

## **Semiotics and Modeling in Science: The Problem of Representation**

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### **Abstract**

This article will address an important and problematic topic: the modeling of scientific entities. For this, the transcendental foundations that allow, in scientific models, homomorphic and isomorphic operations as semiotic conditions of a model for the construction of knowledge will be reviewed. In principle, these semiotic operations imply that some models in science assume a semantic commitment in the way of representing their objects, others, on the other hand, start from the semiotic foundations of iconicity. However, the problem is the following: it is not resolved if a scientific model must assume a commitment to exist with the represented object so that, from there, plausible knowledge is built for a scientific community. In a radical way, an interesting epistemological problem is observed: can a model show the existence of a scientific entity?

Keywords: epistemology, modelling, pragmatics, semiotics, scientific discourse, semiosis

## Introduction

Regarding existence, Bruno Latour (2014) proposes an interesting answer to the Philosophy of science in his article “On the Partial Existence of Existing and Non-Existing Objects”. According to the author, scientific objects or phenomena exist ingrained in the network of scientific practices that produce them. It is within this "network of production" that objects have a determined temporality and spatiality. Thus, any sentence affirming the existence of a scientific object (phenomenon or entity) has a character of truth when circumscribed to the network of production of this knowledge.

Latour puts forward the term "relative existence" (2014, 358 and ss.) to board this set of relations where a scientific entity exists due to its link with other scientific entities that collaborate with its existence within the network of knowledge production. This constitutes a weave of terms, concepts, lab practices, and speeches that locate, within the scientific imaginary, the visibility of a fact. Plus, however, within this plexus, entities persist in time through the institutionalized practices that constitute a "collective body" capable of standardizing the "corporal abilities" and "material organization" as conditions that allow modeling the existent form of the object.

Said pragmatic conditions in the modeling of the object/phenomenon imply a "performativity" where the human agency of the scientist is interrelated with the agency of the natural phenomenon. How an object exists, linked to the collective history of a scientific community, is also determined by the natural conditions imposed by the occurrence of the phenomenon. Thus, the temporality of the phenomenon, in its own occurrence, marks a specific and differentiating agency capable of influencing how this phenomenon can be observed.

It is interesting to question, within Bruno Latour's characterization of pragmatic conditions in the historicity of scientific knowledge, the role that scientific models play in the

visualization of a phenomenon. Therefore, we will not discuss in this essay the epistemological basis for the historicity of science. Instead, we will focus on the semiotic-transcendental conditions involved in the modeling of a scientific object. Although we accept, together with Latour, that the existence of an object is determined by the pragmatic conditions of the production network, we will only focus on highlighting some semiotic operations that constitute the epistemological conditions of said existence.

Nevertheless, we will insist on the semiotic-transcendental conditions as conditions of possibility for a scientific object. By doing so we establish a contrary position to that of Umberto Eco (1999), for whom knowledge, from a semiotic scope, implies a construction process in a non-transcendental key (139 and ss). In any case, it is mandatory to revise "transcendental" as a concept to locate it, together with Karl Otto Apel ([1975] 1997), as a necessary condition for science. This obliges to stand a pragmatic posture that has no fundament on the Kantian transcendental subject.

So, in this exploration, we will firstly review in an operative way the semiotic conditions of a scientific model to consider the operations that allow building the object as an imaginable phenomenon. In this point, we will defend a nominalist stand of science in the semiotic construction of the scientific experience and that of the experienced object. However, secondly, we will evaluate the semiotic-transcendental conditions involved in the construction of the scientific reality of objects. From there, we will evaluate the epistemological value of a scientific model as a hypothetical approach with the transcendental function of affirming the conditions of possibility and necessity; however, prescriptively, it does not permit to state the truth of a particular existence.

Finally, to deepen the pragmatic conditions of knowledge from a semiotic approach, we will devote the last section of this essay to discuss the indexical function as the principal semiotic operator in science making. Facing a nominalist view of the scientific models (which

would only verify their internal functioning), we will compliment this review by contrasting a realistic stance from the position of Ch. S. Peirce, which defends the icon and index as categories that enable thinking, knowing, and modeling the effective existence of the world.

