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Imagination and Reason

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On the Dual Anthropological Nature

The second issue of *Dialogues on Design* is dedicated to the topic of artistic research. In keeping with the concept of *Dialogues on Design*, theoretical and scientific contributions are brought into dialogue with creative and artistic works produced at the Design Department of Bielefeld's University of Applied Sciences and Arts. This constellation is likewise characteristic of artistic research. But what exactly is artistic research? There seems to be no simple answer to this question. Does this mean that the question itself is misguided? Should we rather ask about the practices and methods that turn artistic or design activities into research? Is artistic research merely an effect of the academisation of the arts and design pursued in science policy in the second half of the 20th century? Or has it always been inherent in the arts, without ever having been explicitly stated? Does artistic research confiscate the historically attributed disinterested pleasure of beauty, and of art more generally, as a prerequisite for aesthetic experience? What are the epistemological differences between the concepts of research and knowledge in design and the arts on the one hand, and the social sciences, humanities and natural sciences on the other?

More than half a century of design and artistic research, and their reflection in the Anglo-American sphere, two decades after their introduction in German- and French-speaking academic areas, these questions are still debated, as this special issue also attests. Against this backdrop, Josef Früchtl could still ask in 2019 what the ghost of artistic research actually is—something that everyone talks about, yet no one has ever seen; or rather, that everyone talks about, but no one knows exactly what it means.[1] Yet, the more intangible the signified, the more signifiers—or chains of signs—it produces. As a result, there are now numerous attempts to define artistic research. Some describe the know-ledge of the arts as implicit, non-propositional knowledge, embodied in creative processes and designed artefacts. Others emphasise the enhancement of experience and world disclosure through these very processes and artefacts.[2] Methods and method development in the arts also play a central role in this context.[3] Furthermore, material analyses and empirical surveys of recipients and users have been identified as specific research components of artistic and design practices. This is often more evident in application-oriented design than in art, which is considered to be purposeless to a greater or lesser extent.[4]

For Früchtl, clarifying the relationship between art and science proves more fundamental than these diverse—and at the same time one-sided—definitions of artistic research.

He identifies four positions within philosophical aesthetics:[5] 1.) The antagonistic model, according to which art and science are mutually exclusive. True knowledge can be attained either through science or through art, with the path of logo-centric science historically regarded as the silver bullet. 2.) The complementary model, where art and science are independent in their respective approaches to knowledge: art through the senses, science through logical discourse. In their particularity, they complement each other without merging into a synthesis. 3.) The difference model, in which the independent approaches of art and science each denote something completely different and cannot be judged according to a common standard of value. Here, too, art represents a sensual and pre-conceptual approach to knowledge, while science represents a discursive, conceptual one. 4.) The identity model, which Früchtl demonstrates has two variants. When the opposition between art and science is examined closely, it dissolves into a multitude of binary opposites. The supposedly static opposition is thus subject to deconstruction. The other variant assumes that both art and science are "culturally crystallized ways of reacting to indeterminate, not yet understood or explained experiential situations."[6] In doing so, they start from the same affective, perceptive, imaginative, and cognitive modes of knowing. The only difference lies in the weighting and interaction of these modes and their corresponding media of knowing and expression. Science is determined by cognitive modes of knowing, and is therefore based on formulas, laws, and reduction; this, of course, neglects the cognitive and conceptual aspects of design and art practices. Art, by contrast, seeks to balance these modalities and thus represents a holistic approach. According to Früchtl, artistic research can be classified under the fourth model: the identity model. This model not only assumes the equivalence of different artistic and scientific approaches to knowledge, sharing a common foundation in the same modes of knowing, but also pursues their synthesis.

How this synthesis manifests itself in detail remains open. In accordance with the self-conception of design and artistic research, it presupposes that the designed object or process is not merely subjected to scientific analysis, nor that its creation is based exclusively on research conducted or knowledge gained in other sciences. Rather, the defining characteristic of artistic research is that scientific research is directly linked to creative and artistic practises, and that the corresponding findings are embodied in the artistic processes and artefacts themselves—thus creating a synthesis between science and art. The examples and contributions collected in this special issue demonstrate this in their own way. Generally, a definition of artistic research is more likely to

