

# 10 What If?

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## 10.1 Asking *What If?* in Science and Art

In the initial conversation about abstraction between the authors at the café Kaf in Copenhagen, attention was suddenly drawn to the dotted glaze on the plate (Figure 10.1). Try an experiment: imagine that each dot on the plate represents a single star in outer space. The plate is then—potentially—a kind of map, a representation. Could the dots correspond, in their relative placement and size, to a real field of stars? Is there at least *one* vantage point in the universe from which the projection of visible stars onto a surface would produce the exact pattern on this plate?

How might we refine this thought experiment? Might it help to consider parallel universes or alternative realities? Could the dots represent worlds depicted through art or told through fiction, where our laws of physics might not apply, and stars—and planets—possess strange properties? The Kaf plate thought experiment opens up a multimodal space in your mind.

Imagination and fantasy are necessary for asking *what if?* We invite you to ask how our world might be different if, as individuals or societies, we could inspire behavioral change via new ideas and art-making across fields with the aim of getting us to rethink and act anew in our lives. This approach could help us address many small issues as well as giant ones—even the anthropogenic mass extermination of life on Earth.

*What if?*-thinking is standard practice in scientific modeling and map-making. To represent the world theoretically, we have to imagine how we could simplify and idealize it as if it contained just a few kinds of processes and objects. What would evolution look like if it only occurred at the individual level, or gene level? What if a gas mixture consisted of vanishingly small, inelastic atoms or molecules bouncing around that neither attracted nor repelled each other? Scientific experiments are also a form of *what if?*-thinking: What if we simplified material processes by including only a few types of objects and their interactions in a controlled and randomized manner (in a beaker, on an inclined plane, in a fruit fly breeding design)?



Figure 10.1 A Kaf plate. This plate, used at the Nørrebro, Copenhagen café Kaf, is a Stonecast design by Churchill China in England. Authors' image

Even alternative realities can be built with *what if?*-thinking. New ontologies need not be based on the actual world. In this regard, the creative explosion of asking *what if?* serves particularly well in art and fiction.

Drawing on choice scientific and artistic achievements, as well as on our own previous philosophical and artistic work, we show how *what if?*-thinking provides a unique and powerful lens—both a telescope and a microscope—onto matters of abstraction and representation (and imagination and even the spiritual).

This is an experimental and fully collaborative chapter resulting from conversations, exhibition visits, and studio visits. In this contribution, both authors access and emphasize their respective subject matter—philosophy of science and contemporary art—from a somewhat outsider perspective. How we draw these boundaries is itself ripe for *what if?*-thinking. We may question how our lives are circumscribed and closed in by the assumption that each of us already occupies what Winther has called a “world navel.”

Whatever collective we are part of—say, the academic ivory tower or the contemporary art world—isn't, after all, the *entire* world (Winther, 2014a, 2020a, 2020b).

We have tried to make the text modular and therefore more digestible to readers who may zoom in on different sections. Even if this approach might make the text a bit jumpy, it is meant to facilitate your efforts at asking how our shared world could be different.

## 10.2 Marie Tharp as a Scientific *What If?* Thinker

Let us move from the stars to the oceans. “Could the waters of the Atlantic be drawn off,” says 19th-century American oceanographer M. F. Maury, “the very ribs of the solid earth, with the foundations of the sea, would be brought to light, and we should have presented to us at one view the empty cradle of the ocean” (Heezen, Tharp, and Ewing, 1959, epigraph, p. iv). Cartographer, oceanographer, and geologist Marie Tharp (1920–2006), along with her scientific partner Bruce Heezen, took the indisputably biggest step toward this vision of the exposed ocean floor of anyone in the 20th century. Tharp did this by pairing *what if?*-thinking with tools of abstraction and representation. “First,” she says, “there is only one proper way to sketch or to contour the ocean floor and that is to present it as it actually exists *as it would be seen if* all the water were drained away” (Tharp, 1982, p. 22, emphasis added). What would the ocean floor look like if we could draw off or drain the oceans?

Tharp's skilled hand visualized the ocean bottoms for us.<sup>1</sup> In 1952, she discovered, properly and systematically, the rift—also referred to as the median rift, rift valley, graben, or V-shaped cleft—along the Atlantic Mid-Oceanic Ridge. It “took a whole year” to convince Heezen of the rift's existence (Tharp, 1996; cf. Wertenbaker, 1974, p. 144). As a logical extension of this discovery—and using data about earthquake epicenters that closely correlated spatially with the rift—Tharp, together with especially Heezen, suggested that there was effectively a long, continuous ridge—with a median rift—that “went all the way around the world for forty thousand miles” (Tharp, 1997). Discovering and establishing the Atlantic median rift, and inferring, with Heezen, a global mid-oceanic ridge system were two immense accomplishments, requiring creativity and fortitude. Tharp accomplished this despite encountering sexism and personal style harassment (Winther, 2019), including not being mentioned in the publication announcing both the proper discovery of the median rift along the mid-Atlantic Ridge and the inference of a global ridge system (Ewing and Heezen, 1956).<sup>2</sup>

Perhaps more memorably, Tharp's work with Heezen at Lamont-Doherty Earth Observatory at Columbia University gave us abstract



*Figure 10.2* Marie Tharp at the drafting table. Tharp paints or touches up the left half of the North Atlantic physiographic diagram in what is almost certainly a staged photograph, likely from 1961.<sup>28</sup> The map cartouche discussed in note 4 can be found under her arm. On her right is plate 22 of Heezen, Tharp, and Ewing (1959), “Six Trans-Atlantic Topographic Profiles.” These were made by comparing and collating countless echograms or fathograms, ideally PDR (precision depth recorders) readouts—developed at Lamont (Luskin et al., 1954)—two of which are shown on her left. In her own words: “To make the map, we first plotted lines of soundings taken by ships tracking across the ocean. Then we converted the sounding lines into two-dimensional profiles of the seafloor. Then we made three-dimensional sketches based on the profiles and plotted them along the ship tracks. Finally we sketched in areas with no soundings by extrapolating trends observed in profiles made by actual soundings. In other words, we made educated guesses to fill in the dataless gaps” (Tharp, 1999). More poetically, and also in her own words: “Deep sea soundings obtained along a ship’s track ... were as a ribbon of light where all was darkness on either side” (Felt, 2012, Loc. 1721). Behind her, note the rolled-up maps and other visual resources, perhaps PDR readouts “tens of meters long” (Higgs, 2020, p. 234). Finally, the globe was likely made with “acrylic applied to a basketball” (Doel, Levin, and Marker, 2006, note 72, p. 625), painted “in blacks, blues, grays, and browns, brushing dark colors over the tasteful pastels already there. Red had always been reserved for the rift valley” (Felt, 2012, Loc. 1986). Reproduced with kind permission of Lamont-Doherty Earth Observatory and the estate of Marie Tharp.

representations—maps—forged in *what if?*-thinking: What if the ocean floor exhibited an unexpectedly rich and variegated structure, with flat abyssal plains as well as seamounts, and with wild ridges? What if there indeed was a continuous mid-oceanic ridge system running along the ocean floor? These two questions have major implications for geological theories about the origin and structure of continents and oceans, including the theory of plate tectonics as a mechanism for continental drift. In addressing these questions, Tharp's imagination and desire to inspire the map reader "contributed to a revolution in geological thinking. Because now they're using the ocean and plate tectonics to redo the geology on the land" (Tharp, 1997).<sup>3</sup>

In creating all of her maps, Tharp used standard cartographic generalization and abstraction protocols, such as selection (scale, projection), simplification, and exaggeration (Winther, 2019, pp. 101–109). Even so, Tharp's best known maps are the ones she co-produced with Heezen and the Austrian painter Heinrich Berann, which were published by *National Geographic* (Tharp, 1997; Felt, 2012, Loc. 2810). Much of the literature on Tharp has emphasized these maps because of their dramatic beauty and public influence. As for Tharp's more scientific maps, commentators have focused on the physiographic diagrams of, for example, the North Atlantic (first published in 1957<sup>4</sup>; reprinted in Heezen, Tharp, and Ewing, 1959 as an inset; and deemed an "abstract view of the sea floor ...[which] can be seen in no other way but in the mind's eye" by Heezen and Hollister, 1971, p. 7) and Indian (Heezen and Tharp, 1964) oceans. We are the first to comment on Tharp's scientific maps beyond the physiographic diagrams.

The scientific maps of Heezen and Tharp (1965) are exercises in the two *what if?* questions discussed immediately above. Among Tharp's papers with Heezen, this one is the most theoretically sophisticated and contains the widest variety of fascinating and detailed maps of the ocean bottoms (e.g., Figure 10.3).<sup>5</sup>

The two aims of Heezen and Tharp (1965) are: (1) empirically, a summary of prominent features—recorded and inferred—of the bottoms of the Atlantic and Indian oceans; and (2) theoretically, an evaluation of what they thought was an uneasy fit between the theory of continental drift and the complexity of the Indian Ocean. Heezen in particular believed that the Indian Ocean, with its "scattered linear micro-continents" (p. 94; e.g., Madagascar and the Seychelles) could not be easily explained or predicted by continental drift.<sup>6</sup> The authors declaim, "the Mid-Oceanic Ridge appears to be a feature created by extension of the Earth's crust and the emplacement of new material from the mantle below" (p. 100). This sentence can be read both from a continental-drift-via-plate-tectonics perspective (or "convection current hypothesis") or from Heezen's own favored continental-displacement-via-an-expanding-Earth perspective (p. 105).

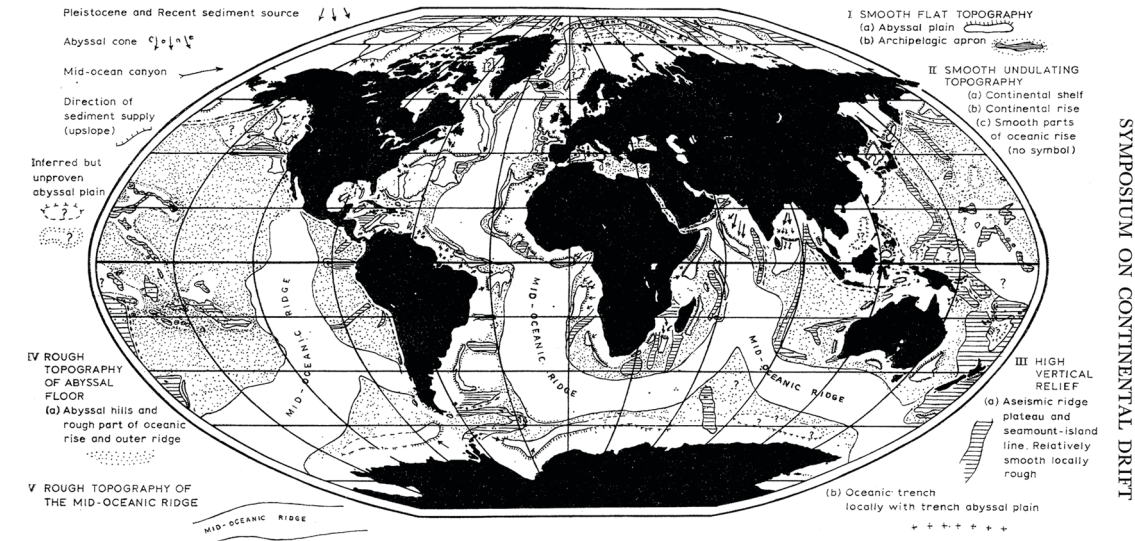


FIGURE 11. Distribution of smooth and rough topography in the world oceans. (North Atlantic, after Heezen, Tharp & Ewing 1959; South Atlantic after Heezen & Tharp 1961; Indian Ocean after Heezen & Tharp 1964; Pacific Archipelago Aprons after Menard 1956; Arctic after Dietz & Shumway 1961.)