At the end of the day, this slight review has the objective of complementing the tradition of the Philosophy of science that focuses on the discussion of the epistemological conditions of scientific models; however, in the subsequent lines, we will attempt posing said objective from a semiotic epistemology, contributing different scopes to the philosophical discussion that, other than that, has intentionally left out from its field of observation the discussions related to the semiotic construction of the scientific object.

## **Diagrammatic Thinking and the Semiotic Function of a Model**

We could sustain, in principle, that a model has a categorial function: that is, it allows to establish a relation between a substance and a predicable quality of said substance. Immediately, Bruno Latour's (1999) historicist approach could seem a feasible counterargument, as the substance-quality relation could suggest an object of nature that exists on its own. If this was the case, a model could permit the observation of reality independently from the model itself and from the observer.

Nevertheless, from a semiotic approach to the constitutive functioning of scientific models, we have insisted on the transcendental nominalist function (Horta, 2014; 2018; and 2021). In these lines we will synthesize some relevant points of the discussion, aiming to gain clarity about the processes of modeling a scientific object.

In any case, an important distinction is in order: the epistemological functioning of scientific models seems to be better characterized by Ch. S. Peirce's ([1992] 2012) diagrammatic thought, than by E. Kant's ([1787] 2007) transcendental schematism. When Kant derives his

categories as logical principles that regulate thought, he does so departing from the notion of "transcendental synthesis". This, due to his interest in showing how the internal structure of the subject (spirit) carries out a synthesis of knowledge (concepts/intuitions). That poses a problem: how can pure concepts (categories) synthesize something from the experience departing from the subject himself? For that, it is necessary to postulate principles that regulate the synthesis of the spirit and its understanding faculty. This makes up "transcendental deduction": a metaphysical<sup>1</sup> deduction that explains the way in which *a priori* concepts can refer to objects without implying content from experience. In other words, Kant considers existence as a rector principle of understanding, previous to the experience of the object, capable of articulating the internal structure of the subject (mind, spirit). Such principle is a fundament that allows constructing the object, as an *a priori* synthesis, that afterward derives in a series of successive syntheses with "self-consciousness" as the culminant point.

Since synthesis is the foundation of the representation of knowledge, Kant considers it evident that the logical form of categories can be deduced from the logical forms in which understanding establishes said foundation (logical forms of judgment). The relevant point is as follows: transcendental deduction supposes *a priori* subjective principles that determine the object and, with that, a clear demarcation between knowing subject and known object arises. The reality of the object is a matter of "constitution" by the side of the subject. Accordingly, the Kantian scheme is an *a priori* model and criterion of unity that allows the subjective synthesis of thought and mediates between categories (logical operations of the understanding) and the sensitive data from experience. In this sense, a relevant question can be asked: are there innate models-schemes that allow giving shape and meaning to experience?

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<sup>1</sup> It is stated as "metaphysical" since this operation is based on a "supreme principle" (what Kant calls "transcendental synthesis of apperception"), which constitutes a part of the internal structure of the subject (spirit or mind). Kant supposes that starting from this subjective foundation, all the conditions of possibility for theoretical knowledge can be established (Cf. Kant, Emanuel [1787] 2007, 120 and ss.).

Facing this modality of Kantian schematism, Ch. S. Peirce ([1992] 2012, Vol. I) postulates a semiotic solution in non-transcendental key: the diagram is a sort of constructivist scheme constituted *a posteriori*; that is, after the abstraction and interpretation of different experiences. It is in that sense that Eco (1999) considers the diagram, after Peirce's dissertations, as "un programa que sólo ocasionalmente se representa visualmente [...] siendo precisamente puro ícono, el diagrama exhibe un estado de cosas y nada más [...] se limita a mostrar relaciones de inherencia"<sup>2</sup>.

Peirce's notion of diagram derives from a different posture. It is not a part of pure understanding and the subjective structure as a foundation to deduce the principles of synthesis of knowledge. Instead, the Peircean pragmatic posture considers the logic of the research and, from there, deduces the objective validity of the inferential synthesis. Within this logic, the validity of knowledge rests on the "critique of meaning" (Apel [1975] 1997) that considers the intersubjective consensus of the members of a community of thought as a necessary condition for the validity of a certain knowledge. In this way, the diagram has a constructivist logic, where the relations that make up the representation of the object emerge as a result of successive interpretations which trigger a continuous *a posteriori* process. This process ends up building a diagram made up of symbolic elements codified by a certain community.