Fig. 1: Patrick Pollmeier, Theory of Everything: Lights All Askew in the Heavens, Inkjet-Print, 60 x 80 cm, 2016

be pursued inductively, on the basis of concrete cases. What is striking about the examples is that research *for*, *about*, and *through* design and art usually go hand in hand.[7] Flawless research through design alone—without recourse to the findings, methods, and media practices of other sciences—represents an ideal borderline case. This is particularly true in the age of technical images, when much visual production can be traced back to technologies based not only on physical theories, mathematical methods and statistics, but also on a long history of apparatuses and machines originally used in fields other than the arts and later adopted by them. Conversely, the natural sciences have a wealth of models, metaphors, and visualisations, and continue to employ the formal and iconographic visual languages and media of the arts to this day. Aesthetic excesses often appear in the publication of scientific results when research data is presented in a particular way, for example through colour and form.[8] Hannah Rogers' contribution from the field of Art, Science, and Technology Studies illustrates the reciprocal nature of the relationship between art and science in this context. (Fig. 1)

The categorical separation of science and art,[9] challenged by recent artistic research, is both a *hallmark* and a *symptom* of modernity. Few epistemological approaches exemplify this division more clearly than that of the French philosopher Gaston Bachelard, who held the Chair of History and Philosophy of Science at the Sorbonne in Paris from 1940 to 1954. The following brief examination of his two groups of work on scientific knowledge and creative imagination in literature and the arts can be read as a parable for the dynamic relationship between science and art.

Bachelard's historical epistemology of the natural sciences, focusing on physics and chemistry, began in 1928 with his doctoral theses[10] and continued until his last relevant epistemological work, *Le matérialisme rationnel*, in 1953. In this group of work, Bachelard examines the epistemological upheavals chemistry underwent in the last third of the 19th century and physics in the first third of the 20th century. These were triggered, on the one hand, by the quantitative determination and corresponding periodic arrangement of chemical elements, initially based on atomic weight and later on the number of neutrons and protons in the nucleus. In physics, the theory of relativity and quantum mechanics became particularly significant. The new mathematical frameworks underlying them, including Riemannian geometry for curved space, Einstein's field equations for gravity, and Hilbert space vectors, enabled purely theoretical calculations of natural phenomena, even those not yet verified by observation or experiment. The theoretical, and arguably speculative, calculation of natural phenomena preceded their concrete verification. This was recently demonstrated by the measurement and visualisation of gravitational waves using laser technology. Einstein had previously derived these waves mathematically in his theory of relativity.[11]

Therefore, Bachelard views modern mathematics as more than just a language that describes natural laws in abstract terms; he also considers it to be an instrument that facilitates the discovery of phenomena. He writes: "Mathematical activity is the very axis of discovery; only mathematical expression makes it possible to conceive of the phenomenon."[12] If mathematics is a rational instrument of acquiring knowledge, then laboratory experiments are its empirical counterpart. The two are connected in that modern mathematical calculations give rise to experimental setups designed to empirically verify them. The new mathematical thinking thus appears "as a programme for the realisation of experiments."[13] (Fig. 2)

