

Towards Aesthetics of Science*

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Introduction: From an Anthropological Point of View

Postmodern trends have brought significant advances in overcoming some habits of philosophical thought, of classical divisions, stereotyped notions etc. And yet, it seems to me, the project of freeing theoretical thought from the widespread, but unfounded, suppositions, and from the comfort of conventionalism is still far from its completion. An attempt to cross the still existing dividing line between the domain of science and the realm of art, that I am going to undertake here, may well serve as a sort of test for this assumption.

I dare to say that (especially after the International Congress of Aesthetics that took place in Tokyo) we experience a sort of "aesthetic turn". In the spirit created by this new impulse I am going to challenge some standard preconceptions of aesthetics, and at the same time some erroneous conceptions of the science. I hope that in so doing we will be able at the end to outline a revision of the dualism built on contrastive or exclusive terms between science and art, cognition and emotion, knowing and embodiment, exactness and expressiveness, 'truth' and 'beauty', etc.

This in turn will require a shift in general attitude and for that matter exercise in practicing holistic view as opposed to the specialist's or particularized perspective. It is important to stress at this point that it is not a step against authenticity of any of these symbolic languages; what I do want to claim is that differences in the type of language or expressive form (scientific and artistic) should be no obstacle to recognition of the common features that underlie both creative processes. In short, the strategy is *not reductionistic, but anthropological*. In other words, it is not meant to lead toward conclusion that due to the common creative roots it is possible to reduce one to the other, but rather intends to show that the *human agent* exercising these distinct activities displays in both cases basically the same creative properties. Accordingly, it is difficult to conceive of a great artist that would be reasonless, as it is difficult to imagine that aesthetically insensitive and emotionless scientist would be capable of bringing about great discoveries.

1. The Myth of the Two Incommensurable Rivals

Any project that aims at investigating science-art interrelatedness first confronts the well established and for long cultivated dualism based on the polarity between the rationality of science and 'irrationality' of art, between exactness and expressiveness, logic and emotion, between measuring and metaphors, calculation and imagination, etc. Maintaining of these contrastive features does nothing

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more or better than confirming the classical schema according to which science and art are two *incommensurable rivals*.

There is a number of (mostly philosophical) misconceptions about the nature of science, on the one hand, and equally so erroneous ideas about the essence of art, on the other hand, that have contributed to the establishing of such a stereotype. (In this section I am going to touch upon some of the basic fallacies concerning the so-called hard sciences, for which I use the term 'myths'¹). The myths that patterned not only the common-sense prejudices about science are numerous; for the present purposes let me just mention some of them. "The myth of strictly logical nature of scientific reasoning" (the unfounded belief that what rules scientific enterprises and guarantees their success is logic); "the myth of the straight road to truth" (basically positivist attitude that science proceeds in steps from observation to formulation of theories in a consistent induction-like way); "the myth of neutrality of observation data and origin of facts" (a nowadays heavily disputed empiricist belief that neutrality of sense-data can secure objectivity of scientific facts); "the myth of impersonal 'scientific thought'" and to it related "myth of a bodiless scientist" (a common notion that the required standard of objectivity and exactness is secured just through scientist's impersonal attitude, basically understood as free from any bodily influences).

The scope of misconceptions about science can be further extended by adding that the language scientists use is not a clear-cut unambiguous language that can always be successfully formalized; that scientist too, like common observer, is not in the possession of a 'naked' or 'neutral eye' that could pick up nature 'as it is', etc. Instead, ambiguity accompanies theoretical language of science, no less than it is the case with the ordinary language; metaphoric is an unavoidable instrument in scientific descriptions, explanations and model-building; scientific observation and facts are theory-laden; and the factual turns out not to be completely devoid of traits of fiction, etc.

Let me recapitulate briefly: Standard approaches to interrelatedness between science and art follow the supposition that these two different types of artefacts, two irreducible symbolic languages also belong to two distinct spheres of creativity, performed by two different kinds of minds, whereby a profound fact is neglected, namely that such divisions and polarizations are not given in any way, but fabricated by us. It means that respecting that there are reasons which justify divisions there are also justifiable reasons to initiate unity of the creative act beyond dividing lines of specific fields and disciplines (and that is the one I am advocating here).

As a reaction to a long-standing empiricist-positivistic dominance in theoretical thought and in an opposition to rigid rationalism (strict propositionality of thought, logical foundation of scientific discovery, verification etc.) there emerged "romantic, irrational, even surrealistic idealism"². Due to this radical reaction (and revision) it is nowadays all too easy to slip into the irrationality debate, but this

¹ I draw here on M.D. Grmek's terminology and examples as expounded in his (1997) essay.

