

Kant and the heuristic function of images: The poetics of scientific investigation

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Abstract. My reflections center upon the heuristic function of images in the creative process of producing scientific knowledge. I take as a starting point Leonel Ribeiro dos Santos's idea of a transcendental heuristic in order to discuss the creative and original strength of scientific genius, here considered as talent or ability by means of which the intuitive faculty of imagination is placed at the service of the conceptual faculty of reason. My goal is to present the outlines of a transcendental theory that is consistent with the heuristic use of both concepts and images. My aim is not to adhere to the letter, but instead to the spirit, of Kantian philosophy in order to understand, in the context of contemporary physical theories, especially quantum theory, the non-representational function of intuitive images for explaining concepts that do not conform to any intuition. As applied to the specific case of quantum mechanics, I hold that the free play of imagination and understanding or reason is not restricted to the aesthetics of taste and the artistic production of artworks only, but is also extended to the cognitive and scientific production of theories. In my view, it is precisely this creative, fictional dimension of scientific theories that constitutes Kantian radical enlightenment in the case of scientific knowledge. Thus "*Dare to know!*" is also "*Dare to create!*".

Keywords: Kant, transcendental heuristic, scientific genius, fictional images, quantum theory

1 Introduction

Leonel Ribeiro dos Santos is one of the great exponents of Kantian thought in Portuguese, and a brilliant and original interpreter of Immanuel Kant's philosophy. His interpretation of Kant's works can be characterized as a "transcendental poetics" or a "transcendental heuristic", based on the transcendental fictionalism of Hans Vaihinger's philosophy of "As if" (1935). According to Vaihinger, we find in the "Transcendental Dialectic" as well as in the "Transcendental Doctrine of Method" of the *Critique of Pure Reason*, the conception of ideas as heuristic fictions that extend the scope of theoretical reason and practical reason. In Vaihinger's (1935, p. viii) words: "for Kant a large number of ideas, not only in metaphysics,

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but also in mathematics, physics and jurisprudence, were fictions”. By the expression “transcendental heuristic”, Ribeiro dos Santos (2012, pp. 70-71) wants to characterize “Kant’s effort to highlight the assumptions of the work of mind (whether it is called understanding, reason, imagination, judgment or genius) in the process of invention and discovery of new knowledges and concepts, whether in the domain of science and philosophy or in the domain of arts and fine arts”. Thus, following on from the interpretation he proposed, which combines the creative process of art with the poetics of scientific investigation within the horizon of a reflective metaphysics, I will analyze the heuristic function, not of concepts and ideas, which are usually treated, but of images, in the creative process of making sense of theoretical concepts, with a particular focus on the function of fictional intuitive representations and/or fictional images in the specific case of quantum physics.

2 Reflective metaphysics and transcendental semantics

We need to take into account the fact that for Kant, especially in the “Appendix to Transcendental Dialectic” of the first *Critique*, in the Introductions and in the Second Part of the third *Critique*, empirical knowledge presupposes, in addition to an inductive process of investigation, a heuristic process of proposing hypotheses. The former or inductive process is regulated by the rules of pure understanding and the determining power of judgment. The latter or heuristic process is not governed by logical rules, but instead is a function of the free activity of reason in relation to the faculty of imagination and the reflecting power of judgment. In the heuristic procedure, reason makes use of *a priori* and in a certain sense fictional hypotheses, in order to unite in a single system empirical propositions acquired via the inductive procedure. It is in relation to this heuristic procedure, therefore, that I identify the original power of scientific genius, which is responsible for creating new ideas and images (Kauark-Leite, forthcoming).

By the concept of “scientific genius”, I mean the talent or ability through which the intuitive faculty of imagination is placed at the service of the conceptual faculty of understanding and reason and the reflecting power of judgment. We know that Kant in the *Critique of the Power of Judgment* limits the creative and fictional activity of the genius to artistic creativity only (*KU*, AA 05: 307; Kant, 2000, p. 186). However, I am developing this concept of scientific genius, which is not properly presented in Kant’s writings, on the basis of the new role that the faculty of imagination acquires in the context of the third *Critique*’s conception of the creativity of artistic genius (Crawford, 2003; Figueiredo, 2004), with the aim of providing a more comprehensive understanding of the process of scientific creativity. Nevertheless, I do not want to hold either that the process of scientific creation can be subsumed under the process of artistic creation, or that the activity of the scientific genius can be identified with the activity of the artistic genius. There are similarities, but there are also profound differences. And it is these differences that I will try to highlight in this essay. My point is that this expanded perspective on the nature of imagination in its free play with the understanding and reason can help us to understand philosophically relevant problems related to the problem of objectivity in the field of microphysics, in which images are taken as heuristic tools rather than simply empirical determination of concepts.