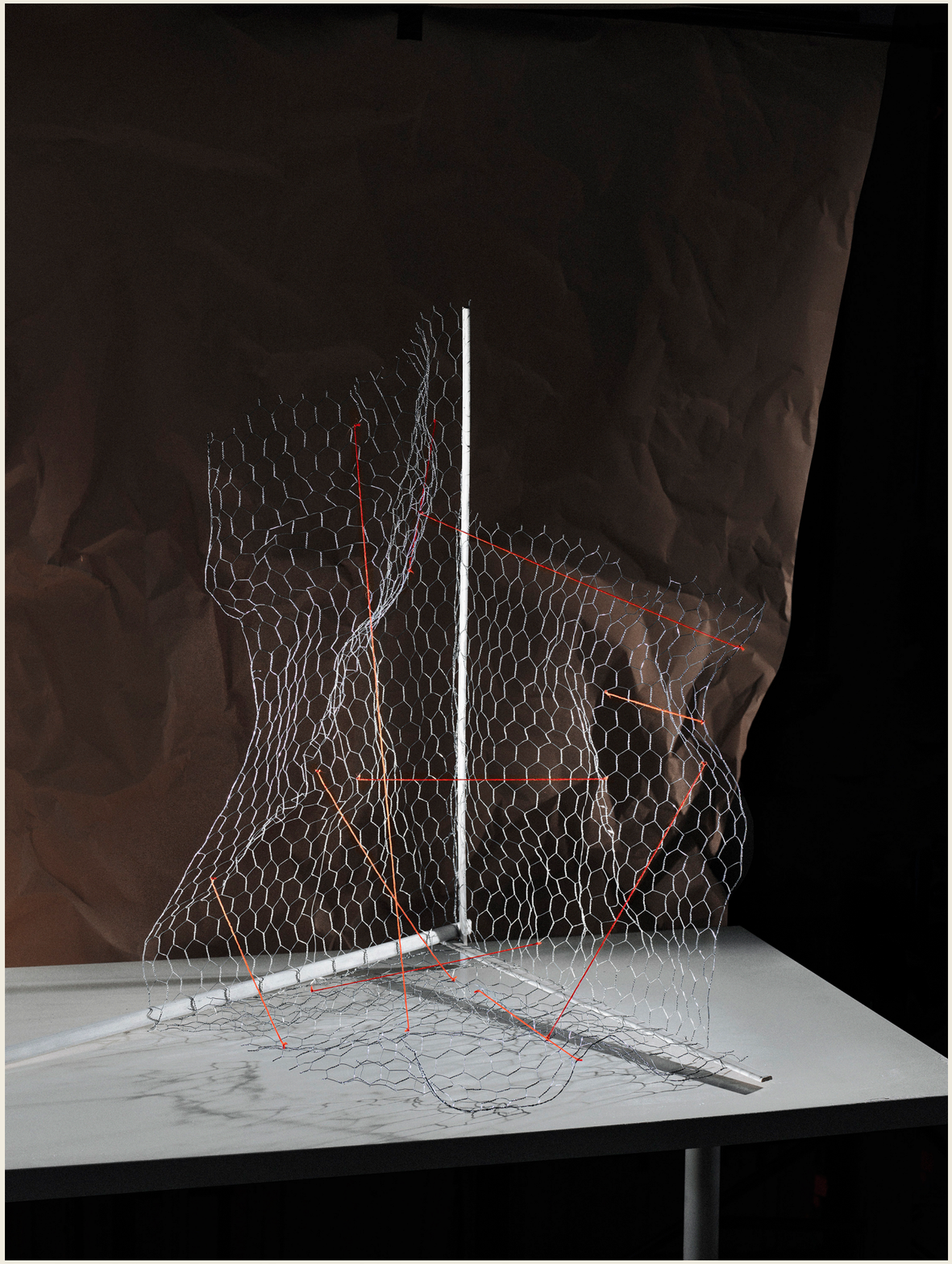


Fig. 2: Patrick Pollmeier, Theory of Everything: Calculemus, Inkjet-Print, 30 x 40 cm, 2016

Fig. 3: Patrick Pollmeier, Theory of Everything: Common Ancestor, Inkjet-Print, 30 x 40 cm, 2019

All experiments, even if theories are objectified in instruments and arrangements, display material obstinacy.[14] Each instrument or technical procedure influences what is examined and represented; it is far from a neutral medium through which phenomena simply shine through. Bachelard notes that in an experiment, “one must sort, filter, and purify the phenomena, pour them into the mould of the instruments; indeed, they are produced at the level of the instruments. Well, instruments are nothing more than materialised theories. This results in phenomena that bear the imprint of the theory everywhere.”[15] (Fig. 3)

He emphasises that experimental arrangements decisively shape what emerges as scientific facts. Modern chemistry and experimental physics thus engage in a “phenomenotechnique” that learns from what it produces instrumentally, “what it constructs.”[16]

Bachelard highlights the constructive nature of scientific knowledge, anticipating insights of recent science studies.[17] At first glance, this seems to contradict the 19th-century ideal of objective knowledge, nourished by new recording devices and standardised measurements. Bachelard locates objectivity instead within the scientific community that modernity has differentiated—what he calls the cité scientifique[18]—with its laboratories and institutions as places where experiments are repeated, verified, and classified. Objectivity is the product of intersubjective negotiation on a theoretical-experimental basis.

