



7f]h]ei Y'UbX'U'GWYbW'Zcf'h\Y'GU_Y'cZ'5fh.: fUMUg'UbX'h\Y'J]gi U'5fhg
5i h\cf fyt' BcY'; fUm
Gci fW. '@yCbUFXcZ'J c'" &(ž' Bc"' ' f% - %ž' dd"' ' %+!' &\$
Di V']g\ YX' Vm' H\Y' A ÷H' Df Ygg
GhU'Y'I F @: <http://www.jstor.org/stable/1575574>
5 WYggYX. '\$) #\$(#&\$%\$' &' .%{

Your use of the JSTOR archive indicates your acceptance of JSTOR's Terms and Conditions of Use, available at <http://www.jstor.org/page/info/about/policies/terms.jsp>. JSTOR's Terms and Conditions of Use provides, in part, that unless you have obtained prior permission, you may not download an entire issue of a journal or multiple copies of articles, and you may use content in the JSTOR archive only for your personal, non-commercial use.

Please contact the publisher regarding any further use of this work. Publisher contact information may be obtained at <http://www.jstor.org/action/showPublisher?publisherCode=mitpress>.

Each copy of any part of a JSTOR transmission must contain the same copyright notice that appears on the screen or printed page of such transmission.

JSTOR is a not-for-profit service that helps scholars, researchers, and students discover, use, and build upon a wide range of content in a trusted digital archive. We use information technology and tools to increase productivity and facilitate new forms of scholarship. For more information about JSTOR, please contact support@jstor.org.



The MIT Press is collaborating with JSTOR to digitize, preserve and extend access to Leonardo.

<http://www.jstor.org>

Critique and a Science for the Sake of Art: Fractals and the Visual Arts

Noel Gray

Drawing attention to the Kantian aesthetic that underpins Benoit Mandelbrot's [1] argument for 'an art for the sake of science' does not represent a sufficiently critical engagement of fractal geometry's entry into visual discourse (an entry made largely transparent by the suggestion that art acts as a handmaiden to science). Merely pointing to the extent of this aesthetic debt leaves the necessity for its adoption unexplored. It also leaves fractal imagery outside the orbit of contemporary visual critique by affording an unproblematic status to this geometry's intervention. This status is made possible by the fact that a transcendental aesthetic, in its traditional form, displaces any notion of a critical visual practice by reducing all engagements of the visual to judgments of taste [2].

The necessity of adopting this aesthetic is apparent in the claims that first emerge in Mandelbrot's remarkable and impressive book *The Fractal Geometry of Nature* [3] and later reappear, though often only by implication, in his *Leonardo* article. Indeed, the title of this earlier work indicates the truth value Mandelbrot ascribes to his discourse. Namely, the implication is that nature's truth is fractal geometry: the geometry of chance and change, the geometry of the vernacular, the measuring of the everyday. (Fractal images have, in part, a descriptive role in the dissemination of this truth.) The basic concepts that Mandelbrot advances for fractal geometry, as points of differentiation from traditional geometry, can be broken down into two categories: those related to the generative concepts that inform his practice and those connected to the resultant aesthetic and truth value conclusions drawn from this practice.

GENERATIVE CONCEPTS

Mandelbrot positions his practice against the background of what he perceives as the inability of traditional geometry to describe the everyday forms of nature—forms such as clouds, rivers and lightning. He states that nature's forms cannot be reduced to classic geometric shapes. Mathematics also, he maintains, has been differentiated like traditional geometry, along conceptual and experiential lines, demonstrating an ever-increasing tendency towards esoteric pursuits and thus creating a widening gulf with nature and failing to address directly what can be seen or felt. Nature, for Mandelbrot, is not simply a higher complex version of Euclidean geometry; rather, it operates at a completely different level of complexity.

It is important here to note the significance of this claim of a different complexity. For what Mandelbrot appears to be saying is that fractal geometry is nature's *own* geometry. The complexity witnessed in fractal geometry mirrors the self-

same complexity evident in nature, evident even at the macro-level of ordinary perception.