I propose to examine this issue in the context of contemporary science, taking quantum theory as an example. This theory requires us to redefine the nature and task of metaphysics and, therefore, also of semantics and epistemology. My opinion is that such a redefinition can be conceived in a contemporary Kantian perspective, which Michel Bitbol (2010) calls “reflective metaphysics”, with an emphasis on the reflecting power of judgment as it is related to the critical function of imagination and its free play with understanding, rather than on the determining power of judgment, its transcendental analytics of pure understanding, and its underlying transcendental semantics. When we seek to establish a relationship

between Kantian theory of knowledge and the epistemic justification of quantum theory, we are led to recognize a radical extension of the limits of human cognition. A Kantian reflective metaphysics, as proposed by Bitbol, which seeks to reflect on the conditions of possibility of knowledge of contemporary physics, allows us to correct the naturally antinomous illusion that arises when we transform regulative ideas – which are, as Kant emphasized in the first *Critique*, heuristic or hypothetical ideas for the investigation of nature – into constitutive principles of the possibility of the objects themselves.

From the point of view of the *Critique of Pure Reason*, the Kantian solution to the semantic problem of the meaning of synthetic *a priori* judgments lies in the fact that the predicate of judgment is determined through pure intuition, which in turn has direct application to empirical intuition: that is, the predicate must express a concept that has empirically meaningful content. In Kantian semantics, determinate predicates are distinguished from indeterminate predicates. According to Kant, an indeterminate predicate is entirely nugatory and empty, “because it is posited entirely outside the sphere of objects that can be given to us” (*KrV*, A 479n / B 507n; Kant, 1998, p. 504). In this sense, a concept has empirically significant content if it concerns a domain of objects that are given to empirical intuition. The determinate predicates refer to concepts with empirical content and the indeterminate ones refer to empty concepts, to which no intuition corresponds. The solution to the semantic problem of meaning is, therefore, found in the Kantian theory of the determinability of the predicates of judgments (Longuenesse, 1998; 2005; Hanna, 2001; 2006; Loparic, 2000; 2005), which in turn presupposes what one can call the theory of “givenness”, present in the transcendental aesthetics of the first *Critique*. In the light of such a theory, Kant offers us a semantic answer to the problem of the validity of synthetic *a priori* judgments, inasmuch as judgments are determinate only if their predicates immediately refer to given objects of pure or empirical intuition.

Therefore, according to the doctrine of transcendental aesthetic of the first *Critique*, the objects of an empirically significant theory must necessarily be given to intuition. The doctrine of the transcendental analytic adds that objects given to sensible intuition undergo a process of logical determination carried out by the faculty of understanding, through the rules given by their pure concepts. The determining power of judgment can therefore determine “whether something stands under a given rule (*casus datae legis*) or not” (*KrV*, A 132 / B 171; Kant, 1998, p. 268).

As we know, the reality of material bodies, such as trees, houses and dogs, for the transcendental idealist – who, for Kant, is also an empirical realist – is not inferred but is immediately perceived (*KrV*, A 371; Kant, 1998, p. 427). And furthermore, according to Kant, “that whose existence can be inferred only as a cause of given perceptions has only a **doubtful existence**” (*KrV*, A 366; Kant, 1998, p. 425). Turning now to quantum mechanics, the problem is that, unlike classical physics, the objects of quantum mechanics are in no way assimilable to ordinary material objects that are given empirically in intuition and can be spatially located, referenced, individualized, and made subject to *a priori* principles of substance, causality and reciprocity. Thus, to be consistent with transcendental idealism, we must hold that microphysical entities, such as electrons and photons, whose reality cannot be immediately perceived, but which can only be inferred as causes of certain perceptions, have only a doubtful or problematic existence (Kauark-Leite, 2016).

Quantum objects are also not assimilable to geometric objects such as points, lines, numbers, circles and triangles, whose concepts, which are formally defined *a priori*, can be constructed and represented *a priori* and *in concreto* in a pure intuition through the faculty of imagination.

Furthermore, the objects of quantum mechanics should not be confused with metaphysically real objects which, in the framework of an atomist ontology that is no longer compatible with current quantum theory, are considered as unobservable “things in

themselves”, that is, as mind-independent entities in the Kantian sense of positive noumena (*KrV*, B 306-312; Kant, 1998, pp. 360-363). Therefore, microphysical objects are not assimilable to a “transcendental object”, whose mind-independent existence could be intuitive only by appealing to some kind of intellectual intuition. Quantum theory, therefore, entails a notion of the objectivity of microphysical entities that is not similar either to the notion of empirical objectivity, or to mathematical objectivity, or to noumenal or transcendent objectivity.