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SYMPOSIUM ON CONTINENTAL DRIFT

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Figure 10.3 “Distribution of smooth and rough topography in the world oceans” (Heezen and Tharp, 1965, p. 99). Tharp drew this map from scratch, possibly on a Denoyer Semi-Elliptical projection,<sup>29</sup> using new data as well as the various sources cited. The entire article page is here reproduced to give the reader contextual information. Reproduced with kind permission of The Royal Society (UK), from Tectonic Fabric of the Atlantic and Indian Oceans and Continental Drift by Heezen, B. C. and Tharp, M. in *Philosophical Transactions of the Royal Society of London. Series A, Mathematical and Physical Sciences*, volume 258, issue 1088, 1965; permission conveyed through Copyright Clearance Center, Inc.

The article deploys *what if?*-thinking, dialectically considering what possible kinds of ocean floor topographic, sedimentation, or general geological features continental drift or continental displacement theories would suggest, and which actual features fit better with which of the two theories. While interestingly granting concessions to continental drift—“a northward drift of India is suggested by palaeomagnetic measurements” (p. 100)—the article cautiously defends a now-discarded expanding Earth theory. Still, this defense was not unreasonable, and the article was a sophisticated descriptive and theoretical intervention in the literature.<sup>7</sup>

Tharp’s maps are instrumental to the article’s effectiveness. Even just a list of the map names from Heezen and Tharp (1965) provides a glimpse into the richness and diversity of scientific maps Tharp created (Table 10.1). Elsewhere, Winther has classified five types of Heezen–Tharp maps: physiographic diagrams, profiles, perspective panorama maps, angled panorama maps, and absolute panorama maps (Winther, 2019, p. 116). Only the first two types are scientific, while the last three describe the maps co-produced with Berann. To be complete, this typology would have to be extended to include geographic and geological maps, with new kinds of semiotics. Setting this complexity aside, a too-brief exploration of only one of these figures, Figure 10.3, will have to suffice.

Table 10.1 Maps Drawn by Marie Tharp in Heezen and Tharp (1965)

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- “Bathymetric sketch of portions of the Chain and Romanche Fracture Zones.” (Fig. 3, p. 91; reprinted from Heezen, Bunce, Hersey, and Tharp (1964), p. 14—the 1964 figure caption concludes thus: “contours by Heezen”)
  - “Topographic profiles in the vicinity of Vema Fracture Zone.” (Fig. 4, p. 92; reprinted from Heezen, Gerard, and Tharp (1964), p. 736)
  - “Fracture zones in the equatorial Atlantic.” (Fig. 5, p. 93)
  - “Bathymetric sketch of Atlantis Fracture Zone.” (Fig. 6, p. 93)
  - “Arabian Sea, Red Sea, and Gulf of Aden. ... portion of the Physiographic Diagram of the Indian Ocean” (Fig. 7, p. 95)
  - “Madagascar Ridge, Mozambique Ridge and Mid-Oceanic Ridge. ... portion of the Physiographic Diagram of the Indian Ocean” (Fig. 8, p. 96)
  - “Northwest Indian Ocean.” (Fig. 9, p. 97)
  - “Diamantina Fracture Zone, Broken Ridge, Ninetyeast Ridge in the east central Indian Ocean. ... portion of the Physiographic Diagram of the Indian Ocean” (Fig. 10, p. 98)
  - “Distribution of smooth and rough topography in the world oceans.” (Fig. 11, p. 99; Figure 10.3)
  - “Organic productivity of the world ocean; a generalized interpretation based largely on oceanic circulation patterns.” (Fig. 12, p. 102)
  - “Sediment thickness.” (Fig. 13, p. 102)
  - “Tectonic chart of the world.” (Fig. 14, p. 104, on a Mercator projection)
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Note: Original captions, truncated.

The semiotics of Tharp's topographic oceans map are exquisite (Figure 10.3).<sup>8</sup> First, ocean floor topography is classified into five general types: "smooth flat," "smooth undulating," "high vertical relief," "rough... abyssal floor," and "rough... mid-oceanic ridge." It is almost as if there are three semiotic moments here:  $-$ ,  $l$ , and  $^^^$ . That is, the first two types are basically horizontal, flat, and smooth (i.e.,  $-$ ), the middle one vertical (i.e.,  $l$ ), and the last two rough (i.e.,  $^^^$ ). Second, abstract dots, lines, and closed shapes are combined in different ways to mark off different areas of the ocean floor (e.g., abyssal plains such as those off the African west coast or off several mid-oceanic ridges). In this way, the limits of knowledge are also accepted, and extrapolation and interpolation called out, with symbolization for "inferred but unproven abyssal plain." Finally, the subtlety of some of Tharp's abstract signs and symbolic implications is sublime, including: " $c \downarrow o \downarrow n \downarrow e$ " for abyssal cones; the remarkable absence of any structure in the white void labeled "mid-oceanic ridge"; and, in a moment of oceanic revenge, the implicit plea to the reader to not pay any attention whatsoever to the solid black void of the continents. What if you focused your mind's eye on those parts of the ocean bottom that are much harder for you to imagine, beyond the mid-oceanic ridges (e.g., the Indian Ocean Ninety East Ridge or the vast abyssal floor of the Pacific Ocean)? We invite the reader to procure a magnifying glass and closely study Figure 10.3 for your own enjoyment.

Thus, Heezen and Tharp (1965), and in particular Figure 10.3, serve as a snapshot of *what if?*-thinking and abstraction in Marie Tharp's opus. Tharp's highly diverse maps tell many a story about the ocean; her semiotics involve significant consideration and sophistication; and her deft hand created highly informative and beautiful maps, synthesizing the scientific and artistic.

### 10.3 *What If?* in Visual Arts

Scientists such as Tharp make the world visible using data secured by microscopes, telescopes, and echosounders (cf. Wise, 2006). Artists also show us invisible worlds, often by depicting or accentuating features of the real world. In art, the process of abstraction is even more imaginative than in science or the philosophy of science. The abstract in art, a product of the artist's imagination, draws us in to participate in the artwork—to use *our* imagination. The artwork can be a portal to our own inner world and to alternative realities—not just utopias, but also states and spaces without a purpose other than the viewer's experience. The abstract in art implores and strongly invites the spectator to engage in *what if?*-thinking.



### 10.3.1 *The Abstract in Visual Arts*

In depictive, figurative or representational art—say, Dutch Golden Age painting or 19th-century Realism or Naturalism—we have a common ground: namely, a desire to faithfully reproduce our shared world, as presented to the senses. Viewers do not have to say out loud that a chair is a chair or a face a face. In contrast, the abstract in art invites unlimited possibilities in its visual language. In our desire to categorize and decode, one association will turn into the next, and the next, and so on. Abstract art issues in mystery and potential. In simplifying creatively, the abstract in art includes geometrical forms, the void, sheer color, and, in general, semi-otic codes. For instance, a painter in a dialogue by Piet Mondrian says: “In painting you must first try to see *composition, color, and line*, and not the representation *as representation*. Then you will finally come to feel the subject matter a hindrance” (Mondrian, 1992/1919, p. 283; emphasis in original). What is essential here is not an exact 1:1 match with the physical world but the invitation to open alternative realities (cf. the Kaf plate).

The abstract in art is subjective—it will be experienced differently from viewer to viewer. Higher degrees of abstraction will leave more to individual interpretation. Many abstract artists active during the period of Minimalism in the 1960s (e.g., Agnes Martin and Robert Ryman) wished for the spectator to experience the artwork with their body, rather than to decode it. The spectator’s mindset and imagination are co-creative of the artwork, even if its theoretical and temporal context, the artist’s intentions and artwork title, and the role of art historians and theorists in communicating about it also remain essential aspects of the artwork. Indeed, the viewer’s experience of the abstract invites a wide range of *what if?* questions: What if the artwork implored you to imagine alternative, previously invisible worlds? What if the artwork did this by depicting formal structures gleaned from the visible world and deployed in surprising ways?<sup>9</sup> The abstract is generous.

Thinking of abstract art may call to mind its best known form: the early 20th-century work of Wassily Kandinsky, Piet Mondrian, and Kazimir Malevich, among a few select others (but see below), as well as American Abstract Expressionism of the mid-20th century. But we will deliberately start further back and out than this obvious apotheosis of abstraction, appealing also to, for instance, Cubism and Minimalism.

Consider the geometrical forms associated with early 20th-century Cubism.<sup>10</sup> Cubism captures harmonic beauty with a multi-perspectival geometrical reconstruction of reality premised on collapsing or projecting—and recreating—regular three-dimensional space and experience onto the canvas’ two dimensions (cf. Ozenfant, 1992/1916, p. 224), an act

reminiscent of our Kaf plate thought experiment. For cubists, geometry permitted an aesthetic *what if?* decomposition and recomposition of the world: “geometry is to the plastic arts what grammar is to the art of writing” (Apollinaire, 1992/1912, p. 181). Furthermore, “avantgarde artists and art theory in the years up to World War I” considered “abstraction, anti-mimetic form-language and especially geometrical figures” to be “a significant method to express the metaphysical and spiritual sides of the world” (Schou, 2019, p. 63; Winther’s translation).