The epistemic break in the natural sciences at the turn of the 19th to the 20th century marks a dual departure from the perceptible world of physical things. On the one hand, we no longer approach things and the processes that govern them directly, i.e. with our senses. However, they are not merely represented or derived mathematically. Instead, possible mathematical calculations now point to existing natural phenomena that may exist.[19] On the other hand, after the telescope and microscope had already opened the macro and micro worlds in the 17th century, modern chemistry and physics penetrated the nano worlds of atomic structures and energetic states of matter, which can only be calculated in terms of probabilities. Objects of knowledge are no longer simple, tangible substances, but complex, relational, and dynamic structures. (Fig. 4)

Fig. 4: Patrick Pollmeier, Theory of Everything: Lights All Askew in the Heavens, Inkjet-Print, 80 x 60 cm, 2016

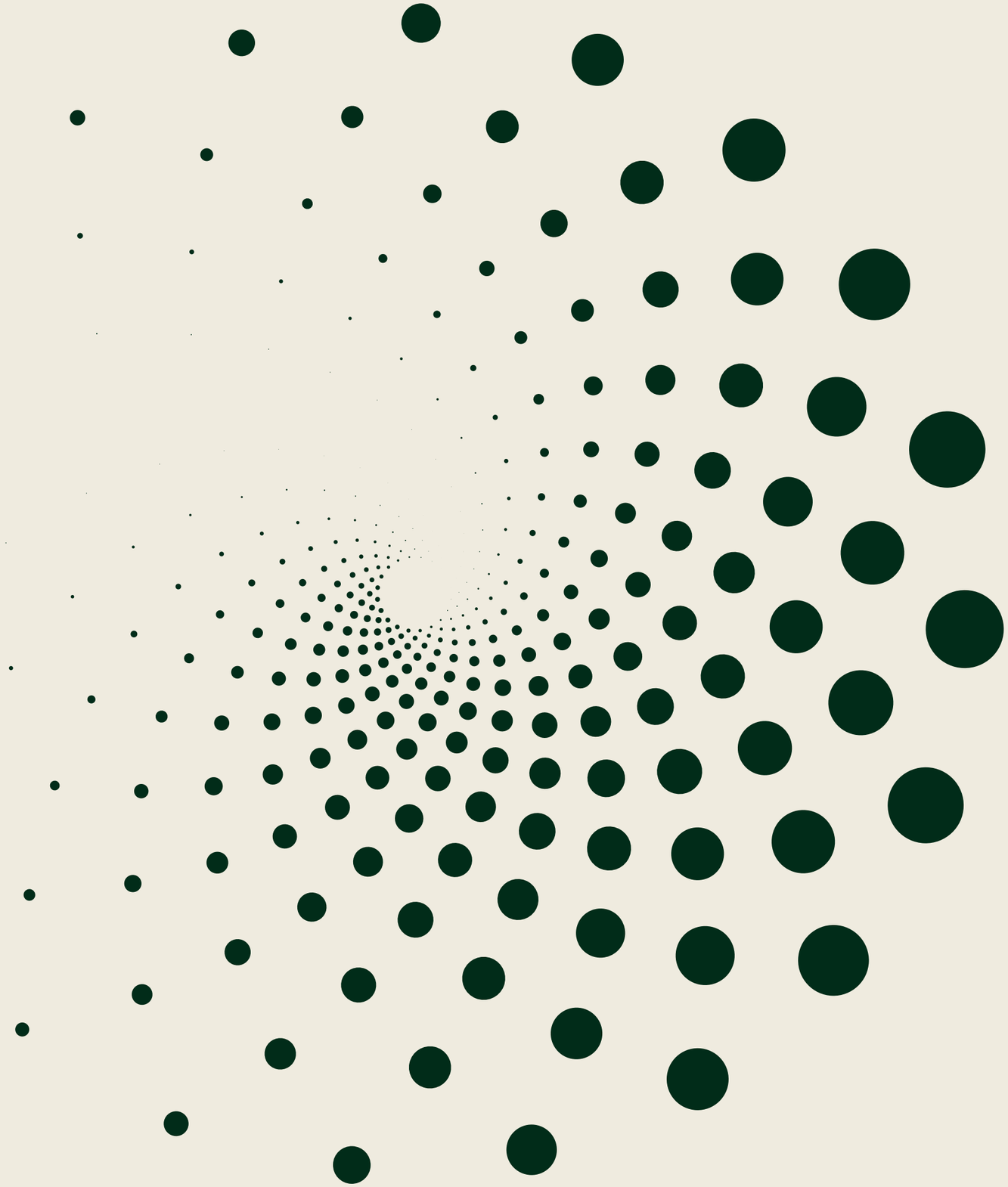
These characteristics, which Bachelard considers to be genuinely scientific, distinguish modern science from pre-modern and pre-scientific natural science. The latter's experimental culture[20] was still rooted in direct sensory perception and physical complexes of ideas. Bachelard critically addresses these complexes of ideas in *The Formation of the Scientific Mind*, published in 1938. They are based on everyday experiences that are transferred unquestioningly and often unconsciously to the substances and processes under investigation. Many are rooted in human physicality or corporeality. Accordingly, substantialist and animistic 'images', as Bachelard refers to these figurative concepts, are frequently encountered in the history of science. They can be traced back to a body that encloses an interior and is itself enclosed by coverings, such as clothing or architecture. Because it is alive, the embodied subject enlivens the things around it. However, these images often contradict the actual behaviour of substances or processes, obscuring them rather than explaining them. Bachelard therefore calls them obstacles to knowledge. The 'naive realism' of everyday experience from which they arise does not enable knowledge—it inhibits it. The task of progressive science is to become aware of these images in order to overcome them.[21]