In view of this, the transcendental semantic problem of the validity of synthetic *a priori* judgments relating to unobservables, or microphysical entities, whose contents cannot be immediately given to intuition, does not find a transcendently coherent solution within the Kantian theory of the determinability of predicates of judgments, offered us by Kant in his first *Critique*. Our current leading physical theories thus require a different kind of solution to the semantic problem of the relationship between concepts and intuitions, one that takes into account the special nature of their objects.

3 Quantum intuitions

Thus, in the context of a reflective metaphysics consistent with quantum theory, it is necessary to take into account the definitive disappearance of our univocal and intuitive representations of microphysical processes, since the conceptual framework of quantum theory no longer applies to an intuitive and three-dimensional space, as in the case of Euclidean geometry, but instead in a multidimensional conceptual phase-space, for which no image, not even an intuitive representation by mathematical construction in the Kantian sense of schematism, is possible. We find ourselves thus facing the following paradoxical situation: on the one hand, intuitive representations are required, and, on the other hand, they fail to explain the quantum phenomenon. As the neo-Kantian philosopher Grete Hermann (2016, p. 265) acknowledges in her analysis of the philosophical foundations of quantum theory, “[t]he effort of classical research to obtain an adequate account of natural processes through intuitive constructions has failed: in place of an intuitive description of natural events comes the formal assignment of a wave function, which already makes any intuitive interpretation difficult if not impossible by developing not in the usual three-dimensional space but rather in a higher-dimensional phase space”.

Thus Hermann, following Bohr and Heisenberg, recognizes the impossibility of intuitive descriptions of microphysical events or, in other words, it is impossible to describe the formalism of quantum mechanics in terms of spatiotemporal intuitive images. Nevertheless, even recognizing this impossibility, a second impossibility is still required: that of eliminating intuitive representations completely. Bohr’s principle of complementarity seeks to define precisely the place of intuitive images in atomic phenomena by establishing the connection between the data of perception and the conceptual scheme of theory through intuitive and classical representations. They are restricted to what is empirically observed. The necessary use of intuitive images in our grasp of quantum phenomena is not intended to describe the formalism of wave function, but instead it has the purpose of describing an experimental situation that the physicist must account for. The complementary and mutually exclusive use of intuitive representations imposes itself as a necessity attached to our inability to observe atomic phenomena directly. As against certain interpreters of quantum mechanics who completely deny the role of intuition in the microphysical domain, Hermann agrees with Bohr and Heisenberg about the need for our intuitive representations, thus retaining a necessary role for transcendental imagination. In her words: “Despite this unintuitive character, the quantum mechanical formalism ultimately signifies *no detachment from intuition*; as the correspondence principle shows, in each interpretation of a sensation, in each passage from one observational context into another, it [the quantum mechanical formalism]

seamlessly retains the connection to the intuitive space-time constructions of classical physics. To wish to eliminate these constructions thus means to obstruct the access to intuition and thus to a meaningful association between the data of sensation and the posits of a physical theory” (Hermann, 2016, p. 268).

According to Hermann’s analysis, there is a very specific meaning that can be attributed to images and empirical intuitions in quantum theory: they are limited to macroscopic processes. Thus, the semantic relation between nouns and objects can be defined only contextually, i.e. in reference to a specific experimental situation. It no longer makes sense to assign any ontological and mind-independent microphysical reality, or to apply any semantic description to microscopic entities as if they were unobservable phenomena. The term ‘phenomenon’, as Bohr pointed out, should be reserved only for what can be observed in three-dimensional space or, in Kantian terms, for what can be empirically perceived. Therefore, the expression ‘unobservable phenomenon’ would contain a contradiction in terms. The answer to the problem of quantum objectivity is not found in a referential semantics for unobservable objects. This problem finds an acceptable solution in the transcendental dimension of the complementarity principle that concerns both the analogical use of intuitive images and the conditions for the possibility of unambiguous communication (Bohr, 1949, p. 209).