Abstraction is not just operative in art that is traditionally called abstract: What if an apparently depictive scene turns out to contain surprising elements of the abstract? Furthermore, abstraction may reach beyond our mind: What if an abstract artwork is an entrance to an alternative reality and imaginary world? Such worlds may be spiritual, as we shall see with Caspar David Friedrich (1774–1840; who discovered *avant la lettre* key elements of the abstract in art) and especially Hilma af Klint (1862–1944; perhaps the first abstract artist, *sensu stricto*). Such worlds may also be secular, teeming with formal structures with open-ended semiotics. For instance, in contemporary art, Marie Raffn’s artworks are frequently motivated by *what if?*-thinking, inviting the spectator to commune simultaneously with the mystical and with the formal and quasi-mathematical. By exploring the work of Friedrich, af Klint, and Raffn, we expand our understanding of *what if?*-thinking as characteristic of the abstract in art.

### 10.3.2 *Abstract Elements in C. D. Friedrich*

We have moved from the stars to the ocean floor and now, with German Romantic landscape painter Caspar David Friedrich, to the mysterious sky and frozen sea. While it might seem surprising to find elements of the abstract in art so early on, Friedrich’s work contains abstract elements such as the void—glossed both as empty space and as a sense of present absence—and cubistic forms.

A monochrome sky fills approximately 80% of the painting *Der Mönch am Meer* (Friedrich, 1808–1810). The grandeur is exalted by a small figure standing on the beach sand with his back toward us while he is looking at a dark sea. According to art historian Dea Schou, *Der Mönch am Meer* “speaks through two channels—one representational and one abstract.” The first channel is the “figurative scene with the monk and the beach,” the latter “the background and the sky... characterized by an abstract, blurred, and material mode, composed of colors, clear texture, and impasto brushstrokes” (Schou, 2014, p. 83; Winther’s translation). Dialectically then, this artwork represents a literal monk on a beach and simultaneously deploys the abstract void—i.e., the empty space and

present absence of the painting's sky, clouds, and light—to invite the spectators into mystery through its depiction of something impalpable, beyond rational comprehension: sublime nature, the spiritual, and God. Art historian Alice Kuzniar points out this potential of the void: “An early anonymous reviewer of 1804, for example, remarks that Friedrich, rather than paint the rays of the sun, leaves it to the viewer to imagine them” (Kuzniar, 1988, p. 368). The spiritual was important to Friedrich, so clearly alluded to in the figure of the monk:

Because Friedrich... imposed upon everything he drew and painted an explicit or implicit sense of supernatural power and mystery in nature, it becomes especially difficult to categorize his various works as either religious or secular in character. They are, in fact, both.

(Rosenblum, 1975, p. 25; cf. Harvey, 2022, p. 82)

Thus, with the abstract void, and its depiction of absence, the viewer is invited in to reflect on and perfect the painting, thereby making it whole and experiencing the spiritual, almost as if we were standing side by side with the monk on the beach.

The abstract nature of Friedrich's work is emphasized by art historian Robert Rosenblum, who with the term “the abstract sublime” drew parallels between the vast void in *Der Mönch am Meer* and the painting *Light, Earth and Blue* (1954) (almost 150 years later) by Mark Rothko, a painter associated with Abstract Expressionism (Rosenblum, 1961). Over a decade later, Rosenblum started his book thus: “The alpha and the omega of this eccentric Northern route that will run the gamut of the history of modern painting without stopping at Paris may be located in two works,” namely, Friedrich's *Der Mönch am Meer* and Rothko's *Green on Blue* (1956)—the “emptiness” or “nothingness” of these two works “bewildered” and “disconcert[ed]” their audiences (Rosenblum, 1975, pp. 10–11).<sup>11</sup>

*Das Eismeer* (Friedrich, 1823–1824) (Figure 10.4) can be productively interpreted as an early experiment in abstract, cubistic style.<sup>12</sup> Schou observes:

One can regard *Das Eismeer* as an abstract investigation into the painting and the boundaries of the painting. The ice fragments have become geometrical forms and are made up of triangles, squares and straight lines—a surface-oriented construction of an iceberg; pure and abstract. By painting abstract, geometrical forms with a meticulous, detailed, extremely naturalistic painting style, Friedrich blends two principles and two spatial figures: the three-dimensional and the surface-oriented. Our gaze oscillates between seeing a depiction of a



Figure 10.4 Friedrich, C.D. (1823–1824) *Das Eismeer*. H 96.7 × W 126.9 cm. Oil on canvas. In *The Sea of Ice* (English title), an entanglement of ice fragments almost hides a presumably smashed shipwreck in the Arctic on the right side of the painting. *Das Eismeer*. (2023, January 5). Reproduced from: [https://en.wikipedia.org/wiki/The\\_Sea\\_of\\_Ice](https://en.wikipedia.org/wiki/The_Sea_of_Ice) by Caspar David Friedrich—The Yorck Project (2002) *10.000 Meisterwerke der Malerei* (DVD-ROM), distributed by Directmedia Publishing GmbH. ISBN: 3936122202. Public Domain.

realistic ice sea, where the mimetic ship becomes an important detail in the pictorial space for creating depth and space, and to see an abstract representation of pointed, broken, white geometrical shapes in an unidentifiable space, which refers back to the [canvas] surface on which the illusion emerges.

(Schou, 2014, p. 53; Winther’s translation)

The complex entanglement of ice fragments, roughly horizontal in the lower third of the painting, and practically vertically oriented in the upper two-thirds, almost hides what could have been the central focus of the painting; the eerily tilted and presumably smashed shipwreck on the right side. Indeed, the geometrical center of *Das Eismeer*—one could even say its central subject, drawing our attention—is *not* the off-center shipwreck, but the immense and abstract, cubistic cornucopia of ice fragments over which sunlight breaks.

What happens when we perceive an object, in this case a field of ice, from multiple points of view at a single moment? How can

three-dimensional space be collapsed onto the canvas' two dimensions neither through smooth, continuous, and literal metric distortions as in cartographic projections (from the globe), nor in (later) surrealist spatial distortions, but through abstract and geometrical elements—namely, the ice fragments?<sup>13</sup> Through *what if?*-thinking, we can thus complete the painting and experience nature's sublime power, fearing for the souls on the wrecked ship.

In these two artworks by Friedrich, the void and geometrical forms, respectively, help awaken potential, curiosity, and imagination. Through *what if?*-thinking, we connect to the sublime in nature and even to the spiritual. Rosenblum states: "Friedrich's search for new symbols to elicit transcendental experience was so intense that it converted almost all earlier categories of secular painting into a new kind of religious painting" (1975, p. 32). Friedrich himself apparently said:

Close your physical eye, so that you may see your picture first with the spiritual eye. Then bring what you saw in the dark to the light, so that it may have an effect on others, shining inwards from outside. ... A picture must not be invented, it must be felt.

(Bell, 2012)

### 10.3.3 *The Spiritual in Hilma af Klint*

The spiritual aspect of abstraction can also be understood through the important work of the Swedish artist Hilma af Klint, who was "a pioneer of abstraction" (Wivel, 2004, p. 12; Birnbaum, Noring, Kittelmann, and Stals, 2013, p. 15; Müller-Westermann, 2013, p. 33; *Beyond the Visible—Hilma af Klint*, 2019). In November 1906, she started painting the series *Primordial Chaos*, initiating the cycle *Paintings for the Temple* (Voss, 2022, p. xii, for the paintings; see, e.g., af Klint, 1906–1907 and Guggenheim, 2018). This was abstract art "several years before Wassily Kandinsky, Piet Mondrian, Kazimir Malevich and František Kupka" (Müller-Westermann, 2013, p. 33).<sup>14</sup> Hilma af Klint's "visual worlds" evolved over time, from "organic abstraction" into "geometrical" abstraction; the red thread in this shifting work is the "attempt[] to give shape to invisible contexts and make them visible" (Müller-Westermann, 2013, pp. 33, 45). With sheer colors, sharp forms, balanced composition, and a guided brush, af Klint made visible hidden, spiritual worlds.

In fact, Hilma af Klint believed she communed with spiritual beings from other dimensions. She was influenced by contemporaneous spiritual and occult movements such as spiritualism, theosophy, and anthroposophy (Weise, 2023). In af Klint's own words: "The pictures were painted directly through me, without any preliminary drawings and

with great force. I had no idea what the paintings were supposed to depict; nevertheless, I worked swiftly and surely, without changing a single brushstroke” (Müller-Westermann, 2013, p. 38, note suppressed). Indeed:

If Romantic artists felt like mediums for God, Hilma af Klint felt like a medium for the departed souls that return during spiritualist meetings.

(Wivel, 2004, p. 12; Winther’s translation)

Since 1906, [af Klint] had been attuned to a broader cosmos described by spirals, snails, swans, letters, and abstract figures, with Askets and Vestals. She had spiritual friends called Gregor and Ananda, names from disparate cultural contexts.

(Voss, 2022, pp. 275–276)

What if we could experience and access the spiritual, thereby transcending the limitations of what our senses are able to register in the physical, material reality of everyday life? Hilma af Klint’s abstract visualizations, also inspired by complex, living nature and even by the latest science of invisible electromagnetic waves, are a portal—“an opening with no interpretation” (Wivel, 2004, p. 12; Winther’s translation)—to other worlds and alternative realities.

Across fields and time periods, Caspar David Friedrich, Hilma af Klint, and Marie Tharp share a fascination and dedication to making the invisible visible through the use of their hand. What if we could render visible the ineffable sublimity of God in Nature, the wisdom of the spiritual beyond, or the dizzying beauty of the ocean floors?

#### 10.3.4 What If? *in the Contemporary Art of Marie Raffn*

Contemporary art is often permeated by abstract elements and abstraction, as well as by the desire to invite spectators to engage in imaginative *what if?*-thinking. Much can be said about art in our times, but we will be zooming in on the work of Raffn, with which we have first-person familiarity. This approach also gives us an opportunity to consider sculpture. Raffn’s sculptures are three-dimensional works which nevertheless, like paintings, have two-dimensional interpretations.

Minimalism is a form of abstract art that emerged in the USA in the late 1950s and 1960s (e.g., Carl André, Agnes Martin, Richard Serra, Eva Hesse, Charlotte Posenenske, and Fred Sandback). A number of minimalist artworks consisted of “simple geometric shapes based on the square and

the rectangle” (Tate, 2023). Minimalists often used commercial materials and manufactured their art industrially; color was deployed to mark and define space rather than to capture sentiments, let alone spirit (in stark contrast to Friedrich and af Klint). They also cared about viewer engagement, including the ability of the viewer to move through some of the artworks (Wolfe, 2019). The same applies to land art (inspired by, e.g., Minimalism and Conceptual Art)—the movement of the spectator’s body through space is essential to experiencing the artwork. For land artists such as Robert Smithson (1938–1973), shapes tended toward the organic, and the artistic transformation of geology and ecology was a significant driver.