In this argument, fractal geometry is thus not simply another system of static measurement; rather, it duplicates to all intents and purposes the actual process of the generation of nature's complexity. Unlike the static reductive geometries of the past that have concentrated on fixed states and/or linear systems, fractal geometry engages the very nonlinear dynamics that characterize nature itself. This concept, regarding the imaging of nature's process of change, is essential to Mandelbrot's claim of differentiation of fractal geometry from earlier systems of geometry. In short, the generative concepts informing Mandelbrot's practice are as follows: (1) Fractal geometry deals with the real world of everyday perception. (2) Fractal geometry is nature's own geometry. (3) Fractal geometry imitates nature's process of change.

RESULTANT CLAIMS

Moving from his premises of practice, Mandelbrot's resultant truth claims are, as would be expected, logically extended from his generative concepts. For instance, he says, "My previous essays stressed relentlessly the fact that the fractal approach is both effective and 'natural'. Not only should it not be resisted, but one ought to wonder how one could have gone so long without it" [4].

With this statement, the veracity of the earlier generative claim, that fractal geometry is nature's own geometry, now enjoys the status of an undisputed higher truth. Indeed, this quote suggests not only that fractal geometry's truth is of a higher order than previous geometric systems by virtue of its effectiveness and 'naturalness' but also that it is transcendental in character and has merely been awaiting adequate theorization. In this transcendental register the truth is unproblematic by definition, i.e. it is assumed to be given in

ABSTRACT

Recently, the author argues, proponents of fractal geometry—most notably, Benoit Mandelbrot—have effected what they claim is a novel intervention into the discourse of the visual. The author examines the relationship between Mandelbrot's theory of geometry and his theory of aesthetics and notes that this intervention is dependent on a displacement of contemporary critical visual practice, a practice that, once restored, affords the opportunity for a critique of scientific theory through the visual register. The author concludes by suggesting that Mandelbrot's claim of novelty of intervention may have at least one historical precedent.

Noel Gray (sculptor, graduate student), Box 201, Holme Building, University of Sydney 2006, N.S.W. Australia.

Received 23 July 1990.

intuition as a self-evident truth and known to be so given by recourse to reason alone [5].

Further, embedding this claim in the authority of the history of mathematics and mathematicians, Mandelbrot states that “I show that behind their very wildest creations, and unknown to them and to several generations of followers, lie worlds of interest to all those who celebrate Nature by trying to imitate it” [6]. This reference to imitation, coupled with a traditional archaeological notion of disclosing hidden treasures, leaves little room to doubt the idea of a timeless-truth-to-nature. Clearly, for Mandelbrot, fractal geometry is the practice of this truth. It is worth emphasizing that this notion of an unproblematic transcendental truth, truth-to-nature, is the pivotal point of this practice.

Bearing in mind the significance of this point, Mandelbrot’s aesthetic position and the relationship of this aesthetic to the posited truth value of his geometric practice remain to be examined [7]. One or two extracts from Mandelbrot’s writings serve to bring this relationship into focus. First, in the opening sections of *The Fractal Geometry of Nature*, Mandelbrot states,

This essay brings together a number of analyses in diverse sciences, and it promotes a new mathematical and philosophical synthesis. . . . Furthermore, it reveals a totally new world of plastic beauty. . . .

. . . In addition, fractal geometry reveals that some of the most austere formal chapters of mathematics had a hidden face: a world of pure plastic beauty unsuspected till now. . . .

. . . The fractal ‘new geometric art’ shows surprising kinship to Grand Masters paintings or Beaux Arts architecture. An obvious reason is that classical visual arts, like fractals, involve very many scales of length and favour self-similarity. For all these reasons, and also because it came in through an effort to imitate Nature in order to guess its laws, it may well be that fractal art is readily accepted because it is not truly unfamiliar [8].

In *Leonardo* Mandelbrot states,

What we call the beauty of a flower attracts the insects that will gather and spread its pollen. Thus the beauty of a flower is useful—even indispensable—to the survival of its species. . . .

