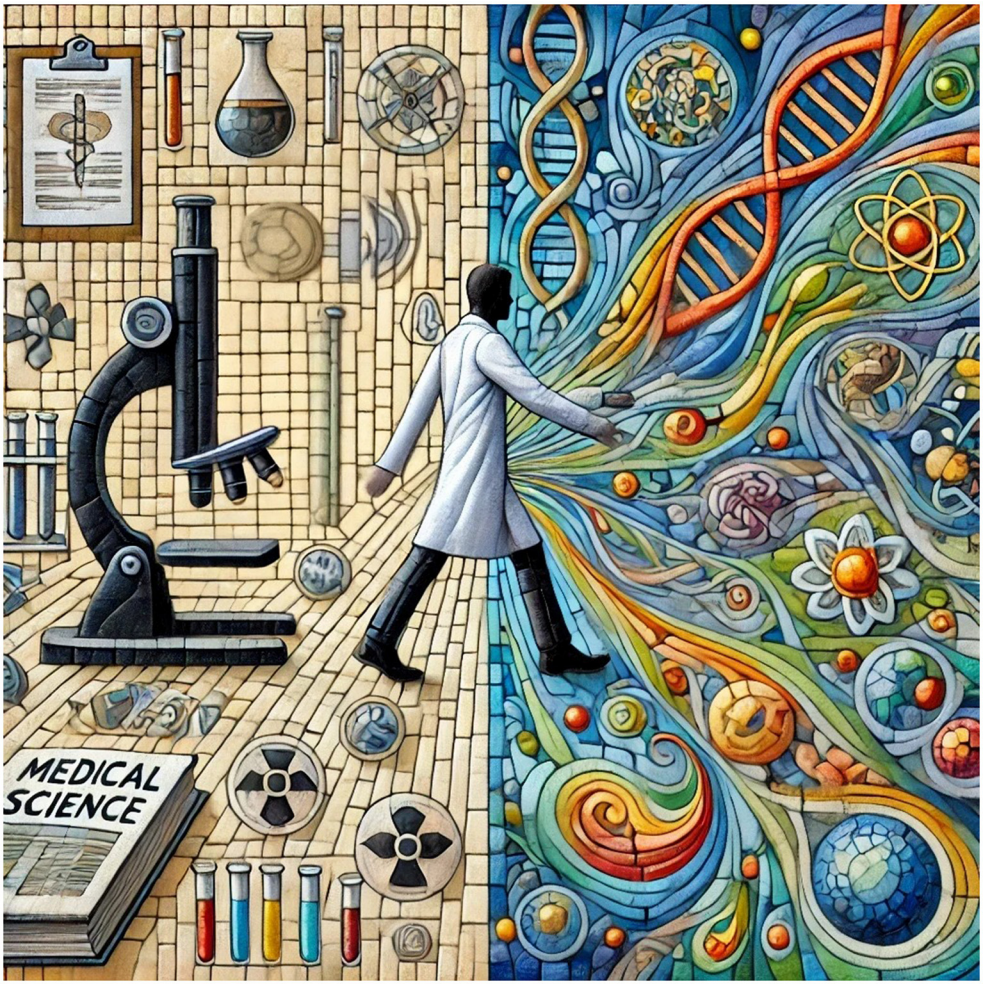

FIGURE 1
Bridging science and art: the aesthetic integration in medical discovery. This artistic representation illustrates the convergence of scientific precision and creative exploration. On the left, traditional scientific tools and symbols emphasize structure, order, and rationality, depicting how science approaches problems through data, experimentation, and analysis. On the right, flowing vibrant forms represent art's role in fostering creativity, intuition, and empathy. The figure symbolizes how the combination of both fields enables medical professionals and scientists to navigate the complexities of biology with more innovative and holistic perspectives. The figure underscores the idea that art offers essential insights into understanding and embracing the intricate, often chaotic nature of scientific inquiry. Created by the authors in GPT-4o (no permission required).

Science is practical when it comes to deciphering complexity. However, traditional scientific methods, which favor reductionism—breaking problems down into smaller, more manageable parts—can sometimes struggle with emergent properties that only emerge when a system is viewed as a whole. This is where art becomes a valuable tool.

Art prepares us for this complexity. It teaches us not to fear the unknown or the chaotic but to engage with it, to find patterns within it, and to embrace its unpredictability (Koob, 2008). Just as an artist takes raw materials and transforms them into something meaningful, so too can scientists and clinicians approach complex datasets with a creative mindset (Zagalo, 2012). Rather than being daunted by the volume of information, we should see it as an opportunity to uncover new insights that may emerge not through traditional methods but through imaginative leaps and aesthetic sensibilities.