The diagram starts from an initial hypothetical inference in the interpretation process, and maintains, thus, a dual semiotic dynamic: on the one hand, it conditions the subject's cognitive experience; and, on the other, it is built episodically in a procedural way, permanently exchanging with the sensitive data of experience. Therefore, "a diferencia del esquema, es tentativo, revisable, dispuesto a crecer por virtud de interpretación"<sup>3</sup> (Eco 1999, 139). Although

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<sup>2</sup> "A program that is represented visually only in occasions [...] being, precisely, only icon, the diagram exhibits a state of things and only [...] limits itself to show inherence relations".

<sup>3</sup> "Unlike the scheme, it is tentative, revisable, willing to grow by virtue of interpretation".

the diagram, like the scheme, is configured by a “figurative imagination” (Eco 1999) or by a “productive imagination” (Kant [1798] 2010), the peculiarity of the diagram is determined by its element of secondness: that is, it is re-elaborated from the constant occurrences that determine the existence of the phenomenon in the experience.

By this, a scientific model considered as a diagram in its semiotic characterization (Horta, 2021; Tondl, 2000; Sebeok and Danesi, 2000; Nöth, 2018) allows us to account for an inherent problem of the Philosophy of science which assumes two types of models (theoretical and material), each of which addresses different processes of modeling an object. In general terms, this epistemological problem (Van Fraassen, 1980; Bunge, 1973) seems to be justified if we consider the modeling function from the Kantian notion of a scheme. As we have stated, this perspective establishes a demarcation between subject/object by giving priority to the internal structure of the subject (mind, spirit) as a necessary condition for the constitution of the object. This makes it possible to argue for a dichotomy in scientific models. Following the description proposed by Alain Badiou (2009), scientific models have two fundamental functions: for one thing, the model constitutes a theoretical-artificial construction that allows observing relations in the complexity of phenomena (which has been generically characterized as "theoretical models" or "mental models"). This type of model reproduces, on some level, the relations of a more complex system and makes it possible to foresee some later functions. On the other hand, some models build spatial representations of non-spatial events or phenomena, seeking to establish formal structures similar to the proportion of the objects of experience they represent (also called “material models”). However, and despite the diversification of this classification in the scientific and philosophical literature, if we appeal to a semiotic notion of model-diagram, we can establish that this dichotomy is, in fact, problematic.

The semiotic operations isomorphism, analogy, and homomorphism, as fundamental semiotic functions of a model (Cfr. Tondl, 2000), state relations within a specific experience, not

with a specific empirical object. Model's operations –even those of material models– are determined by their link to objects that are part of previous knowledge, known objects codified inside a community of interpreters. Latour's "historicity of the object" (2000), in the specificity of semiotics, consists of all the formalization resources of the scientific object, in such a fashion that a scientific entity, when textualized, acquired qualities and a spatial/temporal configuration that gave it existence in the scientific imagination. In that sense, the spatial and temporal construction of an object consists of maneuvers of intertextualization and metaphors from which the phenomenon had a formal representation from the discursive environments edified over the best-accepted theories in a specific historical time.

Ever since a scientific model replicates theoretical content accepted by a community at a particular time, it is closely related to Peirce's (2012, Vol. I and II) "dynamical object". Namely, a model allows a recognition of the content of theories already accepted by the community. At the same time, it enables its problematization by recognizing previous knowledge; however, it does so from a different focus. Nevertheless, as an immediate object, it constitutes a dynamic and changing structure, not a fixed one, since it has a dialectical articulation where the data from experience affect the model; at the same time, it gets also modified by the communication interfaces in the community members. For this reason, and as a parody to Latour (2000 and 1999), a scientific model has a double function as a translator agent: it allows to translate levels of theoretical information relevant for scientific explanations and, on the other hand, it allows to translate the properties of natural agents (in the peculiarity of phenomena) into codifiable qualities.