² ... "A psychology of scientific discovery, which invokes in a quasi-mystical manner the 'personal genius' of researcher, must be judged with the greatest severity." See Grmek (1997: 35).

leads to the repetition of the same type of mistake: irrationality of science that replaces rational ideals with their negation cannot be but another myth; it is rationality turned upside down. In other words, it seems that the overexaggerated triumph of the logical reason is replaced by the ubiquity of the irrational. Thus, rather than looking for and analyzing what is *not* logical and rational in the sciences we should be concerned here with a more subtle aspect of *relating* what seems not to be rational (that is, intuitive, emotional, aesthetic, etc.) to forms of rational operating reasoning. Thus, the approach is that of *integration* rather than of *exclusion*.

2. 'Cognitio sensitivae'

A way toward conceptual integration can be made either from the science part or from the art-world (I believe that both perspectives are complementary, and accordingly that both should be taken into account).

A historical leap all the way back toward the 1750 (-58) when Alexander Gottlieb Baumgarten published his *Aesthetica*, might prove as a helpful starting step toward a revision of the dual schema. The work is worth remembering because of Baumgarten's conception of aesthetics as '*cognitio sensitivae*', as sensual way of *knowing*. It was the subject of the, at that time, new philosophical discipline. The title itself clearly associates sensuality and knowledge. Baumgarten's definition of aesthetics reads: "*Aesthetica* (theoria liberalium artium, *gnoseologia* inferior, ars pulchre cogitandi, ars analogi *rationalis*) est *scientia sensitivae*." (1ff) (emphasis added).

It is a great, and brave, move that Baumgarten undertakes as he not only links sense experience (*Sinnlichkeit*) and knowledge (*Erkenntnis*), and in such a way affiliates emotion (*Empfindung*) with thought (*Reflexion*), but also makes the former be a part of the latter. Baumgarten clearly grants aesthetics as *cognitio sensitivae* (*die sinnliche Erkenntnis*) cognitive status. The Cartesian principle of "cognitio clara et distincta", which is also a demand on any rational thought, undergoes through Baumgarten's conception of aesthetics its profound revision; sensual knowledge, considered by Descartes to be "obscura et confusa", is now recognized as a form of knowledge. Aesthetics defined in such terms thus recognizes the sensitive-emotional in its cognitive capacity. It was then just a matter of additional logical step to attribute 'claritas' (*Deutlichkeit*) to sensual knowledge, and so next to the 'clear thoughts' also have 'clear emotions' (*klare Empfindunge*), whereby they appeared as a form of reason (*Vernunftkenntnis*).

The idea was important and farfetched in several respects. First, the 'beautiful' (connected to the *cognitio sensitivae*) became a form and dimension of thought ("*schönes Denken*"). Second, it was constituted as a feature of scientific reasoning ("*Theorie von schönen Wissenschaften*", which is German translation of *theoria liberalium artium*). Finally, aesthetics as *cognitio sensitivae* is itself a science (*Wissenschaft*) – "*Wissenschaft von allem, was sinnlich ist*" (a science of the sensual)³.

³ That there are many uncertainties and ambiguities concerning the use of the terms will be here neglected.

However, for some reasons, this notion of aesthetics has never been fully recognized. Instead, it was 'beauty' understood and interpreted in many other ways that won theoretical dominance. Since Greek times "beauty" has become a lasting thematic motive within the philosophy and it remains to be so. For the current purposes though I want to concentrate on the elements of 'beauty' in the sciences in order to show basically that it is not incompatible with knowing, which is very much in accord with Baumgarten's definition of aesthetics. In a sense my approach is a sort of test meant to provide a support to this basic idea. And it seems logical that in order to prove the assumption that aesthetics can be cognitively relevant one should concentrate on that field where the power of knowledge comes best to expression.⁴

Yehuda Elkana (1979), for instance, includes 'beauty' into the 'sources of knowledge'⁵, and, more than that, says: "In some cases, analogy or beauty are not only sources of knowledge, but can become science-guiding norms of behavior." (1979: 281)

3. 'Beauty' of Mathematics

One of the classical examples that strongly favors aesthetic component of mathematics is Dirac's famous quotation: "[...] it is more important to have beauty in one's equations than to have them fit experiment [...] It seems that if one is working from a point of view of getting beauty in one's equations, and if one has really a sound insight, one is on a sure line of progress" (Dirac 1963: 47).

Well-known is also Poincaré's view on the rôle of intuition and beauty that he ascribes to mathematics: "It's a real aesthetic feeling that all the mathematicians recognize, and this is truly sensibility [...] The useful combinations are precisely the most beautiful [...]" (Poincaré 1908: 59). For some mathematicians "beauty is the first test: there is no permanent place in the world for ugly mathematics" (in Osborne 1984).