In the same year that *The Formation of the Scientific Mind* was published, Bachelard released *The Psychoanalysis of Fire*, initiating a group of work on creative imagination in literature and the arts. Several subsequent volumes explored the cosmological elements—fire, water, air, and earth—as well as space and reverie, the latter being a fundamental activity of creative imagination. In these works, the four elements, whose teachings date back to antiquity, are still encountered as tangible solid, fluid or gaseous bodies, whose material properties evoke physical sensations and trigger actions. This group of work sees the four elements of fire, water, air, and earth reappear, having been reduced by modern science to reactive mixtures of chemical elements or atomic structures. While Bachelard draws on early modern alchemy for most of his examples of substantialist, animistic and sexual images in *The Psychoanalysis of Fire*, subsequent volumes on the elements focus on 19th- and 20th-century literature. They offer a wealth of body-related images that resonate in the physicality of the reader. Thus, this second group of work recovers all the imagery that Bachelard had excluded from modern science, even attempting to "exorcise" it, as he puts it.[22]

Through these two groups of work, Bachelard separates science and art, reason and imagination, concept and image. In doing so, he reproduces a division that is characteristic of modernity. Bruno Latour refers to this division as the "bifurcation of nature": "a split between, on the one hand, things that are true and acknowledged by science but are inaccessible outside of it; and, on the other hand, living beings, human subjectivity, the way people imagine this world, and their feelings when confronted with truly wonderful things."[23] Bachelard traces this split, but he also reproduces it—even within his own existence—by viewing himself as both a rational, science-practising, book-writing "day person" and a reading, dreaming "night person."[24] Both sides represent distinct approaches to knowledge. In Bachelard's work, they interact dialectically without merging into a synthesis. His approach aligns closely with the complementary model described by Josef Früchtl.

For a long time, reception of Bachelard focused either on his epistemological writings or on his works on literary imagination. It is only in the past two decades that the connections between these two groups of work have been increasingly highlighted—connections that extend beyond the simple fact that they were written by the same person.[25] Refer-

ences to these connections can be found within the texts themselves. In *Le matérialisme rationnel*, the "night person" and the "day person" form the dual foundation of a complete anthropology: "Once the separation between imagination and reason has been clarified, the problem of the 'dual nature' of the human psyche can be understood more clearly. It is indeed a problem of dual reality that arises when one wants to address the relationships between the realm of images and the realm of ideas. […] Oneirism and intellectualism are always somewhat unstable polarities, both in the investigator and in the investigated. […] Oneiric values and intellectual values remain in conflict. Often, they even confirm each other in this conflict."[26] Bachelard still adheres to this division in this work, though it



proves by no means static. The instability of the line separating reason and imagination is evident in the fact that even the greatest intellectual efforts of modern science occur against a dark "background of the psyche, where images germinate."[27] Making these images transparent remains part of the task of science and scientific criticism. Both of Bachelard's groups of work demonstrate how powerful the images anchored deep within our body are. For here, as there, we move within "a vast realm of convictions rooted in an inner materialism inscribed in every fibre of our being, an unconscious materialism reinforced by immediate kinaesthetic sensations."[28] The final overcoming of the corresponding images would require the abandonment of the body.