Even though this semiotic characterization of a model enables us to understand the non-transcendental character of scientific knowledge, just as Eco (1999) proposes, there is room to question: how can we still maintain a semiotic-transcendental posture to account for the process of knowledge? The following section establishes an answer to that question.



## **Transcendental Semiotics and Transcendentable Arguments in the Epistemology of a Scientific Model**

So far, we have managed to determine some semiotic precisions about the functioning of a scientific model. Along with pragmatic semiotics (Peirce, 2012; Eco, 1999), we accept one condition of models: they are not, in themselves, a representation (they are not objects nor things); however, taken as a relation, a model allows to build representations (objects).

This leads us to state some important conditions of the functioning of scientific models as diagrams:

1. They are sign structures determined by suprasubjective and intersubjective levels of relation
2. They are not the outcome of subjective cognition
3. They constitute a determined experienced reality that is only valid and plausible within the habits of a particular community of thought

These three elements allow us to consider a problem within the scientific realism of modern sciences and, maybe, of factual sciences: to postulate the subject and his experience as the foundation of knowledge. In this framework, real existence is a term that alludes to the empirical existence of the object (as a thing): in this sense, existence is a necessary condition of experience, given that the fact that "S" has a direct experience of "X" leads us to consider an existing state and a way of existence in the face of something.

In this scheme, the immediate apprehension of sensitive data constitutes a necessary condition for knowledge and, as well, a necessary condition for experience. Nevertheless, it is not properly experience what determines, in an epistemological sense, what is considered knowledge, as the particular experiences of every individual do not necessarily get to constitute

as 'knowledge' of what is experienced. The "causal metaphor" (Rort 2010, 122 and ss) refers to the capacity of the "transcendental ego" to constitute nature. The knowing subject, in the free play of its faculties, has the intelligence to determine the order of the natural. That is why, even if there is something in the experience that is given to the subject, they are his faculties and representations the ones that constitute the order of what is known: they are the cause and condition of possibility of knowledge.

This fundament of factual and experimental sciences, and, as a consequence, of scientific models derived from modern epistemologies, implies retroactive consequences over the impossibility of perceptual knowledge of the physical world that Ch. S. Peirce ([1992] 2012, Volume I) had already glimpsed in some of his texts just as "Some consequences of four incapacities", "The fixation of belief", and "Questions concerning certain Faculties claimed for man".

In this work, we are only concerned with highlighting some Peircean fundamentals of what Karl-Otto Apel (2010) calls "transcendental semiotics": that is, a type of semiotics that establishes the conditions of possibility of knowledge from intersubjectivity as a foundation, not from the subject.

According to Peirce's ([1992] 2012, Volume II) article titled "How to make our ideas clear", what is real is identified with the last opinion that results consistent within the community of researchers and, in that sense, it leaves no space for further dissents. This supposes permanent progress in the state of knowledge since every opinion, seen as a hypothesis, results plausible – however not conclusive– within the community: it is, before anything, a suggestion of meaning that must be questioned inside the community's habits and beliefs.

But, the latter leads us to suspect this metaphysics condition as mere conventionalism that only argues (in appearance) the efficiency of practice and the pertinence of a provisional validation of any conviction. To avoid the emergent problem, Peirce proposes –in agreement

with Otto Apel (1997 and 2010) –two conditions to work as "counter-instances" facing conventionalism. One of them is to consider the Kantian transcendental presuppositions, but following the scheme from the postulates of the practical reason: this is, establishing a "regulating principle" to determine a finality for the process of knowledge; however, as an end, it is only a hypothetical supposition not necessarily achievable (in a factual manner). In the perceptive pragmatic sense, this regulative principle lies in supposing as an end ultimate consensus, final agreement in which the community members have consented to the truth of the object and, thus, its reality.

And so, the idea of an infinite evolution of knowledge allows us to infer the hypothetical existence of a community that is infinite as well. A regulatory ideal that supposes absolute consensus as a hypothetical end allows establishing metaphysical limits (not factually achievable) leading the behavior of subjects towards the consecution of that end. It is from there that, within this infinite evolution of knowledge, reason first materializes in behavioral habits and laws of thought to then become concrete in the community of knowing subjects that have reached consensus about the sense of their reality.