The current Danish artist Marie Raffn is influenced by Minimalism<sup>15</sup> with strands or overtones of Cubism and a playfulness found in Dadaism and concrete poetry “objects composed of words, letters, colors, and typefaces, in which graphic space plays a central role in both design and meaning” (Aube and Perloff, 2017). In her solo exhibition *an oval, a vowel, an e* (Raffn, 2021a; Figure 10.5), concrete forms are rooted in concepts and questions concerning dimensionality in a physical meeting with the body.<sup>16</sup> The press release for *an oval, a vowel, an e* opens with *what if?*-thinking and embraces the more-than-human:



Figure 10.5 Raffn, M. (2021a) *an oval, a vowel, an e*. Vestjyllands Kunstpavillon, Videbæk, Denmark, June 26–July 18, 2021. Curated by Paola Paleari and Anne Zychalak Stolten. Photo: Jacob Friis-Holm Nielsen. Dimensions variable. Steel, plaster, pigment. © Marie Raffn 2021. Installation view of organic line formations with embedded dyed reliefs in grouped compositions that could resonate with a drawing, a notational score or a scribble from a distance.

What if one found oneself, in body and mind, within a cubist, polysemic universe—within an abstract language? ... [the exhibition] leads our thoughts and associations towards a spatial, enlarged, fragmented drawing. A kind of three-dimensional, pluralistic and fractal translation of two-dimensionality. ... We all reduce dimensionality in our own fashion; and somehow depict and understand the world cubistically, in different ways. Some species emit sounds and orient themselves by following echoes from surrounding objects. Can the works in the room detect each other and establish a similar relationship?

(Paleari, Stolten, and Raffn, 2021)

In this way, “with an experimental approach, Raffn distorts the given uniformity of language” (Bhullar, 2022).

The geometrical sculptures, in the large installation, are three-dimensional but feature prominent, two-dimensional surfaces inviting inspection (similar to Friedrich’s ice fragments). The outlines of the spatial wavy lines and the sculptural, dyed sheer color reliefs change significantly depending on the angle from which they are viewed, creating various formations and compositions. The cubistic “preference for discrete, palpable objects” (Rosenblum, 1975, p. 192) and multi-perspectival geometrical reconstruction of reality comes to the fore here: “my sculptures are rooted in material and textual worlds,” Raffn says. “New connections... arise through associations and games that welcome other ways of understanding” (Raffn, 2021b). The abstract reveals itself as a metaphysical layer of higher-level-thinking, which may equate to an enigmatic kind of mysticism.

Whereas the installation *an oval, a vowel, an e* spreads over physical space, the sculpture *Untitled (VEAAVI)* (Raffn, 2023) (Figures 10.6 and 10.7) is an open-ended steel collage of the signs of the notational system of Raffn (2019), where each sculptural fragment is a “movement notation” somewhere between a letter, a sign, and a drawing. The capital letters in the title *Untitled (VEAAVI)* are taken directly from those signs that resemble letters in the lower “row” of the sculpture (Figure 10.6), emphasizing how something concrete and simultaneously open and formal turns into an increasingly abstract language. As with Hilma af Klint, this is an exploration of the potential of what signs or symbols could mean, rather than the search for one specific answer.

Raffn’s engagement with concrete poetry again elevates visual form and the spatial composition of words in addition to semantic, meaning-laden output. This applies to her spatial installations as well as to her artist books:





Figure 10.6 Raffn, M. (2023) *Untitled (VEAAVI)*: frontal view. Approx. H 240 × L 75 × W 290 cm. Steel. © Marie Raffn 2023. The Danish Art Workshops, Copenhagen, Denmark. Photo: Jenny Sundby. The sculpture has a slender construction rising upwards that appears both loose and tight, constructed by fragments in a compressed composition.

I have chosen to tell you about the artists' book from a Swedish perspective but without stopping at any borders. My method has not primarily been chronological. The history running from Asger Jorn and C O Hultén up to Marie Raffn and Lina Nordenström has not been hung on a timeline, quite simply because that would give the impression that one thing leads to the other. This rarely happens. The history is much more interesting than this, with threads, thoughts, expressions crossing, mixing, combining.

(Millroth, 2021, p. 29)

Viewed head on, *Untitled (VEAAVI)* looks almost two-dimensional (an uncanny appearance since this would make it impossible for it to balance) (Figure 10.6). In the sensory encounter with the spectator's moving body,

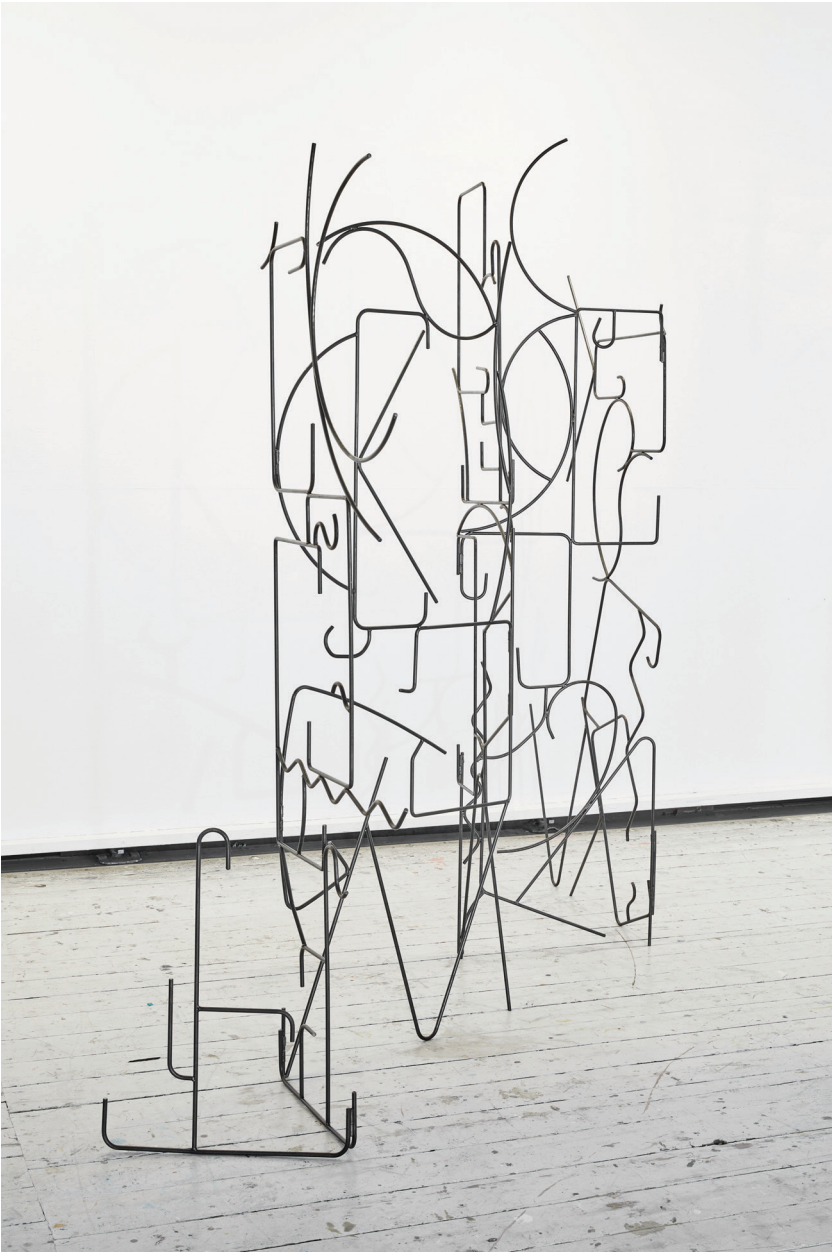


Figure 10.7 Raffn, M. (2023) *Untitled (VEAAVI)*: 45-degree angle view. Approx. H 240 × L 75 × W 290 cm. Steel. © Marie Raffn 2023. The Danish Art Workshops, Copenhagen, Denmark. Photo: Jenny Sundby. The sculpture has a slender construction rising upwards that appears both loose and tight, constructed by fragments in a compressed composition.

the artwork's lines dissolve into geometrical, organic fragments overlapping in a cubist manner, and a bewildering number of voids emerge. Especially when viewed from the narrow side, the sculpture appears almost kaleidoscopic in its infinity (Figure 10.7).

From a distance, Raffn's works could read as drawings, notational scores, or scribbles. There is a consistency. Ocean. Something fluid? A visual poem. The unexplainably abstract. For instance, at the vernissage of *an oval, a vowel, an e* on June 26, 2021, selected sculptures served as a graphical score, read and interpreted by a violinist. The abstract relationship and translation between image and sound was also important to Kandinsky, as Müller-Westermann (2013) reminds us: "Synaesthetic perception became crucial for him: colors evoked tones and in turn, tones evoked colors" (p. 45). Furthermore, Wivel (2004) points out, a "cardinal point" in Kandinsky (1977/1912) is that the "visual arts should mimic music" (p. 13; Winther's translation). Likewise, abstract expressionist Agnes Martin desired her paintings to be a kind of music:

It's not about facts, it's about feelings. It's about remembering feelings and happiness. A definition of art is that it makes concrete our most subtle emotions. I think the highest form of art is music. It's the most abstract of all art expression.

(Beasley, 2021)

Raffn's *an oval, a vowel, an e* expresses a different, more liberated and perhaps less obsessive kind of vibrating humming than what is found in the immense, impressive installations of handwritten notations by conceptual artist and minimalist Hanne Darboven.<sup>17</sup>

[N]umbers, words, and dates fill Darboven's grids to the saturation point. Often using the simple, reduced means of pencil and paper, she copies out by hand vast sequences so that "The writing fills the space as drawing would." And if a line from one of Darboven's works that is a letter to Sol LeWitt reads "writing writing"—as if "writing writing" were the fundamental operation of the work itself—then could we not see Agnes Martin "drawing drawing"?

(Fer, 2006, p. 184, note suppressed)

To spiral back: the uncomfortable and incomplete synesthesia of sound, drawing, and sculpting were woven together at the vernissage of *an oval, a vowel, an e*.

If *an oval, a vowel, an e* captures dynamic, cubistic perspectivism—an abstraction from the world's entangled processes—then *Untitled (VEAAVI)* embodies the empty and present absence void within and between the

signs of one communication system among many—an abstraction of pure semiotics. The feminine invisible in these artworks is yet to be made visible and analytically explicit.<sup>18</sup> Again, with absolutely no pretensions of even scratching the (flat? curved? fragmented?) surface of contemporary art, we turned to Raffn's 2021 installation and 2023 sculpture as subtle cases of geometrical forms, the void, and the mystical, not to say spiritual, in the abstract in (contemporary) art.