Bachelard also identifies structural similarities between imagination and reason. Both images and concepts are creative and generative; neither simply imitates or represents the world. Each produces the world in its own way, generating novelty.[29] Art and science thrive on such innovations. This connection is reflected in Bachelard's epistemological writings. Regarding mathematics, he speaks of the "poetic, creative, reality-creating impulse of mathematics,"[30] or mathematical intuition. In literature, language opens up entirely new worlds through phonetic sound, semantic condensations and shifts, as well as syntactic combinations. This is not a language that represents reality; rather it is a connotative and ambiguous language capable of containing contradictions. Just as modern mathematics speculates about yet unproven realities, using a formal symbolic language, poetic language creates possible worlds.

In addition, both fields are subject to dialectical processes. Not only do art and science relate to each other in this way, but they also do so within their historical development. Within the history of science, new theories and experimental research approaches emerge that differ radically from traditional ones yet incorporate elements of them. Riemannian geometry of curved space contrasts with classical Euclidean geometry, while also leading to an expansion of geom-

etry within which Euclidean geometry becomes just one type of geometry among many. Imagination is guided by a comparable dynamic interplay of opposites. In *The Poetics of Space*, published in 1957, for example, a spatial interior does not derive its meaning solely from a spatial exterior.[31] Instead, the interior and exterior can constantly shift into one another, so that the interior turns itself inside out, proving to be permeable and boundless. Significantly, the new physical theories of space and Bachelard's spatial images converge in that they neither follow the laws of three-dimensional space nor have to assume the Euclidean exclusivity of place. In reverie and physics, there are nested and dynamic spaces. (Fig. 5)

Ultimately, art and science find common ground in matter—or, to use Bachelard's terms "inter-materialism."[32] Long before the 'material turn', matter formed a central starting point for both groups of work. For Bachelard, matter does not mean isolated substance, nor does it mean substance that is objectified in a form or perceived as a thing and thus as an entity, but is always a reactive mixture and amalgam of several substances. The human body, itself a mixture and amalgam of substances that absorb and excrete substances, is integrated into this inter-materialism. This is also evident in the writings on the four elements, in which creative imagina-

Fig. 5: Patrick Pollmeier, Theory of Everything: Calculemus, Photogramm, 30 x 40 cm, 2019

tion finds a rich source of images not so much in the individual elements as in the connections that the elements maintain with each other. In direct or tool-mediated interaction with materials and their mixtures, the boundaries between object and subject become porous. It is not always clear to the active subject where, in the processing of materials, the unarmed or tool-equipped hand ends and the tool and the processed material begin. Additionally, depending on their material properties, different materials have different characteristics that suggest a particular type of processing, as well as their own level of resistance.

Many of Bachelard's insights remain relevant to contemporary epistemology. In particular, the concept of phenomenotechnique has been adopted to emphasise both the constructive and contingent nature of knowledge gained in experiments. Experimental systems, as defined by Hans-Jörg Rheinberger, directly influence what is investigated due to the materiality of instruments, apparatuses, and technological procedures. These systems also often yield unexpected and unintended results when objects behave differently from how they were designed to, or when completely new phenomena emerge. Rheinberger explicitly links this contingency to art:[33] both science and art incorporate chance whenever they proceed experimentally.

In the arts, Bachelard's phenomenotechnique intersects with the media-materialist insight that creative and artistic processes, as well as their artifacts, are conditioned by the media used. Since the 19th century, technical images and imaging processes—photography (including micro- and macro-photography), computer graphics and, currently, AI image generation—have created a shared pool of instruments and technologies for recording and visualising both natural and socio-cultural phenomena. This is illustrated by the contributions of Sonja Mense and Christian Doeller to this issue. Their works make perceptible what lies beyond sensory thresholds in terms of spatial or temporal scales, while also providing access to abstract "data spaces,"[34] such as those created in science through the recording and processing of traces. In doing so, they reveal the technological processes of scientific research itself, which they also criticise insofar as they do not consider the phenomena under investigation only in terms of their economic or strategic utility, nor do they view them in isolation. (Figs. 6, 7)

Fig. 6: Patrick Pollmeier, Theory of Everything: Calculemus, Inkjet-Print, 60 x 80 cm, 2019