And H. Weyl provokes even more as he makes truth be dependent on the 'beautiful': "My work always tried to unite the true with the beautiful; but when I had to choose the one or the other, I usually choose the beautiful" (in Curtin 1982: 5).

"It is a recognized technique in elementary particle physics to seek theories which are compact and *mathematically beautiful*, in the expectation that they will then prove to be the ones realized in

⁴ In order to show that metaphor is not just 'nice but not necessary' figure of speech I concentrated in my former research on the theoretical language of science (and not on the literary language); analogously, it seems to me that it is more appropriate, and challenging, to analyze (and, yes, test) the assumption of the cognitive import of aesthetics in the scientific field (rather than in the art-domain).

⁵ "Sources of knowledge can be: experience, ratiocination, revelation, authority, tradition, analogy, competence, originality, novelty, beauty and many others." (1979: 277). And also: "Images of science determine what will be considered: important, interesting, worthwhile, risky, harmonious, symmetrical, beautiful, absurd ..." (280).

nature” (J.C. Polkinghorne; emphasis added). What the authors here mean by the ‘aesthetic’ is nothing marginal, it is rather something essential for science (and life too): “If nature were not beautiful, it would not be worth knowing and life would not be worth living [...]” (Poincaré, in Curtin 1982: 7).

The aesthetic perfection of mathematics (here spelled out in terms of ‘beauty’) bridges in a long historical arc Kepler’s world (“Die Mathematik ist das Urbild des Schönen der Welt”/ Mathematics is the epitome of the beauty of the world) with that of Dirac (“God used beautiful mathematics in creating the world”).

Chandrasekhar is but one among great scientists who acknowledges fundamental importance of the beautiful.

This ‘shuddering before the beautiful’, this incredible fact that a discovery motivated by a search after the beautiful in mathematics should find its exact replica in Nature, persuades me to say that beauty is that to which the human mind responds at its deepest and most profound. (quoted in Curtin, 1982: 7)

Such and similar examples are habitually taken as a support for the very general view that there is a place for aesthetics in the world of science. However, for us philosophers and theorists of science such ‘crowning evidence’ expressed by natural scientists and mathematicians themselves is but a starting point, sign or symptom for whose full explanation we have to get involved in a pretty ignored field of research and try to build own conceptual means. Though ‘Begriffsklärung’ is sometimes unavoidable, and in this case would be helpful, here I will not be interested so much in a systematic account of the meaning of ‘beauty’ or ‘aesthetics’, but will rather try to see to what fundamental features of their creative process and work do scientists refer when they speak of beauty or aesthetics.

4. ‘Beauty’ of Physics

For Dirac “beautiful mathematics” is not a means in itself but serves as a precondition for successful foundation of physical theories. Thus he says: “It seems to be one of the fundamental features of nature that fundamental physical laws are described in terms of a mathematical theory of *great beauty and power*” (1963: 53). Theoretical physicist Steven Weinberg does not quite share the same view with Dirac⁶, and in his own words it reads:

Actually I agree with Dirac, but only partly. Beauty is our guide in theoretical physics, but it’s not the beauty of the equations printed on a piece of paper that we are searching for, it is the beauty of the principles, how they hang together. We want principles that have sense of inevitability. It doesn’t matter whether the equations are more or less beautiful. (1987: 107)

Yet, clearly if there were reasons enough to introduce the notion of ‘beautiful mathematics’ there

⁶ More on Dirac’s and Weinberg’s opposing views on the role of the aesthetic in the science in Engler (2001).

are no less reasons to talk about ‘beautiful physics’ whereby the application of the expression is by no means limited to the more recent developments in physical science. Actually, an ascent of modern science that started with Copernicus (as we learn, for example, from Holton (1995)) is also marked with an aesthetic appeal. Copernicus sees astronomy as: “the discipline which deals with the universe’s God-like circular movements, and which explains his whole appearance. What indeed is more beautiful than heaven, which of course contains all things of beauty?” He further acknowledges to his reader “the strongest affection” he has for these “studies concerned with the most beautiful objects” (in Holton 1995: 26).