This permits us to deduce some important conclusions regarding knowledge provided by a scientific model. Reality or the world that establishes the articulation between theory and phenomenon, by the mediation of the model, is not a provable matter within a particular state of knowledge. In all cases, it is a provable evidence *a posteriori*, as an end, not as a mean.

So, a model, as a result of a specific way of knowledge, cannot establish an exhaustive and determinant link with a potential reality. It is, in any case, a possibility of knowledge that cannot be proven in the factualness. A science's factualness, from transcendental semiotics, does not depend on the particular experimentation, but on the accumulative evolution of a community, of consensus determined by humanity and, from this point, of the possibility, itself, of scientific

knowledge to state an ultimate final interpretant. All these conditions do not depend on the scientist nor a particular institution, but on the ends, themselves, of humanity's knowledge.

This is a relevant point because Peirce's ([1992] 2012, Volume II) semiotic realism does not establish the existence of the outer nor physical world. Instead, the knowledge of nature's structure, as "real habit of the world" ([1992] Peirce, 2012, Vol. II, p. 503), is a teleological condition: a regulative ideal that determines the sense of science, not an empirical condition particular to research. The diversity of models and epistemological scopes enable this episodic evolution of knowledge which ponders the world's reality as an achievable possibility for the community of thought as an endless end.

From this point, it is convenient to clarify that, from transcendental semiotics, a community that has knowledge of totality as an end is, in fact, temporarily incapable of accessing that level of reality through its theories and scientific models. This knowledge of the real, as an end, is evolutionary: it implies the consensual integration of all the possible knowledge by a universal community.

But science materializes as a practice in every stage of human life. Finally, from transcendental semiotics, is the specific scientific knowledge developed by a particular social community relevant? In any case, maybe we must reevaluate the specific function of a model and its factualness. This leads us to establish one last definition: a scientific model is a particular way of a transcendental argument that allows establishing the conditions of necessity and possibility of the experience, but not of universality.

To answer the question, from the scope of apelian transcendental semiotics, the universality and generality of knowledge occur in a teleological way: it is an evolutionary condition of knowledge that will, in its final stage, establish the 'continuity' between humanity's habits and beliefs regarding the real habits of the world. But we, in the social world, act and

know the world starting from concrete models and theories. The final reflection of the present work seeks to establish a point about it: concrete models work as transcendental models<sup>4</sup>.

The latter reflection has as an origin the notion of "modality" that Kant ([1787] 2007) proposes concerning the "categories" of the faculty of understanding. About his notion of category, the Prussian philosopher states a specific guideline: "las categorías no tienen pues aplicación (...) sino a medida en que éstas sean asumidas como objetos de una posible experiencia"<sup>5</sup> (Kant [1787] 2007, 164). This brings clarity regarding the use of a scientific model: from this nomenclature, when a concrete model is applied to a particular experience, if it was the case, this model would necessarily be built up by categories, not concepts.

Concepts are assumed in the semantic modality of a theory, but categories would have to be the foundation of a scientific model if, in any case, one would want to insist on the factual character of science. Departing from the notion of category, Kant ([1787] 2007) proposes four levels of relation and order of categories: quality, quantity, relation, and modality. Here we find it interesting to reflect on the level of modality.

Along the same lines, for Umberto Eco (1999), Kantian categories are a first system of operations that enables ordering complex and contingent elements of the experience. From this point of view, they are relevant operations for the semiotic epistemology, as they determine a level of relation and order that precedes, as a foundation, the semiotic-cognitive level. In any case, for Umberto Eco, Kantian categories do not manage to explain how we link signs to objects, but they do allow us to show how cognition proceeds facing experience.

In this sense, following Kant ([1787] 2007, 247 and ss), a model implies a relation at the level of "modality" due to its link with the possibility of postulating an empirical thought.

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<sup>4</sup> A "transcendental argument" is a philosophical modality that problematically derives from a Kantian philosophy that tries to establish the possibility conditions of knowledge. This proposal started with the philosopher Immanuel Kant's work, *Critique of Pure Reason*. Here we go through some epistemological consequences contemporary to that thought.