### 10.3.5 Integrating Abstraction through Robert Smithson

Robert Smithson's *Map of Broken Glass (Atlantis)* (Figure 10.8; Smithson, 1969a), an installation that "occupied a beach in Loveladies along the New Jersey coast... for twenty days in July 1969" (Hailey, 2020), permits us to sharpen up themes in Tharp, Friedrich, and Raffn.<sup>19</sup> Smithson was taken by the idea of a lost continent of Atlantis: "[there are many] hypothetical arguments in favor of Atlantis. Conjectural maps that point to this non-existent site fill many unread atlases. ... From Plato's *Timaeus* to *Codex Vaticanus A* the documents of the lost island proliferate" (Smithson, 1996/1969, p. 133). What if such a place had existed? One sketch for this artwork, *Map of Broken Clear Glass (Atlantis)*, also from 1969, presents a large outline—with zigzag lines inside, representing glass shards—similar in shape to the outline of Atlantis from a map in Lewis Spence's *The History of Atlantis*, which is affixed to the sketch's upper-right hand corner (Smithson, 1969b). Another drawing from December of the same year, *A Surd View for an Afternoon* (Smithson, 1970/1969), shows another planned, immense project, in context: "The drawing's eccentric epicenter is *Island of Broken Glass*, which rests at the origin of an Archimedean spiral" (Hailey, 2020). As a minimalist working with land art, Smithson's work was suffused with maps and mapping (Wood, 2010, pp. 207–208; Siegert, 2023).

Much like Tharp's maps, Smithson's *Map of Broken Glass (Atlantis)* attempts to make visible the invisible ocean floor, in this case the fictive, even spiritual, *Atlantis*. His submarine topography was rough and sharp, hers rough or smooth. The artwork's glass shards are reminiscent of Friedrich's cubistic ice fragments, and the work's void, whether on a beach in New Jersey or cradled in a white cube, is the air above the installation representing several kilometers of frigid ocean water over the lost continent.<sup>20</sup> In *A Surd View for an Afternoon*, *Island of Broken Glass* is shown sitting at the center of a spiral and a "triangulated spiral".<sup>21</sup> Raffn is inspired by Smithson—an oval, a vowel, an e resonates with his work's fragility, mapping between two-dimensional and three-dimensional space, and ambiguous semiotics. Might large shards represent rocky outcrops while small shards along the edges are a kind of mathematical device

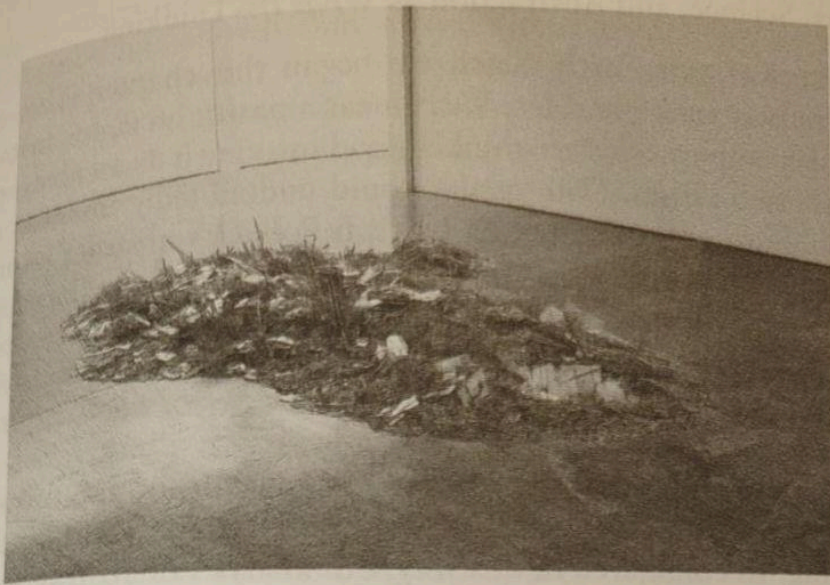


Figure 10.8 Robert Smithson, *Map of Broken Glass (Atlantis)*, 1969. Dia Art Foundation; Partial gift, Lannan Foundation, 2013. © 2023 Holt/Smithson Foundation/Licensed by Artists Rights Society (ARS), NY. Photo: Florian Holzherr, courtesy Dia Art Foundation, New York. H 48 × L 240 × W 192 in. Glass. Smithson's artwork consists of turquoise-tinted glass shards of different sizes pressed against each other, with surprising vertical effects, and likely in the outline of Lewis Spence's Atlantis. The image is available online at [www.diaart.org/collection/collection/smithson-robert-map-of-broken-glass-atlantis-1969-2013-027](http://www.diaart.org/collection/collection/smithson-robert-map-of-broken-glass-atlantis-1969-2013-027)

where groups or sets of glass infinitesimals asymptotically approach a smooth topography? We are here far from the regimented semiotic codes of Tharp's maps.

The elements of the abstract that we have considered are represented in Smithson's *Map of Broken Glass (Atlantis)*:

- the mapping and abstraction of topography in various ways (e.g., selection, simplification, and exaggeration protocols);
- geometrical, cubistic forms (including circles and spirals);
- the void;
- the play between the two-dimensional and the three-dimensional;
- manufactured and raw materials;
- semiotic codes.

Should we imagine these elements as simultaneous layers of abstraction, or is each an independent, particular form of abstraction? Can and should we use lessons from the history of art and art theory to illuminate the abstract—and abstraction practices—in philosophy of science?

#### 10.4 Art, Science, and Abstraction as *What If?*-Thinking

Recall the Kaf plate with which we began this chapter. This everyday object can play multiple roles. We can eat a pastry on it, for instance. But we can also employ *what if?*-thinking and imagine it as an abstract object, in at least two senses. (The reader could undoubtedly imagine more.) It could allude to artwork such as Jackson Pollock's abstract expressionist paintings. The plate could also, you will recall, be imagined as a star map. In that role it invites many open-ended investigations and even paradoxes about space, cartographic projections, and existence. It also invites us to an important meta-question: *What if we thought of abstraction as what if?-thinking?*

In this chapter, we have drawn on examples from art and science to show that different kinds of abstraction result from different kinds of *what if?*-thinking. Reconfigured in this way, our analysis of abstraction and the creative practices it invites can be seen as substantively contributing to the philosophy of science literature on representation, broadening those debates beyond questions of how a representation fits data or matches the world. The account of *what if?*-thinking we propose here is in line with the *multiple representations account*, recently developed by one of us in the context of cartography and philosophy of science (Winther, 2020a; see further developments by Walsh and Rupik, 2023 and Rupik, 2024). The multiple representations account:

explores the process of how map *becomes* world. ...the first stage or moment is *ontologizing*, when we make the abstraction the world. The second moment is *merely-seeing-as*, when we are aware that our abstraction is not the world. Practice enriches theory in the third, synthetic moment of *pluralistic ontologizing*. Here a scientific community or the lay public uses various representations to measure, change, or understand the world, with the ability to test different representations for these purposes side by side.

(Winther 2020a, p. 128; note suppressed)

According to this account of representation, one can proceed through different stages of representation, first conflating representation and reality, then refraining from doing so, then finally taking up different representations and experimentally employing them to understand, and intervene in, the world. Winther's multiple representations account asks: What if different scientists developed a variety of models about the same, as it were, system or part of the world?<sup>22</sup> These models or maps themselves originate in prior processes of abstraction involving *what if?*-thinking.<sup>23</sup>

Our open-ended exploration of abstraction as *what if?*-thinking in art and science has shown that abstraction can neither be reduced, without conceptual harm, to a philosophical moniker, nor can it be reduced to a single relation or practice—e.g., “omission,” “distortion,” or “simplification,” as some in philosophy of science would have it. Roughly put:

*Abstraction is a cognitive, aesthetic, and social process of analyzing, creatively adding to, and what-if?-thinking about (1) the actual known, shared world; (2) alternative realities that may still be actually existent (e.g., scientific experiments); or (3) artistic or fictional imaginary worlds—eventually presenting (in language, mathematics, visual representations, music, etc.) and storing (in the mind, as computational data, on a canvas, etc.) information about salient (in a particular context, for a particular question) aspects of such worlds.*

This is our rather imprecise, rule-of-thumb characterization of abstraction, which we will call *creative abstraction*.<sup>24</sup> Let us distill it more:

*Abstraction is a creative deconstruction (analysis) and reformulation (synthesis) of worlds, which may be motivated by asking what if?*

Abstraction both conserves and challenges existing thinking. Even in standard cartography, abstraction involves a subtle tension between representing and questioning the status quo. It is tempting to believe “that which is mapped, *is*, and that which *is*, can be mapped”; on the other hand, and asking *what if?*: “Can cartographic reason re-create our world? Can it bring forth new worlds?” (Winther, 2022; emphasis added).

We have seen how different visual creators bring forth new worlds by abstracting with *what if?*-thinking. First, Tharp abstracts *cartographically-scientifically* by asking: What if we could remove the seawater above the ocean floor, and thereby visualize with maps the otherwise invisible seafloor? Friedrich abstracts *sublimely* by asking: What if an immense and monochrome sky or a field of ice fragments could open our imagination to a metaphysical world? Af Klint abstracts *spiritualistically* by asking: What if I could use color, shape, and composition in serving as a medium to the world of spiritual beings? Raffn abstracts *synaesthetically* by asking: What if the spectator could walk among colorful and enigmatic signs, and experience how sound, drawing, and sculpting are entangled in a fragmented and pluralistic world? Smithson abstracts *cartographically-artistically* by asking: What if open-ended, disjointed, or physical maps could point toward realms of mental potential?

If Winther (2020a) explores how cartography could enrich philosophy of science, this chapter, and perhaps this edited volume in general, seems part of an investigation into how art, art history, and aesthetics could teach philosophy of science. What if philosophers of science looked to entire other domains of human expression—e.g., cartography and art—to understand science? *When Maps Become the World* was premised around the map analogy: “a scientific theory is a map of the world” as explored in its Chapter 2: “*Theory Is to World as Map Is to Territory*” (Winther, 2020a, p. 29, pp. 28–57). At least implicitly, our chapter also points to an analogy that can be stated via *what if?*-thinking: *What if mathematics is to the natural sciences as abstract art is to depictive art?*<sup>25</sup> Just as abstract art is non-depictive, systematic, mystical, and even spiritual, so mathematics is transcendent, imaginative, and explores the possible—both are steeped in creating alternative worlds.<sup>26</sup> They are paradigm cases of *what if?*-thinking.<sup>27</sup> In contrast, perhaps like depictive art, the natural sciences aim at representation, and, like depictive art, are also constrained by our given, shared, and experienced world.

In short, in so far as abstraction involves rethinking and redoing the status quo, abstraction involves *what if?*-thinking. Such creative abstraction helps us make multiple representations that attempt to track the world, and it helps us produce artistic works opening up worlds of imagination. In that sense, our characterization of creative abstraction captures abstraction in science and art.