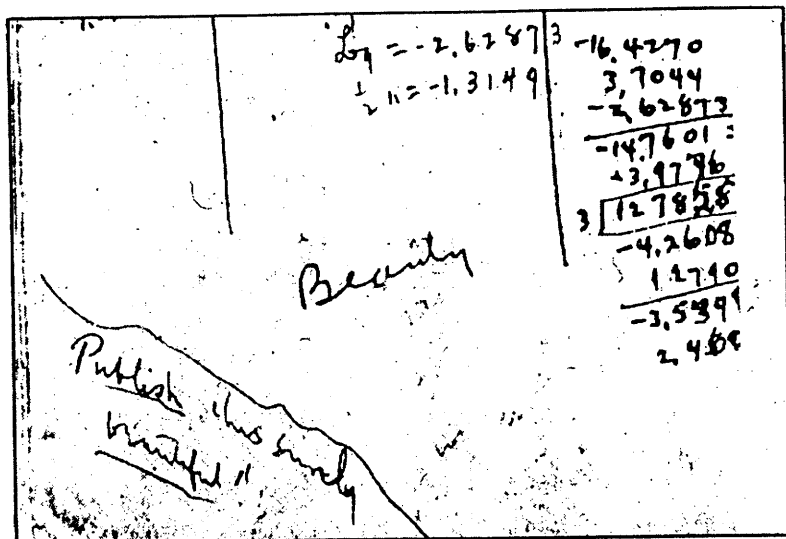
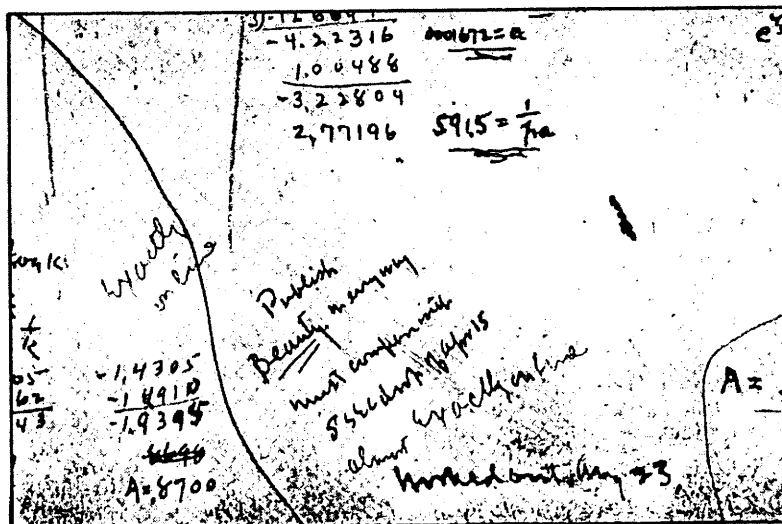
The more recent scientific revolution, namely that of quantum physics, did by no means eliminate the need to describe, and even explain, nature in terms of micro-phenomena using ‘beauty’ not as a side, or psychological, effect of discovery but as a mode of understanding of the processes at stake. In a dialog with Einstein Heisenberg wrote:

You may object that by speaking of *simplicity* and *beauty* I am introducing *aesthetic criteria* of truth, and I frankly admit that I am strongly attracted by the *simplicity* and *beauty* of the mathematical schemes which nature presents to us. You must have felt this too: the almost frightening simplicity and *wholeness of the relationship*, which nature spreads out before us [...] (Heisenberg, 1971: 68; emphasis added).

But is it nature that ‘spreads’ ready-made canons of beauty for us to discover them or is it the creative mind (in this case the scientific one) that provides us with the ‘spectacles’ that enable us to see the nature that way? To put it in more simple and straightforward words, what is that what we appreciate: is it the *beauty of the discovered*, or is it the *beautiful discovery*? At this point one may come up with justified speculation: If we would try to be nothing but ‘neutral observers’ (what is in the positivist tradition a demand on any scientist), wouldn’t we be spared of dilemmas and disagreements of the sort? The answer is plain and unambiguous: An observer that would ‘put aside’ his/her human cognitive structure would probably not be able to see anything at all. For that reason it is superfluous to talk about the ‘beauty’ devoid of the human agent; it is only reasonable to talk about the ‘beauty of the nature’ if there is an ‘aesthetic eye’ that sees it that way. The “aesthetic eye” is thus not an obstacle to supposedly unbiased scientific observation but should rather be conceived as a cognitive instrument of not only observation but of scientific description and explanation too. It is not something we might choose but do not need necessarily. Thus it should be perceived as a constitutive part of scientific enterprise. For that reason “aesthetic eye” is not incompatible with scientific demands for exact observation; it is a powerful instrument of it.

For that matter, the “aesthetic eye” is not in the service of the physical nature and it cannot conform to the dictate of the so-called external reality or the neutral sense-data faithfully representing it; it is rather an organ of the human creative mind that needs it in order to make the world comprehensible to us.

What we appreciate above all is the uniqueness of a creative act that displays aesthetic values - not the capacity to pick up faithfully what already exists in nature as beautiful. We admire an aesthetic completion of a human creative achievement, be it a work of science or a piece of art. I think, it is the way how one can interpret, for example, R.A. Millikan's comments in his own notebook containing calculation on the charge of the electron. "Beauty" he writes on several places. "Beauty in every way ...", "Publish this surely, beautiful!"⁷ (Illustration)



⁷ For more detailed discussion see Holton (1996b).