<sup>5</sup> In this article the reference was cited in the consulted language. The translation of the quote was carried out by the translator of this text. The translated quote is as follows: "Categories, therefore, have no application (...) except as they are assumed as objects of a possible experience".

Moreover, J. Deely (1996) postulates the sign as a condition of “modality”: “en el caso de un signo, lo que es fundamental (la representación que da basamento y funda la relación de significación) y lo que es formal (la relación de significación misma) nunca coinciden”<sup>6</sup> (p.164).

In this sense and following Kant ([1787] 2007, 247 and ss), a model implies a relation at the level of “modality” due to its link with the possibility of postulating an empirical thought. Moreover, J. Deely (1996) postulates the sign as a condition of “modality”: where “in the case of a sign, what is fundamental (the representation that provides the basis and founds the relation of meaning) and what is formal (the relation of meaning itself) never match” (p.164).

In this way, the scientific model, as sign-modality, establishes three postulates about empirical thought (as follows according to kantian categorical logic): the possible-impossible, if it is in conformity with the formal conditions of experience; the real, if it is in relation to the material conditions of experience; and the necessary, as that in which the relationship with the real is determined by the universal conditions of experience.

Transcendental arguments have explored the formalization of two modalities: necessity and possibility. According to I. Cabrera (2007), modal formalization of transcendental arguments attempts to determine the logical relations of experience of the following sort: "it is possible that..." and "it is necessary that..."<sup>7</sup>. Even if the formalization of a model that meets the

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<sup>6</sup> In this article the reference was cited in the consulted language. The translation of the quote was carried out by the translator of this text. The translated quote is as follows: “In the case of a sign, what is fundamental (the representation that provides the basis and founds the relation of meaning) and what is formal (the relation of meaning itself) never match”.

<sup>7</sup> Formalizing the argument allows us to evaluate and distinguish between the subtypes of transcendental arguments. The operator ( $\diamond$ ) indicates a contingent premise that states "it is possible that"; while the operator ( $\square$ ) indicates a necessary premise. The standard formalization of the argument is schematized in the following way (Cabrera, 2007, pp. 9 and ss):

Scheme 1:	Scheme 2:
P1: ( $\diamond$ ) A	P1: ( $\square$ ) A
P2: ( $\sim C \rightarrow \sim \diamond A$ )	P2: ( $\sim C \rightarrow \sim \diamond A$ )
$\therefore \square C$	$\therefore \square C$

Commentary: It is interesting to notice how, by starting from denying the conditions (C) of an argument that states "possibility", we can conclude a necessity of those conditions ( $\square C$ ); and, on the other side, in scheme 2, by stating something as necessary, the conditions of possibility can be denied ( $\sim C \rightarrow \sim \diamond A$ ), and conclude a necessary condition ( $\square C$ ).

Cabrera, in his evaluation, will show us subtypes that derive from these possibility/necessity relations, showing the logical problems involved in the evaluation of transcendental argument as conditions of possibility of knowledge.

conditions of a transcendental argument is still a pending task for the author of this work, there are some notes that we can make in this regard.

A scientific model, with the realistic compromises that we have included to its epistemological and semiotic functioning, would imply some conditions as possibility of knowledge. It is important to stop in a relevant point that arises: from a semiotic perspective, a scientific model cannot propose a condition of necessity without denying itself. A condition of necessity, in transcendental terms, would imply a universal condition for knowledge and, due to the before mentioned arguments, that would imply a non-semiotic function of the model.

Hence, a model could constitute only a contingent possibility: that is, it would allow to affirm the distinction of something (the experience of something), as it only establishes a possibility of the occurrence of that something that, although it may be evident to observation, is not necessary. This would work for material models that function as general patterns that determine possible occurrences of later phenomena.

Now, in its semiotic-transcendental character, a model can postulate an entity as an objective existence; in its character as transcendental argument, a model poses as something given in reasoning the existence of an experience of type X. That is, it assumes *a priori* a possibility that, in fact, has to be demonstrated in terms of its validity.

This might seem like an abstract reflection, but let us consider the use we make of models in specific fields of knowledge. By applying a model, we assume a commitment to the existence of a type of experience or knowledge. One problem is that the correct functioning of a model has to show something as already "given". Thus, for example, a model of narrative analysis assumes a commitment in terms of experience: it assumes for its correct operation that there is a "narrativity" experience assumed *a priori* in the model and that, to be applied, it has to correspond to said given condition.