### Acknowledgments

Chiara Ambrosio and Julia Sánchez-Dorado critiqued the chapter in several iterations, and we are also grateful for their patience and support. Dea Schou engaged with us in conversations on art history. Susan Dunne and Jóhan Martin Christiansen provided superb feedback on contemporary art. Lucas McGranahan copyedited in expert fashion. Laura Laine helped secure figure permissions.

### Notes

- 1 See Wertenbaker (1974), Oreskes (1999), (2021), Barton (2002), Doel, Levin, and Marker (2006), North (2010), Felt (2012), Winther (2019), (2020a), (2022), and Higgs (2020) for parts of Tharp’s biography and context.
- 2 Higgs (2020), p. 238 presents a thought-provoking counterfactual history pointing to an alternative reality in which invisible women scientists are made visible (cf. Oreskes 1996). Elsewhere, Winther will track in detail, in the contemporaneous scientific literature, the general lack of recognition Tharp received for her 1952 proper, systematic discovery of the mid-Atlantic Ridge



- rift (preliminary text available upon request). Theberge (2014a, 2014b, and 2014c) and Oreskes (2021), pp. 194–231 trace the discovery to earlier efforts.
- 3 Regarding Tharp’s imagination: “I also wanted to include mermaids and shipwrecks, but Bruce would have none of it” (Tharp, 1999).
  - 4 The physiographic diagram map was found in Elmendorf and Heezen (1957) “in envelope inside rear cover” (p. 1061). The map cartouche clearly indicates “Bruce C. Heezen and Marie Tharp” as the creators; states a “vertical exaggeration about 20:1”; and codifies four different categories of “fathom relief,” from relatively smooth to strikingly vertical along the mid-oceanic ridge. A rift valley along the middle of the ridge is drawn on the map.
  - 5 Heezen and Tharp (1966) is much shorter; more descriptive; lacks any significant theoretical discussions; and has a lower diversity of scientific maps. We also set aside the scientific maps of Heezen, Tharp, and Ewing (1959) because that volume has been discussed elsewhere, at least in general, and is much more methodological, containing many more profiles than significant maps, as it was their first attempt to map the ocean floor (cf. Figure 10.2). Heezen, Bunce, Hersey, and Tharp (1964) and Heezen, Gerard, and Tharp (1964) are highly descriptive papers filled with figures—including topographic profiles and temperature profiles as well as photographs of the ocean bottom—many of which are not standard maps. Even so, these figures deserve further exploration, particularly figures 1, p. 13, and 6, p. 20, of Heezen, Bunce, Hersey, and Tharp (1964), with their rich symbolization and semiotics.

6

In an ocean such as the North Atlantic or South Atlantic the nearly precise symmetry of these oceans and the lack of any extensive aseismic ridges make such a [mantle “convection cells”—i.e., continental drift] pattern indeed attractive. However, in the Indian Ocean the existence of such divergent trends and the scattered ancient micro-continents make such explanation extremely difficult.

(Heezen and Tharp, 1965, p. 101)

- 7 Heezen (1959) was the first presentation of Heezen’s version of the expanding Earth theory (see especially Heezen, 1959, pp. 295, 300, 302, and the Q&A on pp. 302–304). Heezen was not the only defender of this theory (e.g., Carey, 1975). The theory was an imaginative, if ultimately unsuccessful, use of *what if?*-thinking.
- 8 While there is no reference to the “Distribution of smooth and rough topography in the world oceans” map (Figure 10.3) in the text of Heezen and Tharp (1965), there are ample qualitative descriptions of different regions and features visualized on this map. The map works as a visual summary.
- 9 There are also questions pertaining to cognitive science or even transcendental philosophy here: What if the abstract in art can show us how the eye’s vision is constituted by innate cognitive structures? What if abstraction is a way of representing the mind’s powers of abstraction to the mind?

- 10 A term which, according to art historian Nicholas Wadley, “originated from criticisms of the angular volumes in some of [Georges] Braque’s paintings of 1908” (Wadley, 1970, p. 12). In collecting roughly 200 paintings that either fall under the style or school or movement of Cubism or are influenced by Cubism, Wadley (1970) serves as a window to Cubism.
- 11 What counts as a precursor? In “Kafka and His Precursors,” Borges (1999/1951) writes, “the fact is that each writer *creates* his precursors. His work modifies our conception of the past, as it will modify the future” (p. 365, emphasis in original, note suppressed). The subsequent existence of artists, art styles, or art critics (e.g., Rosenblum, Schou) births the conception of an earlier artist or artwork as a precursor. For Rosenblum, it is the “dilemma” or dialectic between the sacred and the secular that provides the connecting thread “between Friedrich’s *Monk by the Sea* and a painting by Rothko” (Rosenblum, 1975, pp. 10, 12, 218).
- 12 Relatedly, Nielsen (2022) discusses “The Cubistic Iceberg” in relation to the Anthropocene.
- 13 We believe that most surrealist paintings depict figuratively with distortions, while Cubism works with abstract objects. In addition, we here set aside discourse about Cubism and the spatial “fourth dimension” (e.g., Wadley, 1970; Henderson, 1983; and Ambrosio, 2016).
- 14 Hilma af Klint’s biographer, art historian Julia Voss draws an alternative history making invisible women artists visible (Voss, 2022, pp. 305–306). As with Marie Tharp, there is a larger cultural historical context—both then and now—diminishing the work and existence of women pioneers in science and art. Resonating with Higgs (2020) and Voss (2022), our chapter is also a *countermap* (Winther, 2020a) to standard historical narratives.
- 15 However, the imprint of the hand is present in her work, and although you will find commercial materials (steel, fiberglass, etc.) as well as (mathematical) systems, variations, and repetitions in her artworks, these are freer and more organic than what is typical of Minimalism.
- 16 When the exhibition title is said out loud, there is something Dadaistic and rhyming about the flow, emphasizing the play with language and semiotics in the installation.
- 17 Some of Darboven’s handwritten writings on paper—e.g., the numbers and dates of Opus 17—were also composed into music, which she called “mathematical music” (Darboven, 1996; cf. Spice, 2015).
- 18 We are particularly keen and curious to do this by resonating with Cixous (1976), Irigaray (1991), and Niemanis (2017).
- 19 Smithson is perhaps best known for *Spiral Jetty* (1970). The ocean was rarely far from his imagination (see also his *World Ocean Map, 1967*—on display here: *Robert Smithson: Abstract Cartography*, 2021).
- 20 The Gambia Abyssal Plain, labeled on Heezen, Tharp, and Berann’s classic 1968 *National Geographic* foldout map is approximately 5 kilometers deep, and would roughly be the southern edge of Spence’s, and Smithson’s, Atlantis.
- 21 Müller-Westermann (2013) observes that “the spiral permeates Hilma af Klint’s entire oeuvre” (p. 42). On the esthetic and epistemic import of spirals, see Didi-Huberman (2021).

- 22 Cf. Winther (2020a, pp. 253–254); Chapter 5 of Winther (2020a) articulates the multiple representations account as one philosophical account, among several, of scientific representation.
- 23 Winther (2014b) and Chapter 3 of Winther (2020a) contain extensive treatments of abstraction, which have served as hidden anchors for our analysis. Ohlsson and Lehtinen (1997) and Radder (2012) are also *sui generis* inspirations.
- 24 We are glad to acknowledge resonances between our “creative abstraction” analysis and the category of “generative abstraction” developed by Michael Stuart and Anatolii Kozlov (this volume) as well as, *mutatis mutandis*, the notion of “creative similarity” found in Sánchez-Dorado (2019).
- 25 There is so much to say about the relation between mathematics and the natural sciences. Two favorites: Gowers (2002) and Hacking (2014).
- 26 Elisa Caldarola (this volume) remakes the fragile distinction between the abstract and the depictive—we agree that this distinction is not absolute, but are here engaging in *what if?*-thinking.
- 27 We could further explore our *what if?* analysis by turning to one of our effective precursors, Walton (1990) (cf. note 11). But our project differs from his in multiple ways, including that we start with abstraction rather than with representation; we are honest to a systemic history of art; and we focus on artistic (and scientific) practices rather than on epistemology: How could the abstract in art inspire and expand our philosophy of science horizon? Ultimately, Walton’s make-believe and our *what if?*-thinking continue resonating today.
- 28 Likely date confirmed by Marian V. Mellin of the Lamont-Doherty Earth Observatory (pers. comm. July 5, 2023).
- 29 Checked by Tobias Jung (pers. comm. July 5, 2023, Jung, 2023).

## References

- af Klint, H. (1906–1907). Primordial Chaos, No. 8, Group I, Series WU/The Rose. H 52 x W 37 cm. [Oil on canvas]. Stiftelsen Hilma af Klints Verk, HaK 08, reprinted as Plate 20 in Voss (2020).
- Ambrosio, C. (2016). Cubism and the Fourth Dimension. *Interdisciplinary Science Reviews*, 41(2–3), pp. 202–221.
- Apollinaire, G. (1992/1912). The New Painting: Art Notes. In: Harrison, C. and Wood, P., eds., *Art in Theory 1900–1990: An Anthology of Changing Ideas*. Oxford: Blackwell, pp. 181–182. (Translated from the original French.)
- Aube, C. and Perloff, N. (2017). What Is Concrete Poetry? Available at: <https://blogs.getty.edu/iris/what-is-concrete-poetry/> (Accessed 12 July 2023).
- Barton, C. (2002). Marie Tharp, Oceanographic Cartographer, and Her Contributions to the Revolution in the Earth Sciences. *The Geological Society of London, Special Publications*, 192(1), pp. 215–228.
- Beasley, M. (2021). Agnes Martin: Music for Healing. [Press Release]. Available at: [www.pacegallery.com/pacelive/agnes-martin-music-for-healing/](http://www.pacegallery.com/pacelive/agnes-martin-music-for-healing/) (Accessed 5 June 2023).