5. Theories as Artworks

There are relatively few aesthetic qualities that can be counted as part of 'extra factual' realm: "simplicity", "elegance", "economy", "coherence", "order", "harmony", "symmetry" and "unity" (in diversity) or, in another terminology, "perfect structure". All of them are both familiar and yet not unproblematic (but it is impossible to get here into a more detailed discussion of it). Sometimes there is also no clear distinction among them. The term "beauty" is usually (as I understand) used as a more general term (*Oberbegriff*) for some of these expressions or combinations of them.

Let me for the current purposes just briefly comment on the those categories that are most frequently used in judgments of both art-works and scientific theories:

Simplicity is no easily definable term. One aspect of it refers to the choice of relevant data out of totality of experience. This aspect is provided both by Galileo and by Einstein ("From a logical point of view, the progress toward general relativity depended on a *number of choices to be made* [...]"; Bergman 1982; emphasis added). On the other hand, simplicity is affiliated with a *principle of economy*.

In spite of its semantic indeterminacy the term 'simplicity' does bear relevance for those within the scientific community and proved to have philosophical importance. The stand has been spelled out in a most straightforward manner by Nelson Goodman: "Without simplicity, there is no science" (1972: 338), and further: "Science is systematization, and systematization is simplification" (*ibid.*). His strong claim reads: "We cannot choose among them [scientific hypothesis] on grounds of truth; for we have no direct access to their truth. Rather we judge them by such features as their *simplicity* and strength." (1976: 263)

It is crucial to divorce the term from the habitual contrasting to the complexity of the nature or the world. A theory is not simple relative to the structure of nature to which we usually ascribe unlimited complexity. "Simplicity" and "complexity" are both predicates used to describe structure of the theories of nature. (Only relative to a complexity of a theory can we reasonably talk about the complexity of the world). Or, in Goodman's words: "Without science, or some other mode of organization, there is no simplicity or complexity." (1972: 337)

Elegance: It is recommendable to recall of its etymological root: "elegans" = "knowingly and cary chosen". If a proof is described as elegant, what we basically mean is that it successfully avoided unnecessary steps and surplus complications. Scientific rhetoric illustrates that in addition to the empirical and methodological correctness aesthetic elements, such as 'elegance', often influence judgment of the scientific merit of theories.

Perfect Structure

The beauty of simplicity and inevitability – *the beauty of perfect structure*, the beauty of

everything fitting together, of nothing being changeable, of logical rigidity. It is the beauty that is spare and classic, the sort we find in the Greek tragedies. (Weinberg, 1992: 149; emphasis added)

Here comes to full expression what has been already implied or tacitly acknowledged, namely that scientific theories can be perceived, judged or valued in a way analogous to artworks. Even when scientists and philosophers of science do not use the same expressions we apply in aesthetic judgments of artworks (e.g. “organic unity”, “unity in diversity” etc.) it is quite obvious that the request for the ‘structural perfection’ is an immediate analogue to the aesthetic category connected to the arts. The demand for structural perfection is so strong that often scientific merit of a theory is decided on the ground of basically aesthetic criteria. If it is satisfied it is said also to be beautiful. In such a way beauty and truth, value and fact become interdependent. Weinberg’s dictum only confirms this standpoint: “we would not accept any theory as final unless it were beautiful” (1992: 165).

Another example follows from G.H. Hardy: “The mathematician’s patterns, like the painter’s or the poet’s, must be beautiful; the ideas, like the colors or the words, must fit together in a harmonious way.”

And Poincaré: “The measure in which science falls short of art is the measure in which it is incomplete as science ...”. In the following quotation echoes basically the same idea: “The deep satisfaction found in scientific work, akin to the delight derived from genuine art, is one of the fundamental human emotions which is highly intensified by personal contact with the creative mind.” (both quoted in Curtin, 1982: 8 and 9)

All of the above quotations bare the power of authenticity, for it is scientists themselves who recognize the impact and importance of the (soft) aesthetic attitude in the matters of the (hard) science (not eventually an over ambitious aesthetician who may contribute aesthetic qualities there where there are none). True, scientists often give us poor theoretical account of their own personal experiences and are frequently unable to elaborate on them more systematically, and yet their observations and reports are, or should be, found instructive and rewarding for the philosophers of art as they are for the philosophers of science.

We should further warn against a widespread fallacy that aesthetic attitude is something external or additional to the primary task of the so-called exact sciences– that it is something nice but not necessary. Rather it should be perceived as a constitutive part of the scientific enterprise. Not only do we then realize that *beauty is not blind*, we also get to learn that it is something *fundamental*. Weinberg’s concept of “beautiful theories” provides an account of such a view: “It is when we study truly *fundamental* problems that we expect to find *beautiful* answers” (1992: 165; my emphasis), and he poses a rhetoric question: “why do these beautiful field theories work so well [...] if they are not *fundamental*?” (my emphasis)⁸.