Teaching art in medical and scientific institutions

The integration of art into medical education should not be seen as an optional exercise but as a core component of shaping future physicians and scientists. By fostering an appreciation for the aesthetic dimensions of our work, we equip students to approach their practice with greater creativity and empathy. Senior medical scientists, too, stand to benefit from this approach, as the pressures of publishing and producing often stifle innovation and out-of-the-box thinking.

Several medical schools have already implemented structured programmes that integrate art into their curricula. At the Yale School of Medicine, the Program for Humanities in Medicine (https://medicine.yale.edu/humanitiesinmedicine/) offers students opportunities to enhance their observational skills, engage with diverse perspectives, and develop strategies for navigating the

inherent uncertainty of medical practice. This is achieved through a combination of curricular and extracurricular activities, including writing workshops, as well as events focused on poetry, prose, and visual arts (Yale School of Medicine, 2024).

Visual arts training, in particular, has been linked to improved diagnostic accuracy, highlighting the direct connection between visual literacy and clinical reasoning. A randomized controlled study conducted at the University of Pennsylvania found that first-year medical students who participated in structured art observation sessions at the Philadelphia Museum of Art demonstrated significantly enhanced observational skills when evaluating clinical ophthalmology cases, compared to peers who did not receive art training. This benefit stems from the overlap between the core principles of visual arts education—observation, description, and interpretation—and the cognitive processes involved in clinical assessment (Gurwin et al., 2018). Similar findings were reported in a study involving students from Harvard Medical and Dental School, who participated in theoretical training on concepts such as perspective and paradigms, alongside practical observation sessions at the Boston Museum of Fine Arts. Following the training, students showed improved observational accuracy and greater use of fine art concepts—including color, symmetry, and spatial relationships—when documenting physical examination findings (Naghshineh et al., 2008).

Teaching art as a means to engage with complexity allows individuals to break free from conventional frameworks and to view their work through a new, more expansive lens. This practice is especially critical as medicine and science become more interdisciplinary, requiring professionals who can synthesize diverse forms of knowledge and make connections across fields (Ford, 2002).

Moving beyond theory

To move beyond theory, practical steps must be considered. Institutions should develop structured programs that incorporate visual arts, literature, and other creative disciplines into science and medical training. This could take the form of observational drawing exercises in anatomy courses, narrative medicine workshops to refine clinical empathy, or interdisciplinary collaborations between artists and scientists to explore new modes of knowledge communication.

Further research is needed to better understand the mechanisms through which artistic engagement enhances scientific thinking. Longitudinal studies could assess the impact of arts-integrated education on problem-solving abilities, diagnostic accuracy, and communication skills in medical professionals. Additionally, neuroscientific investigations could clarify how aesthetic experiences influence cognitive processes relevant to learning.

Given the increasing complexity of scientific and medical challenges, this interdisciplinary approach is necessity. The ability to navigate uncertainty, think critically across disciplines, and appreciate the interconnectedness of knowledge will be essential for the next generation of scientists and physicians. By embedding art within scientific education, we are cultivating more perceptive, adaptable, and empathetic professionals.

Art and artificial intelligence

As we advance into an age of technological revolution, particularly with the rise of artificial intelligence in medicine, we must not lose sight of the importance of art and aesthetics in shaping our approach to healthcare and science. AI promises to take over many technical aspects of medicine—analyzing vast amounts of data, making predictions, and even performing certain clinical tasks. This shift offers us a unique opportunity to reinvent medical training as a more creative and human-centered field (Gawande, 2014). With robots handling the technical workload, the distinctly human skills—such as empathy, communication, and creative problem-solving—will become even more valuable.

Conclusion

By embracing complexity and by fostering a mindset that is both rational and imaginative, we can produce physicians and scientists who are both technically skilled and deeply aware of the human side of their work. Art can enhance these skills, allowing medical professionals to connect more profoundly with patients and colleagues. It is time we recognize and harness the potential of art and aesthetics, using them to complement the advancements of AI and to enrich the human aspects of medicine.

Author contributions

BA: Conceptualization, Supervision, Visualization, Writing – original draft, Writing – review & editing. MA-P: Conceptualization, Visualization, Writing – original draft, Writing – review & editing. HN: Conceptualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

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Generative AI statement

The author(s) declare that Gen AI was used in the creation of this manuscript. The author(s) used generative AI to produce the illustration displayed in Figure 1. The content is not scientific, and it is rather an artistic view of the role of art in science.

Publisher's note

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