Fig. 7: Patrick Pollmeier, Theory of Everything: Calculemus, Inkjet-Print, 60 x 80 cm, 2016

Fig. 8: Patrick Pollmeier, Theory of Everything, Ausstellungsansicht, 2022

A key difference from Bachelard lies in the current evaluation of models and metaphors. Bachelard permitted them only as secondary didactic tools for teaching scientifically acquired knowledge. In the process of scientific knowledge acquisition, they were to be continually rediscovered and eliminated. However, recent epistemology, as well as current discussions of design practices in the arts and design,[35] have shown how constitutive metaphors and conceptual or physical models are for their respective fields. The change in their significance within epistemology is evident in the understanding of models and metaphors as integral parts of the intersubjective negotiation of scientific knowledge.[36] Models are derived from experimentally obtained data and, in turn, influence experimental systems by suggesting modified or new instrumental series of experiments. They serve to communicate research approaches and results, competing for temporary interpretive authority. At the level of metaphors and models, the dividing line between art and science has also become increasingly blurred. (Fig. 8)

This dynamic is reflected in the artistic work *The Theory of Everything* by Patrick Pollmeier, which explores the as-yet undiscovered universal formula encompassing all forces of nature. The photographs and staged models reflect both the use of models and photography in natural science, conveying the richness of scientific imagery while simultaneously challenging photography's traditional function as a faithful representation of reality. As a phenomenotechnical instrument, photography creates reality rather than simply recording it. (Fig. 9)

The extent to which the structural similarities and reciprocal relationships between art and science are now recognised can be seen conclusively in what Bachelard termed the "night side" of the arts and the "day side" of the sciences. They no longer stand in opposition to each other. On the contrary, the "night knowledge" in Rheinberger, whose epistemological considerations are largely based on Bachelard, describes a straying and groping within experimental research itself. The dark as the irrational, the incomprehensible, and the yet inexplicable has thus advanced into the brightest and clearest realms of science.[37]

Fig. 9: Patrick Pollmeier, Theory of Everything: Lights All Askew in the Heavens, Video, 15.23 Min., 2016

1 Josef Früchtl, ‘Artistic Research: Delusions, Confusions, and Differentiations’ (Eidos. A Journal for Philosophy of Culture (3, 2) 2019, 124–134, https://doi.org/10.14394/eidos.jpc.2019.0022) (28.05.2025)

2 As Früchtl summarises these attempts at definition. Ibid., 126.

3 See the contributions by Timothy Ridlen and Jesko Fezer in this issue.

4 Without going into detail here about these historically outdated attributions.

5 See Früchtl, Artistic Research, 126–128.

6 Ibid., 128.

7 To take up Christopher Frayling’s distinction between “research into art and design”, “research through art and design”, and “research for art and design”, whereby “research through art and design” is now largely understood to mean what Frayling previously identified as “research for art and design”: creative and artistic research whose findings are embodied in the designed artifacts and processes. See Christopher Frayling, ‘Research in Art and Design’ (Royal College of Art Research Papers (1, 1) 1993/94), 1–5, here 4.

8 For an early overview of examples of scientific visualisation, see the relevant discussion in Norbert Elsner (ed.), Bilderwelten: Vom farbigen Abglanz der Natur (Göttingen: Wallstein, 2007).

9 According to Frayling, this was nothing more than an “institutional accident”, given the new context of universities, academies, and polytechnic colleges emerging at the beginning of the 19th century. Cf. Frayling, Research in Art and Design, 4.

10 In which Bachelard deals with the limitations of instrumentally obtained measurements and the understanding of natural phenomena based on approximate values, on the one hand, and with heat propagation in solids, on the other.

11 As occurred in 2015 at the Laser Interferometer Gravitational-Wave Observatory (LIGO).

12 “Die mathematische Aktivität ist die eigentliche Achse der Entdeckung; nur der mathematische Ausdruck ermöglicht es, das Phänomen zu denken.” Gaston Bachelard, Der neue wissenschaftliche Geist (Frankfurt/M.: Suhrkamp, 1988), 57.

13 […] “als ein Programm zur Realisierung von Experimenten.” Ibid., 59. Unlike the present German translation, here “expériences” has been translated not as “experiences” but as “experiments”.

14 On the idiosyncrasy of experimental systems, see Hans-Jörg Rheinberger, Spalt und Fuge. Eine Phänomenologie des Experiments (Frankfurt/M.: Suhrkamp, 2021).