. . . What happened next to fractal art as it evolved brings us to the traditional dichotomy between representational and nonrepresentational art. In the well-recognized forms of art, this dichotomy no longer seems so strongly

etched, and fractal art straddles it very comfortably. The earliest explicit uses of fractals gave me the privilege of being the first person to tackle in a new way some problems that must be among the oldest that humanity had asked itself: how to obtain ‘figures’ that represent the shapes of mountains, clouds and rivers? It turns out that, when the representation of nature by fractal is perceived as successful, it also tends to be perceived as beautiful [9].

Evident in these statements is Mandelbrot’s notion of an unproblematic beauty that is assumed to be transsubjective and an a priori truth. Its presence in relation to fractals is undisputed, although unobserved by past mathematicians. Thus, Mandelbrot’s aesthetic emerges as basically Kantian in character in that he assumes beauty is an inherent universal feature of nature and is recognised as such by everyone. As his fractals ‘imitate nature’, it follows by association that they also will be perceived as universally beautiful [10].

What then is the relationship of this aesthetic with Mandelbrot’s truth claims concerning fractal geometry? In other words, given his comments that his practice is in an essential sense a radical departure from traditional systems of geometry, what then is the significance of attaching a largely conservative aesthetic to his posited radical practice?

The key to this marriage of the radical and the conservative is located in his desire to establish fractal geometry as nature’s own geometry, the truth of which has merely been awaiting discovery. To make such a claim amounts to asserting that fractal geometry itself is transcendental in character—a characteristic that is deducible from his generative claims. It therefore follows that in order to avoid a coherency problem at a fundamental level, namely, a transcendental system of change [11] married to, say, a critical visual theory of the image, Mandelbrot is led into the marriage of his transcendental geometry to a transcendental aesthetic.

On the other hand, if a critical element *were* to be introduced into the images generated by his geometry, or if a critical reader/viewer *were* to enter into any engagement of his images, then two developments would conceivably result. First, the necessary separation between image and theory would be open to critique, a separation imperative to his claim that, first and foremost, it is fractal theory and not the actual existence of fractal images that has been the deciding factor in establishing fractal geometry as nature’s own

geometry [12]. Second, if any critical engagement of the fractal images should produce a reading that is at odds with the theoretical ground that generates these images in the first place (in other words, should fractal geometry enter into the author-reader debate), then not only would the hierarchical structure in the separation of theory and image be at risk, but it would also severely weaken the claim that fractal geometry *is* the truth-to-nature. This truth relies to some degree on the assumption of a correspondence between certain fractal images and visible nature. This correspondence is grounded in Mandelbrot’s claim that the viewer will experience an unproblematic recognition of the visual similarity between nature and particular fractal images, along with an unproblematic acceptance of the beauty of these images.

If fractal geometry, through a critical reading of its images, should be shown to be open to critique in its claim to speak nature’s truth over and above other discourses, then not only does the very idea of an objective-geometric-truth-to-nature become open to critique, but, by extension through this critique, scientific practice in general will be seen to be as much involved with the construction of truths as it is involved in the search for them.

Thus, Mandelbrot’s intervention in visual discourse (an intervention forced on him by the very claim that fractal geometry mirrors nature) provides the ground for visual theorists to critique a major theoretical development in science. The dependency on images that is at the heart of the practice of fractal geometry, made transparent by the image’s relegation to the role of a servant to science, is, in Nietzschean terms, a relationship of promise that can turn and bite its own tail. The promise of the theoretical veracity of *finally discovering* the truth-to-nature by the mathematization and geometrization of creation will itself become increasingly difficult to sustain as the images of this geometric creation are increasingly shown to be problematic. For instance, for a fractal image to be recognised as mirroring nature (or its processes), there must be an existing image of nature with which to compare it. However, as this other image is by necessity also a representation (even if confined solely to the imagination), the fractal image thus emerges as a representation mirroring another representation. By reduction back to the generating

theory, this establishes fractal geometry as simply another technique for producing representations. Thus, fractal imagery can differ from what it is mirroring only in the means of production. But if two different forms of production can produce images that mirror each other, then what determines the privileging of one means of production over the other? The answer is a privileging that is necessary to make sense of the idea of chaos theory *finally* discovering the truth-to-nature. As the 'real' image of nature must always fall within representation, any claim to represent what ultimately generates all images (i.e. nature) will therefore always be a claim to have represented representation. (Note that this claim entails the necessary contradiction of being outside of representation and hence no longer capable of representing anything.) The only way around this impasse is to claim that it is possible to have access to 'real' nature in an *unmediated* fashion, which of course denies all existing knowledge, history and cultural embedment.