But, if we consider the modality of possibility of knowledge as the foundation of scientific representations and models, then we could reach a concrete solution: along with Kant (2007), we would be in conditions to accept that a transcendental function of knowledge consists in accounting for how we know objects, and is not focused in the knowledge itself of those objects.

### **Predicating a Reality: Index as Semiotic-Transcendental Condition of Knowledge**

To summarize, in its double dimension, a scientific model is constituted by semiotic operations such as diagram-type and diagram-index. In its thirdness character, the model forms a conventionalized type that conditions the perception in the experience and determines a specific cognitive activity: the possibility of thinking relations, functions, and structures. The model approaches, in this sense, what Umberto Eco calls "cognitive type" (1999, pp. 143 and ss). However, following W. Nöth's (2018) detailed description, the model-type constitutes an "iconic-legisignic" function, which implies the recognition of a structural pattern of relations based on analogies and likenesses. Also, as legisign, it is conformed by symbolic units, that is, by theoretical terms that constitute the referential content of the diagram. In terms of scientific models, this semiotic characterization allows us to consider the functioning of a theoretical model conformed by structural observation patterns similar to the structures derived from scientific theory. In this sense, not only the theoretical conceptual terms or concepts are represented, but they are also conformed by said elements as symbols that allow directing the function of the model. It is this a priori structure that models the existence of an object in the imaginary of the community of scientists, moreover, it models the shape of non-observable objects as the double helix structure of DNA (Horta, 2021).



On the other hand, scientific models, being material structures, receive feedback from experience data. The secondness level of the diagram –as stated by the "hypoicons" theory (Peirce, 2012, pp. 347)– implies the determination of analogic relations of existence: that is, it points out elements of existing things analog to the elements of the model. This relation can get refuted in the experience and, even if it cognitively conditions the scientist's observation, the model, however, represents a fallible observational hypothesis that may be transformed by the effect of concrete existence in the experience.

Both dimensions acquire an epistemological function that is relevant only as they work as conditions of possibility for knowledge: that is, as transcendental conditions in the process of conformation of knowledge. While its transcendental function does not appeal to the subject as the foundation of knowledge (as Kant's transcendental philosophy does), it is important to argue two things:

1. A scientific model establishes a condition of possibility in relation to the observed and observable object. It enables the establishment of a hypothesis or conjecture regarding a specific state of things.
2. A scientific model also constitutes a transcendental condition in terms of the establishment of a necessary relation: it establishes a necessary condition, within the explicative apparatus of a theory, in the communication between scientists and as specific modeling that allows visualizing the scientific propositions.

These affirmations are links to the idea of a transcendental semiotic, discussed by Apel (1997 and 2002), that establishes the conditions of possibility for knowledge in the intersubjectivity. It is from there that the idea of "intersubjective consensus" as a regulative ideal results in an interesting solution to the problems of modern epistemology, as they allow the construction of a pragmatic truth "located between the phenomenic evidence for the subject and

the intersubjective validity. In other words: said pragmatic truth mediates the interpretation between language and the world" (Horta, 2019, p. 143). These statements are linked to the idea of transcendental semiotics, discussed by Apel (1997 and 2002), that establishes the conditions of possibility of knowledge in the intersubjectivity. This idea of semiotic-transcendental-truth assumes the epistemological foundations proper of percean pragmatism: it accepts the fallible condition of knowledge, the hypothetical character of scientific explanations, and the community of thought as the ultimate criterion of evaluation for the validity of science. However, finally, it postulates the regulative idea of the community as a long-term process: as a finality that tends to get realized along the way as the final objective of humanity. From this point of view, the transcendental condition of the community constitutes a semiotic criterion from which we can postulate the possibility of accessing effective knowledge of the world and its reality.

In this sense, we are interested in making a stand to defend another transcendental condition: the percean notion of index linked to the community of thought. We are, therefore, interested in problematizing the idea of a semiotics of scientific models based on a nominalist posture facing a realist posture of knowledge, where models are means to achieve the knowledge of the world.