- Bell, J. (2012). Caspar David Friedrich at the Edge of the Imaginable. *TLS (Times Literary Supplement)*. 26 October. Available at: [www.homes.uni-bielefeld.de/jgrave/publ/rez\\_cdf\\_tls.pdf](http://www.homes.uni-bielefeld.de/jgrave/publ/rez_cdf_tls.pdf)
- Beyond the Visible – Hilma af Klint. (2019). [Online]. Directed by Halina Dyrschka. New York: Zeitgeist Films.
- Bhullar, D. (2022). Marie Raffn's Sculptures Resist Commonly Accepted Absolutism of Language. Available at: [www.stirworld.com/see-features-marie-raffn-s-sculptures-resist-commonly-accepted-absolutism-of-language](http://www.stirworld.com/see-features-marie-raffn-s-sculptures-resist-commonly-accepted-absolutism-of-language) (Accessed 12 May 2022).
- Birnbaum, D., Noring., A.-S., Kittelmann, U., and Lebrero Stals, J. (2013). Foreword. In: Müller-Westermann, I. and Widoff, J., eds., *Hilma af Klint—A Pioneer of Abstraction*. Ostfildern: Hatje Cantz Verlag, pp. 15–16.
- Borges, J.L. (1999/1951). Kafka and His Precursors. In: Weinberger, E., ed., *Jorge Luis Borges: The Total Library: Non-Fiction 1922–1986*. London: Penguin, pp. 363–365. (Translated from the original Spanish.)
- Carey, S.W. (1975). The Expanding Earth—An Essay Review. *Earth-Science Reviews*, 11(2), pp. 105–143.
- Cixous, H. (1976). The Laugh of the Medusa. *Signs*, 1(4), pp. 875–893.
- Darboven, H. (1996). *Opus 17A*. [CD]. New York: Dia Center for the Arts.
- Didi-Huberman, G. (2021). Inspired by Spirals. *JoLMA. The Journal for the Philosophy of Language, Mind and the Arts*, 2(1), pp. 21–34.
- Doel, R.E., Levin, T.J., and Marker, M.K. (2006). Extending Modern Cartography to the Ocean Depths: Military Patronage, Cold War Priorities, and the Heezen–Tharp Mapping Project, 1952–1959. *Journal of Historical Geography*, 32(3), pp. 605–626.
- Elmendorf, C.H. and Heezen, B.C. (1957). Oceanographic Information for Engineering Submarine Cable Systems. *The Bell System Technical Journal*, 36(5), pp. 1047–1093.
- Ewing, M. and Heezen, B.C. (1956). Some Problems of Antarctic Submarine Geology. In: Crary, A.P., Gould, L.M., Hulburt, E.O., Odishaw, H., and Smith, W.E., eds., *Antarctica in the International Geophysical Year: Based on a Symposium on the Antarctic*. Geophysical Monograph Series, Volume 1. (National Research Council Publication No. 462.) Washington, DC: American Geophysical Union, pp. 75–81. Available at: <https://doi.org/10.1029/GM001p0075> (Accessed 10 June 2023).
- Felt, H. (2012). *Soundings: The Story of the Remarkable Woman Who Mapped the Ocean Floor* (Kindle edition.). New York: Henry Holt.
- Fer, B. (2006). Drawing Drawing: Agnes Martin's Infinity. In: Armstrong, C. and de Zegher, C., eds., *Women Artists at the Millennium*. Cambridge, MA: MIT Press, pp. 168–187.
- Friedrich, C.D. (1808–1810). Der Monch am Mëer. H 110 × W 171.5 cm. [Oil on canvas]. Berlin: Alte Nationalgalerie.
- Friedrich, C.D. (1823–1824). Das Eismeer. H 96.7 × W 126.9 cm. [Oil on canvas]. Hamburg: Hamburger Kunsthalle.
- Gowers, T. (2002). *Mathematics: A Very Short Introduction*. Oxford: Oxford University Press.

- Guggenheim. (2018). Group I, Primordial Chaos (1906–07) by Hilma af Klint. Available at: [www.guggenheim.org/audio/track/group-i-primordial-chaos-1906-07-by-hilma-af-klint](http://www.guggenheim.org/audio/track/group-i-primordial-chaos-1906-07-by-hilma-af-klint) (Accessed 12 June 2023).
- Hacking, I. (2014). *Why Is There Philosophy of Mathematics at All?* Cambridge: Cambridge University Press.
- Hailey, C. (2020). Island of Broken Glass. Available at: <https://holtsmithsonfoundation.org/island-broken-glass> (Accessed 16 July 2023).
- Harvey, A.D. (2022). Caspar David Friedrich and Iconographies of Religious Feeling. *Critical Quarterly*, 64(1), pp. 81–95.
- Heezen, B.C. (1959). Géologie sous-marine et déplacements des continents. In: *La Topographie et la Géologie des Profondeurs Océaniques*. Colloques Internationaux du CNRS, LXXXIII, pp. 295–304.
- Heezen, B.C., Bunce, E.T., Hersey, J.B., and Tharp, M. (1964). Chain and Romanche Fracture Zones. *Deep-Sea Research*, 11(1), pp. 11–33.
- Heezen, B.C., Gerard, R.D., and Tharp, M. (1964). The Vema Fracture Zone in the Equatorial Atlantic. *Journal of Geophysical Research*, 69(4), pp. 733–739.
- Heezen, B.C. and Hollister, C.D. (1971). *The Face of the Deep*. New York: Oxford University Press.
- Heezen, B.C. and Tharp, M. (1964). *Physiographic Diagram of the Indian Ocean, the Red Sea, the South China Sea, the Sulu Sea and the Celebes Sea*. New York: The Geological Society of America. (Map.)
- Heezen, B.C. and Tharp, M. (1965). Tectonic Fabric of the Atlantic and Indian Oceans and Continental Drift. *Philosophical Transactions of the Royal Society of London. Series A, Mathematical and Physical Sciences*, 258(1088) (Special Issue: A Symposium on Continental Drift), pp. 90–106.
- Heezen, B.C. and Tharp, M. (1966). Physiography of the Indian Ocean. *Philosophical Transactions of the Royal Society of London. Series A, Mathematical and Physical Sciences*, 259(1099), pp. 137–149.
- Heezen, B.C., Tharp, M., and Ewing, M. (1959). *The Floors of the Oceans. I. The North Atlantic. Text to Accompany the Physiographic Diagram of the North Atlantic*. Special Paper 65. New York: The Geological Society of America.
- Henderson, L.D. (1983). *The Fourth Dimension and Non-Euclidean Geometry in Modern Art*. Princeton, NJ: Princeton University Press.
- Higgs, B.M. (2020). Understanding the Earth: The Contribution of Marie Tharp. *The Geological Society of London, Special Publications*, 506(1), pp. 231–243.
- Irigaray, L. (1991). *Marine Lover of Friedrich Nietzsche*. Translated by Gill, G.C. New York: Columbia University Press.
- Jung, T. (2023). Note on Fig. 11 of Heezen and Tharp (1965) / Fig 3 of Winther and Raffn (2024): The Denoyer Projection? Available at: [www.rgwinther.com/Divs/Maps/HeezenandTharp1965topographyworldoceansFig11DenoyerProjectionJungforWintherRaffn2024Fig3.pdf](http://www.rgwinther.com/Divs/Maps/HeezenandTharp1965topographyworldoceansFig11DenoyerProjectionJungforWintherRaffn2024Fig3.pdf) (Accessed 20 July 2023).
- Kandinsky, W. (1977/1912). *Concerning the Spiritual in Art*. New York: Dover.
- Kuzniar, A. (1988). The Vanishing Canvas: Notes on German Romantic Landscape Aesthetics. *German Studies Review*, 11(3), pp. 359–376.
- Luskin, B., Heezen, B.C., Ewing, M., and Landisman, M. (1954). Precision Measurement of Ocean Depth. *Deep-Sea Research*, 1(3), pp. 131–140.

- Millroth, T. (2021). *Artists' Books from a Swedish Point of View with Special Attention Paid to the Contributions of Denmark and GDR*. Köln: Verlag der Buchhandlung Walther und Franz König, and ellerströms/tragus.
- Mondrian, P. (1992/1919). Dialogue on the New Plastic. In: Harrison, C. and Wood, P., eds., *Art in Theory 1900–1990: An Anthology of Changing Ideas*. Oxford: Blackwell, pp. 282–287. (Translated from the original Dutch.)
- Müller-Westermann, I. (2013). Paintings for the Future: Hilma af Klint—A Pioneer of Abstraction in Seclusion. In: Müller-Westermann, I. and Widoff, J., eds., *Hilma af Klint—A Pioneer of Abstraction*. Ostfildern: Hatje Cantz Verlag, pp. 33–51.
- Nielsen, P. (2022). 200 år gammelt maleri af eksploderende isbjerg er stadig knugende og særligt aktuelt i 2022. *Information*. 28 January. Available at: [www.information.dk/kultur/2022/01/200-aar-gammelt-maleri-eksploderende-isbjerg-stadig-knugende-saerligt-aktuelt-2022](http://www.information.dk/kultur/2022/01/200-aar-gammelt-maleri-eksploderende-isbjerg-stadig-knugende-saerligt-aktuelt-2022) (Accessed 6 June 2023).
- Niemanis, A. (2017). *Bodies of Water: Posthuman Feminist Phenomenology*. London: Bloomsbury.
- North, G.W. (2010). Marie Tharp: The Lady Who Showed Us the Ocean Floors. *Physics and Chemistry of the Earth, Parts A/B/C*, 35(15–18), pp. 881–886.
- Ohlsson, S. and Lehtinen, E. (1997). Abstraction and the Acquisition of Complex Ideas. *International Journal of Educational Research*, 27(1), pp. 37–48.
- Oreskes, N. (1996). Objectivity or Heroism? On the Invisibility of Women in Science. *Osiris*, 11, pp. 87–113.
- Oreskes, N. (1999). *The Rejection of Continental Drift: Theory and Method in American Earth Science*. New York: Oxford University Press.
- Oreskes, N. (2021). *Science on a Mission: How Military Funding Shaped What We Do and Don't Know about the Ocean*. Chicago, IL: University of Chicago Press.
- Ozenfant, A. (1992/1916). Notes on Cubism. In: Harrison, C. and Wood, P., eds., *Art in Theory 1900–1990: An Anthology of Changing Ideas*. Oxford: Blackwell, pp. 223–225. (Translated from the original French.)
- Paleari, P., Stolten, A., and Raffn, M. (2021). an oval, a vowel, an e. [Press Release]. Available at: [www.idoart.dk/kalender/marie-raffn-an-oval-a-vowel-an-e](http://www.idoart.dk/kalender/marie-raffn-an-oval-a-vowel-an-e) (Accessed 15 June 2021).
- Radder, H. (2012). *The World Observed/The World Conceived*. Pittsburgh, PA: University of Pittsburgh Press.
- Raffn, M. (2019). *Ambiguous Figures and or Performance Notes: Backward Sway | Upper Beam | Forward Swivel | Lower Bound*. Copenhagen: Forlaget Gestus. Available at (in part): [www.marieraffn.com/wp-content/uploads/2021/05/Backward-sway-Upper-beam-Forward-swivel-Lower-bound.pdf](http://www.marieraffn.com/wp-content/uploads/2021/05/Backward-sway-Upper-beam-Forward-swivel-Lower-bound.pdf)
- Raffn, M. (2021a). an oval, a vowel, an e. Dimensions variable. [Steel, plaster, pigment]. VestjyllandsKunstpavillon, Videbæk, Denmark, 26 June to 18 July, 2021. Curated by Paola Paleari and Anne Zychalak Stolten. Photo: Jacob Friis-Holm Nielsen. Available at: <https://svfk.dk/project/marie-raffn-an-oval-a-vowel-an-e> and <https://vestjyllandskunstpavillon.dk/26--juni---18--juli--Marie-Raffn>
- Raffn, M. (2021b). Six Questions for Marie Raffn. Available at: <https://tique.art/six-questions/marie-raffn/> (Accessed 30 October 2021).
- Raffn, M. (2023) Untitled (VEAAVI). Approx. H 240 × L 75 × W 290 cm. [Steel]. The Danish Art Workshops, Copenhagen, Denmark. New artwork, later exhibited at AGA WORKS, Copenhagen, Denmark, 9 December 2023 to 14 January 2024. Curated by Sarah McNulty, Tørreløft. Photo: Jenny Sundby.