CONCLUSION

A critique of fractals could be preceded by a critique of the co-extensive relationship the computer has with both parts of fractal geometry: fractal theory and fractal imagery. This is a co-extension that severely weakens the axiomatic claim of separation demanded by the privileging of fractal theory as the generative condition for the possibility of fractal images.

Hence the question is to what extent the computer and its operator function as the condition of possibility of both fractal theory and fractal images. (This is a point, incidentally, that Mandelbrot raises, but not, understandably, as a critique of his sole authorship of fractal geometry [13].) Would this critique of association establish the computer/operator as the *actual* truth-to-nature? Or does being the possibility of truth relate more to the notion of the creator than to the process of creation?

The critical sensitivity of the notion of an art for the sake of science is further highlighted by Mandelbrot's connection of his 'art' to the significance afforded the notion of novelty in the sciences and the arts: "Therefore, we shall argue that fractal geometry appears to have created a new category of art, next to art for art's sake and art for

the sake of commerce: art for the sake of science (and of mathematics)" [14].

To place this claim of the production of novelty in context, it is relevant to review a small fraction of the history of an art for the sake of science, an earlier moment of novelty, incidentally, that also claimed geometry as the guiding producer of art:

The name KALEIDOSCOPE, which I have given to a new Optical Instrument, for creating and exhibiting beautiful forms, is derived from the Greek words *kalos*, beautiful; *eidos*, a form; and *skopein*, to see. . . .

. . . The fundamental principle, therefore, of the Kaleidoscope is, that it produces symmetrical and beautiful pictures, by converting simple into compound or beautiful forms, and arranging them, by successive reflections, into one perfect whole. . . .

. . . The property of the Kaleidoscope, which has excited more wonder, and therefore more controversy than any other, is the number of combinations or changes which it is capable of producing from a small number of objects. . . .

. . . It will create, in a single hour, what a thousand artists could not invent in the course of a year; and while it works with such unexplained rapidity, it works also with a corresponding beauty and precision [15].

These fragments of history are from the nineteenth-century polymath Sir David Brewster. While Brewster's work did not, as has Mandelbrot's, reshape much of the way in which geometry is conceived, he nevertheless also relied on a Kantian aesthetic in describing the nature of the images produced by his inventions. Also, like Mandelbrot, Brewster expressed the possibility of art assisting in the appreciation and understanding of science and its principles [16].

However, what is even more striking than this shared aesthetic and its connection to theories of discourse dissemination [17] is the similarity of their respective ideas regarding the universal character of visual discourse. This conceptual similarity, though involving works separated by a wide expanse of time, highlights the question of parallelism in the theoretical conditions informing their ideas.

One of these conditions is the assumption that changes in the development of artistic practice can be reduced to the production of visual novelty and/or changes in the means of production. Another condition, with relation to ground, is the Kantian transcendental: 'nature giving the rule to art'.

This second condition informs Mandelbrot's idea that great art imitates nature. The unproblematic transposition of this idea between the discourses of science and art characterizes Brewster's work as well [18]:

If we examine the various objects of art which have exercised the skill and ingenuity of man, we shall find that they derive all their beauty from the symmetry of their form, and that one work of art excels another in proportion as it exhibits a more perfect development [*sic*] of this principle of beauty. Even forms of animal, vegetable and mineral derive their beauty from the same source. . . .

. . . When we consider the immense variety of professions connected both with the fine and the useful arts, in which the creation of symmetrical ornaments forms a necessary part, we cannot fail to attach a high degree of utility to any instrument by which the operations of the artist may be facilitated and improved [19].

Finally, as a prior historical moment pertinent to the relationship of chaos theory and geometry, Brewster writes, "Let him now take a Kaleidoscope, and direct it to the same object: he will instantly perceive the most perfect order arise out of confusion" [20].