⁸ For more on this aspect see Engler (2001).

The very opening of Copernicus' epoch-making book *The Revolutions of the Heavenly Spheres* (1542) displays exactly this fundamental meaning of the beautiful:

Among the many and varied literary and artistic studies upon which the natural talents of man are nourished, I think that those above all should be embraced and pursued with the most loving care which have to do with the things that are very *beautiful*.

In a final instance it drives us to the conclusion that conducting science and making art has much more in common than habitually recognized by theorists. By admitting aesthetic elements in the realm of science a room is opened for the former to potentially play a productive role in the latter.

I believe that we are now in a better position to fully understand and appreciate the claim that scientist, like artist, is not *impersonal*; that his/her creative capacity that lies beyond the logical and propositional and carries distinctive personal traits is not ephemeral to the scientific work but is a constitutive part of it. It further means that scientific reasoning and aesthetic attitude go hand in hand, and that they complement one another in a way that cannot be separated in a clear-cut manner or that the separation cannot be pursued without causing damage to the very essence of the scientific peace of work.

All this may be found to provide support to the idea that a scientist too has his/her personal style or "handwriting"; in other words, that his/her personal "way of doing things" is not only a matter of biographer's interest but above all something relevant for understanding of not only individual scientist's creative process, but as something insightful for understanding of meaning of the very scientific product. According to Polanyi, "strictly explicit knowledge" is a "false ideal" – the idea that he supports by saying:

An exact mathematical theory means nothing unless we recognize an inexact non-mathematical knowledge on which it bears and a *person* whose judgment upholds this bearing." (1969: 195; emphasis added)

Once we have saved scientist from anonymity and once we have rehabilitated him/her as a personality we can better appreciate Boltzmann's words: "Even as a musician can recognize his Mozart, Beethoven, or Schubert after hearing the first few bars, so can a mathematician recognize his Cauchy, Gauss, Jacobi, Helmholtz or Kirchhof after the first few pages. The French writers reveal themselves by their extreme formal elegance, while the English, especially Maxwell, by their dramatic sense."⁹

If "tacit knowing" (Polanyi: 1964, 1969) implies a sort of knowledge that is far from being impersonal should we then not be tempted to introduce the notion of *personal style* related to a scientist

⁹ Quoted in Curtin (1982: 26). New rhetoric of science seems to be more and more concerned with this aspect. (Compare, for example, Dear (1991), and Meyers (1991)).

as we do in relation to an artist, and should it then also not be adequate and just to conceive of *scientific "connoisseurship"* as Polanyi does¹⁰. Talking about "scientific taste" should after all not sound that paradoxical any more.¹¹ The aspect is also recognized by historian and philosopher of science Gerald Holton in many of his studies on scientific creativity, and most explicitly in his (1996a) article in which he talks about "hidden personal aspects": "Scientists from Kepler to Kekulé, from Newton to Crick and Watson, were guided in the early stages of scientific research by a visually powerful, highly symmetric geometrical design. (...) our genealogy should include a new type of resource, 'personal thematic presuppositions'" (1996a: 372). Similarly in his (1996b) article he analyzes different forms of "the private art of scientific imagination".

The western culture is still far away from a more profound reconception of the old polarity of which I talked before, and also far from the true conviction that it is possible to conceive of a single concept that could comprise scientific and artistic traits (as is, for example, the case in ancient Peruvian language where a single word - 'hamavec' - is meant to denote both poet and inventor).¹² And yet I believe that attempts like this one may bring us at least a small step further toward recognition of the integrative power that govern our deeds, and our minds.

In order to proceed toward this monumental goal let me focus in the following on an aspect of it on a reduced scale.

6. "Context of Discovery" and "Context of Justification": Beyond Boundaries

The question that sporadically but repeatedly emerges in the recent discussions is whether aesthetic aspects of science is something that is (or should be) limited to the 'context of discovery' (that is, be recognized as basically heuristic means and be part of psychology of discovery) or whether it is possible to find sufficient support to acknowledge its role also within the 'context of justification' (where a sort of rational reconstruction is required - a logic of discovery). Much of what has been said above amounts to the conviction that one-sided affiliation of the aesthetic with the heuristic "context of discovery" is not adequate or that it is only partial.

Complex nature of scientific inquiry, which cannot be easily reduced to an explicit knowledge and strict propositionality that can always be unambiguously formalized, on the one hand, and our view of aesthetics that cannot be wholly identified with a sort of unreflected immediateness or blind intuition, on the other hand, provide us with a belief that the aesthetic is more profound and more variegated than just to be reduced to forms of acting that require no operations of reason. This implies that the proper place of aesthetics is by no means only within the discovery but equally so within the judgment of

¹⁰ Such an act can be said to be rational if it satisfies our standards of excellence, and the intellectual *beauty of mathematics*, upheld by the passionate *connoisseurship* of mathematics, is such a standard. (Polanyi, 1964: 189; emphasis added).