In a previous text (Horta, 2014), we have proved the epistemological function of a scientific model from a nominalist posture; if we consider the case of non-observable phenomenal entities (such as DNA, atoms, etc.) the model constitutes the possibility of experience. The semiotic function of a model, then, is determined by its function of representation: that is, it constructs the space of observation, experimentation, and intervention where the scientist may put his theories to the test. Facing entities that are not directly observable, the model conditions a series of lab practices directed towards the intervention of the reality structured by the model.

Nevertheless, models subjected to empirical existence (of directly observable phenomenal entities) limit a different case. These diagram-models with indexical functions tend towards the transformation of their functions and structure due to the effect of empirical verification<sup>8</sup>. The recognition of the indexical function in the process of knowing the world is not fortuitous and responds to an interesting dissertation, the core of Peirce's pragmatism ([1992] 2012, Volume II). An index implies a sign instance that leads to contact with the external world. The question arises from there: how does Peirce solve the problem of the relation between an External World (empirical-existent) and the Internal World (mind-thought)? According to the Harvard conferences (1903)<sup>9</sup>, the Anglo-Saxon semiologist has a pragmatic solution: “las reiteraciones en el mundo interno, si bien son intensificadas por el esfuerzo directo, producen hábitos, al igual que lo hacen las reiteraciones en el mundo externo; y esos hábitos tendrán el poder de influir en la conducta real en el mundo externo”<sup>10</sup> ([1992] 2012, Vol. II, 497).

The latter has a striking consequence in the recognition of the external world as a condition of knowledge. On the one hand, percean pragmatism accepts that the inner world (mind) acts indirectly in the external world (existent reality) through the interpretative habits of the community. As Latour would say, these habits are the ones that make up the production practices of knowledge, material culture, and the process of historicization of the object as something existent –even though, here, we defended the ideas of semiotic modeling of the

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<sup>8</sup> Two things must be narrowed down: a) it is clear that type models, of theoretical character, also suffer transformations by effects of changes in the theory itself, not by the direct interaction with any experience of which they predicate any possibility; b) the direct or indirect observation of phenomena in the experience is determined by instruments, observation methods, material culture, etc. Along with Latour (2000 and 1999), we accept that the observable is the result of a network of knowledge production.

<sup>9</sup> During the second stage of his work, in the beginnings of the XXth century, Ch. S. Peirce re-estimated some points of his semiotic theory trying to overcome the problems of idealism and psychologism inherited from the Kantian traditions. One of the fundamental points is in the relocation of the index in the construction of knowledge.

<sup>10</sup> In this article the reference was cited in the consulted language. The translation of the quote was carried out by the translator of this text. The translated quote is as follows: "Reiterations in the inner world, -fancied reiterations-, if well-intensified by direct effort, produce habits, just as do reiterations in the outer world; and these habits will have power to influence actual behavior in the outer world".

object. But, on the other hand, the external world (independent from the mind-thought-knowledge) acts directly on the internal world. That is the point: the index is one of the instances through which the internal is in contact with the external.

Thus, the index implies a collision with the external (alterity), like a force characterized by resisting in the face of habits and beliefs. But, if habits as beliefs imply consensus in the community that lines the way of necessary and universal knowledge, this could seem contrary to the particular character of experience that index supposes as "first impression" of the individual. Here underlies one of the main problems that harassed modern science under the pretense of objective knowledge of the world.

Nonetheless, pragmatism seems to suggest a transcendental path as a viable solution: considering the peculiarity of the index under the horizon of the regulative ideal consensus. For that, we must consider the pertinence of a "meta-index" that constitutes the synthesis of collective impressions of the external world that the community experiences throughout its historical evolution. To state it rigorously, the idea of a meta-index as a condition of possibility (not a necessity) of knowledge as intersubjective consensus is proposed from there. This postulate may seem risky, but maybe we should consider the modes in which society has collectively thought about notions as pain, illness, health, etc. In the basis of rational consensus (as a medical theory, for example) seems to exist an agreement on emotions and impressions of the world, a sort of non-rational consensus that determines a collective perception in the construction of an *imago mundi*: certainly, as the initial construction of a cosmography of the world.

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