Diálogos 111, 2022, pp. 271-302.

MAKING A WORLD

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Resumen: En contra de lo que los realistas creen, el mundo, tanto en el que vivimos nuestras vidas cotidianas como el mundo de la ciencia, no está dado de antemano, o es algo que esté completamente constituido como estando ahí afuera. Más bien es, como creen los idealistas que son fenomenólogos trascendentales, un elaborado constructo intencional.

El mundo de la ciencia física moderna matematizada en particular está constituido a partir de datos sensoriales crudos lo que sugiere la existencia de una realidad trascendente; sin embargo, esto no puede ser tomado como una revelación completa de ella sino es mediante una serie de actos intencionales subconscientes y conscientes, que por la producción de percepciones objetivamente válidas a partir de sensaciones subjetivas entregan, al final, una diversidad matemáticamente idealizada que representa ciertos aspectos formales-abstractos de la realidad perceptual, de tal forma que la matemática puede participar en la ciencia empírica como una herramienta metodológica.

En este artículo, yo repaso los momentos de este proceso, haciendo énfasis en sus múltiples presuposiciones trascendentales (que son el a priori trascendental del mundo) y argumento que sólo una perspectiva idealista tal puede hacer inteligible las muchas aplicaciones de la matemática en la ciencia empírica que lo realistas tienden a considerar como

completamente incomprensibles, "como un regalo que nosotros no comprendemos o merecemos".[1]

Palabras clave: Husserl, idealismo trascendental, fenomenología, constitución transcendental, realismo científico, ciencia empírica

Abstract: Contrary to what realists believe, the world, either that in which we live our daily lives or the world of science, is not a given, something already fully constituted standing out there. It is instead, as phenomenological transcendental idealists believe, an elaborate intentional construct.

The world of the modern mathematized physical science in particular is constituted from raw sensorial data that suggest the existence of a transcendent reality, but that can hardly be taken as a complete disclosure of it, by a series of subconscious and fully conscious intentional acts that, from the production of objectively valid perceptions out of subjective sensations deliver, at the end, a mathematically idealized manifold representing certain formal-abstract aspects of perceptual reality so that mathematics can participate in empirical science as a methodological tool.

In this paper, I go through the moments of this process, highlighting its many transcendental presuppositions (which are the transcendental a priori of the world) and argue that only such an idealist perspective can make sense of the many uses of mathematics in empirical science that the realists tend to see as utterly incomprehensible, a "gift we do not understand or deserve".[1]

Keywords: Husserl, transcendental idealism, phenomenology, scientific realism, intentional constitution, empirical science

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[1] The quote comes from Wigner 1960.

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Scientific realism is realism with respect to science, its domain, truths and theories. It is generally accepted that it comes in three varieties: *metaphysical realism*, for which the world object of the sciences enjoys mind-independent existence; *semantic realism*, for which scientific assertions have definite truth-values – they are in themselves either true or false independently of any verification –; and *epistemic realism*, for which scientific theories do indeed provide objective knowledge about the world.

Realists tend to take these three beliefs as a package, with metaphysical realism at the basis as the more fundamental tenet on which the others depend. It is *because* the world of science enjoys mind-independent existence that scientific assertions have definite truth values independently of any verification and scientific theories are able to provide *objective* knowledge of this world. Any assertion that expresses a *possible* situation in the word or, equivalently, any *meaningful* assertion, is supposedly either true or false, tertium non datur, *because* any possible situation in the world is determinately either a fact or not a fact. There are *no* indeterminate situations in the world *for* this is how mind-independent worlds are *supposed* to be. They are, as I call them, *ontologically* or *objectively complete*, contrary to mind dependent worlds, where certain situations may have been left indeterminate; a mind-dependent world is a world maybe still "in construction". Analogously, scientific theories supposedly provide objective knowledge *because* their truths express *facts* of a mind-independent world, a world out there, an objectively existing world that is supposed to be just like these theories say it is, if they are true.

There are many questions one can raise concerning these apparent truisms. For example, how do we *know* that the world of science is a mind-independent world and, more fundamentally, what does "mind-independent existence" mean? If the world were a coherent and stable collective hallucination, we would not be able to tell; a collectively hallucinated world could very well appear to us as a self-subsistent, mind-independent world; we cannot be sure and must take the mind-independence of the world *on faith*. Metaphysical realism is, therefore, a *metaphysical presupposition*, an eminently rational presupposition, but not in any acceptable way an established *fact*.

However, reasonable as it is to suppose that there is a world out there, a *transcendent*, completely man-independent world which we are "connected" to through our (very limited) sensorial and perceptual systems, this "connection" is not as faithful as I believe metaphysical realists ordinarily suppose, one capable of providing a mirror-image of, or better still, a *direct* access to transcendent reality *as it is*. For besides being very limited and very selective, our sensorial and perceptual systems are also very creative. It is then also reasonable to suppose that the world of science is *not* the transcendent world *itself*, but, as we will see, an intentional elaboration of the sensorial world, the transcendent world *as we perceive and conceive it*. Because, first, sensing the world is not yet perceiving it; perceiving requires *organization* of and the *bestowing* of *meaning* to sensorial stimuli, which necessarily involve *actively*, although maybe not consciously, the perceiving subject. And, secondly, because the world of empirical science, in particular the world of the *mathematized* empirical science, has features that are not directly accessible to perception and must be *intentionally presupposed* by theoretically motivated subjects – for example, that the

world is subjected to strict mathematically expressible legality, among many others.