¹¹ "There is a scientific taste just as there is a literary or artistic one" (quoted in Koestler, 1964: 146-7).

¹² In Koestler (1964: 265).

scientific theories.

Now, in order to provide support for my consideration that the aesthetic is not bound only to the 'context of discovery' (that is, affiliated exclusively with psychology of creativity) but that it can also be an *element of scientific appreciation* or even be *criteria of evaluation* that come into play within the 'context of justification', let me recall couple of historic examples.

For instance, we have good reasons for an assumption that Einstein's rejection of quantum mechanics roots in an aesthetic attitude rather than in deceiving or incomplete empirical evidence. Namely, uncertainty and unpredictability that characterize the world of elementary particles according to the theory of quantum mechanics was not compatible with Einstein's own conviction of the deterministic nature of the "harmony of the world" (Klein and Lachièze-Rey, 1999: 23). That proved to be the reason strong enough for the great genius of modern physics to refute otherwise successful quantum mechanics theory.

According to the above argument theories are not confirmed solely on the empirical and conceptual ground. Of course, no one denies that the merit of theories is basically judged according to the force of empirical data, but from the history of science we learn that the empirical is not always self-evident and undisputable, unambiguous and given once for all times. Empirical data too have to be interpreted, and where there is interpretability there is also an unavoidable intervention of extra-empirical elements. That is how we read and interpret the saying that "facts are theory-laden". Not only facts, observation too, I contend, can be said to be 'theory-laden'. And facts are anyhow not based on a stable and undisputable "bedrock of science"¹³. "A fact is nothing in itself, it has value only through the idea connected with it or through the proof it supplies [...] the fact itself is not the discovery, but rather the new idea derived from it [...] the fact does not itself give the proof [...]"¹⁴

Poincaré is in this respect quite explicit: "It is in its *aesthetic value* that the *justification of the scientific theory* is to be found, and with it the justification of the scientific method."¹⁵

We come to realize that the empirical itself is colored by the extra-empirical, and also that evidence cannot be clearly isolated from preferences, whereby preferences reflect one's global understanding of the world of which aesthetic attitude is a part.

To be clear, it is not implied that the aesthetic brings us always to the right track. The aesthetic, like any other form of knowing, can also deceive us, and it too can be misleading (e.g. aesthetically more appealing notion of circular motion had to be scientifically refuted based on calculations that disprove such a notion; Niels Bohr's first model of the atom from 1914 – the 'onion model' – turned out

¹³ MacCormac (1976)

¹⁴ C. Bernard, quoted in Grmek (1981: 2).

¹⁵ In Curtin(1982: 8; emphasis added).

to be conceptually wrong in spite of its appeal, basically due to the analogical structure to the planetary system). In addition, aesthetic standards are subject to change. But this change is neither arbitrary nor merely accumulative; it evolves and has its history, so that in a paraphrase of art historian Heinrich Wölfflin¹⁶ we can state that ‘not everything is aesthetically appreciable (or beautiful) at all times’, or in a form closer to the original: not everything is aesthetically possible at all times. Aesthetic styles and standards, recommendations and requests do change, and that is what justifies us to talk about art *history*. (Let me here recall an example that Tanehisa Otabe discusses in his (1997) article on Herder’s conception of art. Herder found Shakespeare’s dramatic procedure to be ‘betrayal’ of the old Greek ideal of the ‘unity of action’ [*Einheit der Handlung*] and the lack of the “simplicity of the Greek fable” so that, according to him, these two forms of drama barely deserve to be labeled by the same word¹⁷).

Scientists, as we have seen, do not always choose merely between true and false theories, for which reason verification and falsification (Popper) alone would not do; they often face the problem, particularly in the modern physics, of how to reach a consensus about the *preferable* theory, that is, how to choose among theories that display equally correct empirical evidence, but provide different interpretative horizons of which is aesthetic dimension a constitutive part.