References and Notes

1. B. Mandelbrot, "Fractals and an Art for the Sake of Science," *Leonardo*, Supplemental Issue *Computer Art in Context* (1989) pp. 21–24.
2. The expression *Kantian aesthetic* is used here to refer especially to two central elements of this aesthetic schema: (1) disinterested beauty, i.e. the judgment of beauty *as if* the judgment is universally true and (2) aesthetic judgment in all its modalities acting to reconcile the theoretical (cognitive) with the practical (moral) and the world of nature with the world of freedom (imagination acting as the exemplar of this freedom). The expression *traditional transcendental aesthetic* is used here to refer to the schema that argues that all art objects contain or exhibit in varying degrees a set of a priori aesthetic elements, universal in character. Hence the role or judgment of the informed observer (the critic) is to determine the presence of these elements in the object and to discuss this presence in relation to the notion of 'good art'. Clearly, in this system the artist's intentions, the critic's tastes (selections of objects to discuss) and the a priori elements are all intricately linked. Thus, the a priori elements together with the significance accorded to the artist's intentions tend to confine all discussion by the critic to definitions of the object as 'good' or 'bad' art.
3. B. Mandelbrot, *The Fractal Geometry of Nature* (New York: Freeman, 1983).
4. Mandelbrot [3] p. 3.
5. See N. K. Smith, *Immanuel Kant's Critique of Pure Reason* (London: Macmillan, 1986) esp. A50–52/B74–76, A23–A41/B37–B58, A19–A22/B34–B36, B59–B72/A42–A48, B89–B91/A65–A66. See also S. Korner, *Kant* (Middlesex: Penguin, 1987) p. 35; R. C. S. Walker, *Kant* (London: Routledge & Kegan Paul, 1978) pp. 14–27; W. H. Werkmeister, *Kant: The Architectonic and Development of His Philosophy* (La Salle, IL: Open Court, 1980) chaps. 3–5.
6. Mandelbrot [3] p. 4.

7. See Mandelbrot [3] pp. 2–6, 9, 19, 21–24, 59, 154, C2–16, 406–407. See also H.-O. Peitgen and P. H. Richter, eds., *The Beauty of Fractals: Images of Complex Dynamic Systems* (New York: Springer-Verlag, 1986) pp. 152, 159. Also in this collection, see the chapters by G. Eilenberger, “Freedom, Science, and Aesthetics”, and H. W. Franke, “Refractions of Science into Art”.

8. Mandelbrot [3] pp. 2, 4, 23.

9. Mandelbrot [1] pp. 22–23.

10. For a comparison with Kant’s aesthetic claims, see Smith [5] A1–49, B1–73; and J. C. Meredith, *The Critique of Judgment* (Oxford: Clarendon Press, 1986) bk. I, secs. 1–22. See also Werkmeister [5].

11. It is precisely the lawful character of Mandelbrot’s claims for his geometry that makes possible the cohabitation of the term ‘transcendental’ with the term ‘change’. Change here refers merely to a notion akin to an unfolding-as-law. Even a change into something completely different does not, theoretically speaking within the domain of chaos theory, necessarily constitute a violation of these supposed laws. Indeed, such an event is tantamount to an expression of the ‘naturalness’ and ‘obviousness’ of these laws. As law here has been shifted to refer to process rather than principle, the idea of a transcendental system of change no longer in itself constitutes an incoherence in terminological usage. *The law is things changing*. This move from principle to process, including the attempts at the imaging of process, represents for me the precise point at which the innovative brilliance of Mandelbrot’s work affords an entry for critical visual practice to engage science.

12. See Mandelbrot [3] pp. C16, 22. Even a cursory reading of Mandelbrot’s text quickly establishes the privileging of theory over image. What I have in mind here is the problem of recognition. The idea of a one-to-one correspondence between fractal images and nature presupposes an already existing capacity for the recognition of this visual correspondence. If recognition pre-dates fractal theory, then fractal theory is dependent on an already existing image of nature. Hence the privileging of theory over image is dependent on a presupposed image. With such a dependency, it is difficult to see how a clear separation between theory and image can be sustained. With both parts

of the fractal binary having in common an already existing image of nature, what then is the basis of separation, other than different modalities?