- Robert Smithson: Abstract Cartography. (2021). [Exhibition]. Marian Goodman Gallery, New York, 24 June to 20 August, 2021. Available at: [www.mariangoodman.com/usr/library/documents/main/smithson-2021-ny-checklist.pdf](http://www.mariangoodman.com/usr/library/documents/main/smithson-2021-ny-checklist.pdf) (Accessed 12 July 2023).
- Rosenblum, R. (1961). The Abstract Sublime. *ARTnews*, 59(10), pp. 38–41, 56–58.
- Rosenblum, R. (1975). *Modern Painting and the Northern Romantic Tradition: Friedrich to Rothko*. London: Thames & Hudson.
- Rupik, G. (2024). *Remapping Biology with Goethe, Schelling, and Herder: Romanticizing Evolution*. London: Routledge.
- Sánchez-Dorado, J. (2019). Scientific Representation in Practice: Models and Creative Similarity. Ph.D. Thesis. Department of Science and Technology Studies, University College London. Available at: <https://discovery.ucl.ac.uk/id/eprint/10064872/> (Accessed 14 June 2023).
- Schou, D. (2014). Friedrichs fragmenter—Tomrum, tid, illusionsbrud og hallucination. Master's Thesis. Department of Arts and Cultural Studies, University of Copenhagen.
- Schou, D. (2019). Krigsrus: Ambivalente fremstillinger af krops- og bevidsthedsændringer i tysk billedkunst og litteratur fra 1. Verdenskrig. Ph.D. Thesis. Department of the Study of Culture, University of Southern Denmark.
- Siegert, B. (2023). From Landscape to Mapscape: Robert Smithson's Maps. In: Dorrian, M. and Forster, K., eds., *DMJournal—Architecture and Representation*, Issue 1: The Geological Imagination. Available at: [https://drawingmatter.org/wp-content/uploads/2022/11/DMJ\\_No1\\_BernhardSiegert-1.pdf](https://drawingmatter.org/wp-content/uploads/2022/11/DMJ_No1_BernhardSiegert-1.pdf) (Accessed 14 July 2023).
- Smithson, R. (1969a). Map of Broken Glass (Atlantis). H 48 × L 240 × W 192 in. [Glass]. Dia Beacon, New York. Available at: [www.diaart.org/collection/collection/smithson-robort-map-of-broken-glass-atlantis-1969-2013-027](http://www.diaart.org/collection/collection/smithson-robort-map-of-broken-glass-atlantis-1969-2013-027) (Accessed 8 July 2023).
- Smithson, R. (1969b). Map of Broken Clear Glass (Atlantis). H 16¾ × W 14 in. [Collage, photostat, map, graphite on paper]. Dia Art Foundation, New York. Available at: [www.diaart.org/collection/collection/smithson-robort-map-of-broken-clear-glass-atlantis-1969-2012-004](http://www.diaart.org/collection/collection/smithson-robort-map-of-broken-clear-glass-atlantis-1969-2012-004) (Accessed 8 July 2023).
- Smithson, R. (1970). Spiral Jetty. Dimensions variable. [Basalt rock, salt crystals, earth, red water]. Dia Art Foundation, Rozel Point, Great Salt Lake, UT. Available at: [www.diaart.org/collection/collection/smithson-robort-spiral-jetty-1970-1999-014/](http://www.diaart.org/collection/collection/smithson-robort-spiral-jetty-1970-1999-014/) (Accessed 10 July 2023).
- Smithson, R. (1970/1969). A Surd View for an Afternoon. H 8½ × W 11 in. [Ink on paper]. Holt/Smithson Foundation. Available at: <https://holtsmithsonfoundation.org/island-broken-glass> (Accessed 11 July 2023).
- Smithson, R. (1996/1969). Incidents of Mirror-Travel in the Yucatan. In: Flam, J., ed., *Robert Smithson: The Collected Writings*. Berkeley, CA: University of California Press, pp. 119–133.
- Spice, A. (2015). 100 Minutes of Minimalism: Interpreting the Resonant Drones of “Mathematical Music”. Available at: <https://thevinylfactory.com/features/100-minutes-of-minimalism-hanne-darboven-oliver-coates-whitechapel-mathematical-music/> (Accessed 14 July 2023).

- Tate. (2023). Minimalism. Available at: [www.tate.org.uk/art/art-terms/m/minimalism](http://www.tate.org.uk/art/art-terms/m/minimalism) (Accessed 10 June 2023).
- Tharp, M. (1982). Mapping the Ocean Floor—1947 to 1977. In: Scrutton, R.A. and Talwani, M. eds., *The Ocean Floor: Bruce Heezen Commemorative Volume*. New York: Wiley, pp. 19–31.
- Tharp, M. (1996). “The Niels Bohr Library & Archives Oral History Project: Marie Tharp, Session II”. Interviewed by Ronald E. Doel. American Institute of Physics. 18th December. Available at: [www.aip.org/history-programs/niels-bohr-library/oral-histories/22896-2](http://www.aip.org/history-programs/niels-bohr-library/oral-histories/22896-2) (Accessed 4 June 2021).
- Tharp, M. (1997). “The Niels Bohr Library & Archives Oral History Project: Marie Tharp, Session IV”. Interviewed by Tanya J. Levin. American Institute of Physics. 28th June. Available at: [www.aip.org/history-programs/niels-bohr-library/oral-histories/22896-4](http://www.aip.org/history-programs/niels-bohr-library/oral-histories/22896-4) (Accessed 4 June 2021).
- Tharp, M. (1999). Connect the Dots: Mapping the Seafloor and Discovering the Mid-Ocean Ridge. In: Lippsett, L., ed., *Lamont-Doherty Earth Observatory: Twelve Perspectives on the First Fifty Years, 1949–1999*. Palisades, NY: Lamont-Doherty Earth Observatory of Columbia University. Available at: <https://news.climate.columbia.edu/2020/07/24/marie-tharp-connecting-dots/> (Accessed 20 August 2020).
- Theberge, A.E. (2014a). Discovering the True Nature of the Mid-Atlantic Ridge: Part I. *Hydro International*. Available at: [www.hydro-international.com/content/article/discovering-the-true-nature-of-the-mid-atlantic-ridge-part-i](http://www.hydro-international.com/content/article/discovering-the-true-nature-of-the-mid-atlantic-ridge-part-i) (Accessed 24 July 2023).
- Theberge, A.E. (2014b). Seeking a Rift: Confused by Fracture Zones. *Hydro International*. Available at: [www.hydro-international.com/content/article/seeking-a-rift](http://www.hydro-international.com/content/article/seeking-a-rift) (Accessed 24 July 2023).
- Theberge, A.E. (2014c). Unravelling the Ridge and Rift: Missed Opportunities and Triumph. *Hydro International*. Available at: [www.hydro-international.com/content/article/unravelling-the-ridge-and-rift](http://www.hydro-international.com/content/article/unravelling-the-ridge-and-rift) (Accessed 24 July 2023).
- Voss, J. (2022). *Hilma af Klint: A Biography*. Translated by Posten, A. Chicago, IL: University of Chicago Press.
- Wadley, N. (1970). *Cubism*. London: Hamlyn.
- Walsh, D.M. and Rupik, G. 2023. The Agential Perspective: Countermapping the Modern Synthesis. *Evolution & Development*. Available at: <https://online.library.wiley.com/doi/full/10.1111/ede.12448> (Accessed 15 June 2023).
- Walton, K. (1990). *Mimesis as Make-Believe: On the Foundations of the Representational Arts*. Cambridge, MA: Harvard University Press.
- Weise, A. (2023). Hilma af Klint’s Relationship with Anthroposophy. Interviewed by Charlie Cross. *Das Goetheanum*. 26 May. Available at: <https://dasgoetheanum.com/en/hilma-interview-with-anne-weise/> (Accessed 10 July 2023).
- Wertenbaker, W. (1974). *The Floor of the Sea: Maurice Ewing and the Search to Understand the Earth*. Boston, MA: Little, Brown and Company.
- Winther, R.G. (2014a). World Navels. *Cartouche of the Canadian Cartographic Association*, 89(Summer/Autumn), pp. 15–21.
- Winther, R.G. (2014b). James and Dewey on Abstraction. *The Pluralist*, 9(2), pp. 1–28.



- Winther, R.G. (2019). Mapping the Deep Blue Oceans. In: Tambassi, T., ed., *The Philosophy of GIS*. Cham: Springer, pp. 99–123.
- Winther, R.G. (2020a). *When Maps Become the World*. Chicago, IL: University of Chicago Press.
- Winther, R.G. (2020b). Cutting the Cord: A Corrective for World Navels in Cartography and Science. *The Cartographic Journal (British Cartographic Society)*, 57(2), pp. 147–159.
- Winther, R.G. (2022). Imaginative Maps. The Humanities Institute (University of California, Santa Cruz), Imagination Series. Available at: <https://thi.ucsc.edu/imagination-series-rasmus-gronfeldt-winter/>
- Wise, M.N. (2006). Making Visible. *Isis*, 97(1), pp. 75–82.
- Wivel, H. (2004). Purpurpunktet: Fuldkommenhedslængsel hos Rudolf Steiner og de nordiske disciple Hilma af Klint og Arild Rosenkrantz. In: Thage, J., ed., *Mod lyset*. Holte and Aalborg: Gl. Holtegaard and Nordjyllands Kunstmuseum, pp. 9–14.
- Wolfe, S. (2019). Art Movement: Minimalism. Available at: <https://magazine.artland.com/minimalism/> (Accessed 8 June 2023).
- Wood, D. (2010). *Rethinking the Power of Maps*. With Fels, J. and Krygier, J. New York: Guilford Press.