Conclusions and Further Implications

I hope that at least by this time, it must have become evident were I have been heading to in this article, and that is a broader and more elementary understanding of the scope and role of the aesthetic than we standardly operate with. By talking about and analyzing aspects of aesthetic attitude in the world of science I have been outlining a concept of the aesthetic that is more profound than the one exclusively related to the world of art, and also not reducible to the concept of ‘beauty’. True, aesthetic attitude comes best to expression in the artistic media, and we theoretically get to read and interpret it most fully just in that domain, but all the arguments above were meant to point to the fact that the aesthetic is deeply rooted in the *human creative act* irregardless of the type of symbolic language in which it is spelled out, artistic or scientific. If this were one conclusion another one might be that the meaning and use of ‘beauty’ as key-term of aesthetics exceeds the reference to the pleasurable and appealing. Aesthetics, that can be rightly counted “among the most complex responses of the human mind” (Lipscomb, 1982: 4), cannot possibly be reduced to the blind feeling and uneducated affinity. In its capacity to motivate, guide and articulate scientific process and product it can help us bridge the gap that philosophy has traditionally established between the reason and emotion, logic and intuition, the ‘exact’ and the ‘beautiful’, science and aesthetics.

I want to believe that in such a way the import of the conclusions we have reached here will not only be limited to the specific theme of art-science interrelatedness, but the venues could be opened toward more general issues such as those concerning human nature, and particularly nature of cognition, of human creativity, of mental mechanisms, and mind and body that run them. In that sense our

¹⁶ “Not everything is possible at all times” (1929: 11).

¹⁷ In Otabe (1997: 197).

discussion becomes an issue whose implications are relevant for the general theory of knowledge, philosophy of mind, and maybe even metaphysics. For, after the “aesthetic turn”, neither the classical conception of the mind can remain unrevised nor can the image of the world and our knowledge of it remain unaltered.

A Postscript: Toward Totality of Knowing

I want to believe that much of what has been said here implies such a conception of human creativity that is quite contrary to the specialist’s or ‘separatist’s’ view, and I like to describe this integrationalist view in terms of *totality of knowing*. Taking into account those common and complementary features that have brought us to the integrative picture of the human cognitive capacity also provides the ground for conceiving of the human creative agent *as a whole*, irregardless of the type of symbolic language (scientific or artistic) one chooses as a means of expression. Though due to the long-lasting impact of the crude scientism and the logical-empiristic orthodoxy such a perspective still has difficulties in gaining theoretical recognition, it was already in 1935 that McMurray wrote:

(...) creativeness is a characteristic which belongs to personality in its *wholeness*, acting as a *whole*, and not to any of its parts acting separately. (...) Their *wholeness* and their direct awareness of the world express itself in action which is graceful and *beautiful*, because they are emotionally alive and in direct contact with the world. There is nothing strange or marvelous about this. That is the way human beings are made. (MacMurray, 1935: 45; emphasis added)

Thus my response to the question: do physicist and poet represent two different types of persons (meaning that they possess two distinct kinds of minds)? - would be plainly negative. What is then what makes them different? Above all, it is different media they use for their creative expression. Physicist and poet do use specific and quite distinct symbolic languages, but their ‘path to reality’, in addition to specifics, displays many fundamental common traits and they also share many of the problems that both forms of creativity have in common.

If this is the case then what we have learned from the ‘aesthetics of science’ must be sufficient to initiate questions such as: Is there a reason in an aesthetic attitude (that is, why shouldn’t we be encouraged to talk about *aesthetic reason*)? How can intuition be related to logic? In which way can the bodily help shape the abstract? Is the implicit cognitively instructive for the explicit?

Thus, instead of making splits and than trying eventual meeting points among the fields, separated by our conceptualization, I rather see *totality* of the creative act as primary, treat it as initial state, and then trace the paths across its different domains.

Here we meet a sort of philosophical lesson that we cannot leave undiscussed, or at least untouched. It concerns the fact that differences and contrasts, as well as similarities and affiliations are outcomes of our conceptualization. They are in no way given, neither by the physical nature nor by our biological being. We choose one over the other because we can argue and provide better reasons in

favor of one rather than the other.

In other words it is us who create conceptual divisions and integrations. It is us who decide whether specifics are enough to be split and kept separated or whether similarities suffice for integration. Finally, it is us who decide whether art and science belong to two mutually exclusive worlds or whether they are two expressive forms within the same horizon of human creativity.

If science has seemingly lost its objectivist innocence in its intercourse with aesthetics, it did not, for that matter, become less scientific, less exact or less logical. Science is and remains to be our 'best bet' about the world. Yet, from the aesthetic perspective it might just appear less 'brain-in-a-vat'¹⁸-like or 'zombie'¹⁹-like activity and thus significantly *more human*. After all, in further consequent application of the term, why shouldn't we try to rename the cold, distanced and impersonal *universe* (that thanks its existence alone to observations, descriptions and explanations by the human agent) as – *humiverse*.

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¹⁸ Hilary Putnam's expression referring to artificial systems that can produce mental states but lack human body.

¹⁹ The concept of 'zombie' is introduced in modern discussions on consciousness to denote extreme antimentalistic attitude. It refers to somebody (or rather something) that only externally likens the humans while at the same time possessing no mental states.

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