13. Although to the best of my knowledge Mandelbrot does not ascribe any formative role to the computer in the initial theoretical development of fractal geometry, he does pay considerable credit to the assistance of several computer operators, e.g. [3] pp. 151–160. The following passage brings in the image as a possible generative source, though I think the implication is directed to future changes to fractal geometry rather than to the initial theory of Mandelbrot’s geometry: “Graphics is wonderful for matching models with reality. When a chance mechanism agrees with the data from some analytical viewpoint but simulations of the model do not look at all ‘real’, the analytical agreement should be suspect. A formula can relate to only a small aspect of the relationship between model and reality, while the eye has enormous powers of integration and discrimination” [1] p. 22. On the other hand, in his *Leonardo* article where theory generation is not an issue, Mandelbrot does signal the significance of the computer, albeit in relation to the possibility of fractal art (see [1] p. 21).

14. Mandelbrot [1] p. 21.

15. D. Brewster, *Treatise on the Kaleidoscope* (London: Hurst, Robinson, 1819) pp. 1, 17, 111, 116. For a more extensive analysis of the kaleidoscope with regard to its relationship to philosophy, geometry and the visual, see N. Gray, “Laughter in the Ruins”, unpublished honours thesis, Power Research Library, Univ. of Sydney, Australia, 1989.

16. Like Mandelbrot, Brewster was a tireless advocate of the value and significance of retaining a broad and innovative approach to his practice. For instance, between the years 1800 and 1862, he delivered no less than 299 papers, ranging in topics from the principles of the kaleidoscope and stereoscope to the optical illusion of the conversion of cameos into intaglios and, vice versa, to the Chinese Mirror and its ability to reflect from its polished face the figures embossed on its back. The sad fact that Brewster went blind while conducting his optical experiments directed at the sun makes the extent of his work and his public lectures all the more impressive.

17. The expression ‘theories of discourse dissemi-

nation’ refers here to the long-established use of imagery in explaining or disseminating the complexity of scientific practices. Clearly, the idea of an unproblematic aesthetic greatly aids this dissemination as it assumes that the range of visual responses is largely the same for everyone. Indeed, the use of diagrams in mathematics and geometry is predicated on this principle. For a challenge to this idea of image purity versus specific perceptual responses, see M. Serres, *Hermes, Literature, Science, Philosophy* (Baltimore, MD: Johns Hopkins Univ. Press, 1982).

18. For more on the notion of an unproblematic correspondence between the discourses of science and art or ‘an art for the sake of science’, see F. Nietzsche, *The Birth of Tragedy*, W. Kaufmann, tran. (New York: Vintage, 1967) pp. 52–92. The Socratic promise and science are to a large extent interchangeable in this text. For a concise thesis that uses Greek art to emphasize certain features of Greek geometry (and vice versa), see W. M. Ivins, *Art and Geometry, a Study in Space Intuitions* (New York: Dover, 1946). See also M. Andreose, ed., *The Arcimboldo Effect* (London: Thames & Hudson, 1987) pp. 155, 185, 187, 189. This volume discusses Giovanni Battista Fonteo’s (1546c–1580c) and Gregorio Comanini’s (1550c–1608) poems, which comment about the ways in which Arcimboldo’s paintings (such as the *Four Seasons*) aid the viewer in understanding the underlying lawful principles governing nature. For an analysis of the relationship between Arcimboldo’s paintings and Renaissance science (ordering systems), see N. Gray, “Facing the Mask, Science as Ground in Arcimboldo’s Paintings”, in *Renaissance Essays* (Sydney: Power Research Publications, Univ. of Sydney, 1990). For discussions on the significance of images assisting in the practice of science (specifically, the medical sciences), see Hugh W. Diamond’s extensive use of photography in diagnosing cases of madness in the nineteenth century, in L. G. Sander, ed., *The Face of Madness, Origins of Psychiatric Photography* (Secaucus, NJ: Citadel Press, 1976); and for similar ideas in the twentieth century, see M. Webb and L. Szondi, *The Szondi Test* (Montreal: Lippincott, 1959).

19. Brewster [15] pp. 113–115.

20. Brewster [15] p. 149.