The “Kantian turn” that I identify in Bohr’s interpretation of quantum mechanics implies a more radical renunciation of the notion of objectivity than that required in classical physics (Kauark-Leite, 2012, pp. 335-340). The new notion of objectivity cannot be explained in terms of a transcendental realism or in terms of a restricted transcendental semantics, as we find in the first *Critique*. What is at stake is an even more profound transformation of the “Copernican Revolution” that Kant proposed for traditional epistemology and metaphysics. In Bohr’s “Kantian turn” or “post-Kantian revolution”, the concept of object in quantum mechanics cannot be understood without referring, on the one hand, to the *a priori* formal theoretical conditions of objective representation and, on the other hand, to the dependent experimental conditions in the context in which the observer and the object interact. The theory of experience, restricted to Kant’s first *Critique*, does not take this second type of limitation into account in its semantic analysis of determining judgments.

Translating Bohr’s interpretation in Kantian terms, I mean that the intuitive representations, which quantum mechanics necessarily uses, are no longer related to pure concepts following the rules of the transcendental schematism of the first *Critique*. The principle of complementarity proposed by Bohr reveals, ultimately, the limits of the Kantian doctrine of the subsumption of the object of empirical intuition under the conceptual representations of the faculty of understanding and, therefore, the impossibility of making intuitional representations homogeneous with conceptual representations. In explaining the need to use two mutually exclusive classic images, such as the wave image and the corpuscular/particulate image, which in Kantian terms means using two conflicting empirical intuitions as analogies, this principle also denies the possibility of replacing the two conflicting images with a new intuitive image of the microphysical object that is homogeneous and harmonious to the concept (Bohr, 1958, p. 30). The complementary use of intuitive representations of the imagination, as related to mutually exclusive experimental contexts, reveals the limitation of our faculty of sensibility in the face of the unobservable. The principle of complementarity thus rightly reveals the limits of these representations.

In view of this situation, we cannot transcendently comprehend the activity of the imagination in the context of quantum mechanics as reducible to the synthetic procedure of subsumption of sensible intuitions under concepts, in which it has no freedom to create new cognitive objects. The function of imagination as presented in the first part of the transcendental doctrine of the determining power of judgment or “Analytic of Principles” of the first *Critique*, was restricted to the synthesis of the schematism which unifies through the

schemata the manifold of intuition under the pure concepts of understanding through the temporal determination of the inner sense (*KrV*, A 145 / B 185; Kant, 1998, p. 276; Almeida, 2015). Together with the other transcendental functions of the mind, imagination forms the transcendental basis for explaining how *a posteriori* and empirical statements are logically dependent on *a priori* and transcendental principles. Consequently, the properly creative function of the imagination is highly restricted in the first *Critique*.

Nevertheless, quantum theory makes the use of what Kant calls, in the third *Critique*, ideas of reason, fully explicit. According to Kant, in §49 of the third *Critique*, the idea of reason is the counterpart of the aesthetic idea, which is “a concept to which no intuition (representation of the imagination) can be adequate” (*KU*, AA 05: 314; Kant, 2000, p. 192). This notion fits perfectly with quantum concepts to which, unlike the concepts of classical physics, no intuition can be adequate. We use different intuitive images (like particle and wave), related in a complementary way to the same concept or supposed quantum object (e.g. an electron), whose accuracy for detecting wave-like behavior or particle-like behavior is restricted to different and mutually exclusive experimental contexts.

4 Conclusion

In this way, since scientific reason is not able to dismiss intuition, it creates new intuitive representations, for which no conceptual scheme is adequate, in the service of an aesthetic extension of thought. But, unlike art, which cannot do without aesthetic ideas and which for its production of artworks, understanding puts itself at the service of the imagination, in the case of natural science, which cannot do without ideas of reason, imagination places itself at the service of reason and understanding, in a use that is both dialectical and analytical. In the context of quantum mechanics, the intuitive images associated with quantum concepts, even if they cannot be applied in a homogeneous and harmonious way, namely, without the condition of complementarity, seem indispensable for the explanation of atomic processes, as analogies. However, the notion of analogy here is related to the notion presented in the “Transcendental Dialectic” and in the *Critique of the Power of Judgment*, and not to the notion of analogies of experience in the system of principles of pure understanding. Intuitive images as analogies having a quantum theoretical function work only as heuristic models. This means that even if they do not exactly fit the concepts, they guide scientific research in establishing new predictive models and in assuming a function that is far more regulative than constitutive, and far more reflective than determining. The heuristic function of images provides order and homogeneity, not to nature in itself, but to thought and its products. So in order to align my argument with what Leonel Ribeiro dos Santos aptly calls the “poetics of scientific invention”, I will end this essay with Bohr’s own words, quoted by Heisenberg (1971, p. 41): “[...] we must be clear that, when it comes to atoms, language can be used only as in poetry. The poet is also not as concerned with describing facts as he is with creating images and establishing mental connections.”

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