15 […] “muß man die Phänomene sortieren, filtrieren, reinigen, in die Gußform der Instrumente gießen; ja sie werden auf der Ebene der Instrumente erzeugt. Nun sind die Instrumente nichts anderes als materialisierte Theorien. Daraus resultieren Phänomene, die allenthalben die Prägemale der Theorie zeigen.“ Bachelard, Neuer wissenschaftlicher Geist, 15.

16 Ibid., 18.

17 Cf. Bruno Latour, Science in Action: How to Follow Scientists and Engineers Through Society (Cambridge, MA: Harvard University Press, 1987).

18 In this social character, modern science also differs from pre-modern science. Cf. Gaston Bachelard, Le matérialisme rationnel (Paris: Presses Universitaires de France, 2021), 32f.

19 “Was nach dem Urteil des Mathematikers sein könnte, kann stets auch vom Physiker realisiert werden. Das Mögliche und das Seiende sind homogen.” Bachelard, Neuer wissenschaftlicher Geist, 60.

20 On experimental culture, cf. Rheinberger, Spalt und Fuge, esp. 164–189.

21 Bachelard, one of the first in French philosophy to embrace psychoanalysis, does so with a psychoanalytical gesture.

22 Gaston Bachelard, La poétique de la rêverie (Paris: Presses Universitaires de France, 2016), 45.

23 […] “rupture entre d’une part les choses qui sont vraies, connues par les sciences, mais inaccessibles en dehors des sciences, et d’autre part les choses vivantes, la subjectivité des gens, la facon don’t ils imaginent ce monde ainsi que leurs impressions de voir des choses tout à fait magnifiques.” Bruno Latour, Habiter la terre. Entretien avec Nicolas Truonc, avec la collaboration de Rose Vidal, Paris: Les Liens qui libèrent, 2022, 35f.

24 Cf. Bachelard, Matérialisme rationnel, 55; also Bachelard, Poétique de la rêverie, 56.

25 Cf. Monika Wulz, Gaston Bachelard und die Reorganisation des Wissens (Berlin: Kadmos, 2010), esp. 76–87; Roch C. Smith, Gaston Bachelard. Philosopher of Science and Imagination, revised and updated (New York: SUNY Press, 2016).

26 “Une fois réalisée la division en imagination et raison, on peut voir plus clairement s’établir dans le psychisme humain le problème d’une double situation. C’est en effet un problème de double situation qui se pose quand on veut aborder, sur des exemples nombreux et précis, les rapports du règne des images et du règne des idées. […] L’onirisme et l’intellectualisme sont, chez l’enquêteur comme chez l’enquêté, des polarités toujours un peu instables. […] les valeurs oniriques et les valeurs intellectualistes restent en conflit. Elles s’affirment souvent les unes et les autres dans ce conflit même.” Cf. Bachelard, Matérialisme rationnel, 55f.

27 “[…] un arrière-fond du psychisme où germinent les images.” Ibid., 56.

28 “[…] un énorme domaine de convictions qui tiennent à une sorte de matérialisme inconscient, renforcé par des expériences cénesthésiques immédiates.” Ibid., 58.

29 Cf. Wulz, Bachelard und die Reorganisation des Wissens, esp. 76–87.

30 Bachelard, Neuer wissenschaftlicher Geist, 35.

31 Cf. Gaston Bachelard, Die Poetik des Raumes (Frankfurt/M.: Fischer, 1987), 211–228.

32 Cf. Bachelard, Matérialisme rationnel, 51.

33 Cf. Rheinberger, Spalt und Fuge, 197–203.
34 On the concept of data space in scientific research, cf. ibid., 29–35.
35 Sabine Ammon, Inge Hinterwaldner (eds.), Bildlichkeit im Zeitalter der Modellierung. Operative Artefakte in Entwurfsprozessen der Architektur und des Ingenieurwesens (Paderborn: Wilhelm Fink, 2017); Rikke Lyngsø Christensen et al. (eds.), Artefakte des Entwerfens. Skizzieren, Zeichnen, Skripten, Modellieren (Berlin: TU Berlin University Press, 2020).
36 Cf. Rheinberger, Spalt und Fuge, 36–66.
37 Cf. ibid., 220–224.

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