The world of science is an *intentional construct*. If not, if it were simply *given*, certain things would be inexplicable. For example, how is it possible that the mathematics employed in science, that under the metaphysical realist presupposition mentioned above is a useful instrument of theoretical investigation *because* it is already built into the structure of the world independently of human action, is generally created or "discovered" by mathematicians who are not at all concerned with the world? How is it possible that *man-made* mathematics, which happens to be essential in science, where it plays many roles, as a language and as a calculus, as a conceptual schema with which to represent, to calculate, to think and to invent, is already built into *man-independent* empirical reality? How did it get there, or worse, how did it appear to inventing mathematicians worried with questions that had nothing to do with the empirical world, by divine Providence or established harmony? Some philosophers who have faced the question tend to believe that the phenomenon is either inexplicable, a miracle, or a sign of the centrality of man in the natural order of things.[2] I think instead that the "unreasonable" effectiveness of mathematics in science can only be explained by the fact that the world of science is *not* a given, but an elaborate intentional production expressly constituted so mathematics can be used as a *methodological* tool. Contrary to realist belief, the world *of science*, albeit mind-independent, is not subject-independent.

Realists are very strict about their notion of existence; for them, a thing exists either out of the mind, mind-independently that is, or in the mind. Otherwise, it does not

[2] See Wigner 1960.

exist at all. It escapes them that things can exist *objectively* without being independent of human actions, that a world has many layers, some of which may be contributions of human ways of perceiving and conceiving, sensing and thinking. It escapes them that a world can exist out there *objectively*, the same for all, but still bearing the marks of human *intentional* action, the action of men consciously involved in making human sense of brute sensorial impressions, a world *produced* from human perceptions but containing *more* than what perception can offer, constituted so that a science of the world, eventually a *mathematized* science of the world be possible, a world *out there*, objectively available to *all*, not in any way confined to individual minds, a world that is *consciousness*-dependent, but *not* mind-dependent. About that Husserl says (my translation):[3]

> All their questions [*questions of natural sciences, my note*] refer in fact to a world that, before any science, is already *given* to us in life as an evidence, without noticing that this pre-giveness contains a truly infinity of enigmatic problems, which cannot in any way be seen in gaze's natural orientation. These are the *transcendental problems*, whose discovery was only made possible by a truly scientific philosophy.

Realists take the world, both the world of everyday life and the world of science – which, needless to say, are very different – as *given*, without realizing, as Husserl observes, how *problematic* this pre-giveness is. A truly *scientific* philosophy of science must then face the problem of the constitution of the world, if it does not want to get involved

[3] Husserliana (Hua) XXXII, p.7 (*Nature et Sprit*, p. 35).

with pseudo-problems and "mysteries" that it cannot adequately handle and much less solve.

The perspective that the world of science is an intentional construct, *not* mind-dependent, but certainly conscious-dependent, where by "consciousness" one understands *communal* consciousness, the locus from where meaning flows, which does not reside in the mind, but in the communal space of human perception and thought, is a variant of *transcendental idealism* characteristic of *transcendental phenomenology* and stands in frontal opposition to metaphysical realism.

This variant of transcendental idealism, however, does not have problems with either semantic or epistemic realism. In fact, transcendental idealism clarifies not only the sense of objectivity to which realism naively appeals, but also that of truth-in-itself. Since the *ontological completeness* of the world – be it the everyday world or the world of science – is part of the *intentional meaning* of the world, bestowed on it by intentional action, *not* simply given in perception, any *meaningful* assertion about the word, that is, any assertion with *formal* and *material* meaning, in conformity, respectively, with the grammatical rules regulating the meaningful combination of syntactic categories and the material rules regulating the meaningful combination of semantic categories, has *in itself* a definite truth-value.[4] And since the world of science is a fully objective reality, acceptable scientific theories do indeed provide objective knowledge, knowledge that stands the rigors of logical

[4] This implies that science operates within a horizon of truths still to be discovered. In the words of Husserl: "It is within a horizon of truths 'to be expected' that all investigators work". Id. Ibid., p. 56 (p. 82).

scrutiny and empirical testing and is, therefore, accepted as expressing facts of the world.

But one must be perfectly clear about all this. Although the constitution of the world of science predates and is a precondition for science, it is *not* immune to revisions. Perception is both an initial and contour condition for intentional constitution, which must be, and remain, coherent with it. And when a new image of the world is required by the evolution of science and new available empirical data, science will abandon old conceptions of the world even if it is not clear at all what to put in its place. The development of quantum mechanics as imposed by observed empirical facts, for example, has put unbearable pressure on the "classical" view of the world, the continuity, locality, determinateness and causality of phenomena presupposed by the traditional image of empirical reality, but scientists and philosophers still argue, to this day, which world is this that quantum mechanics describes. Even the ontological completeness of the world is under suspicion: it may be the case that not all meaningful assertions describe *possible* situations. In quantum mechanics, the world became fuzzy and indeterminate in itself.[5] Even though, other intentional presuppositions resist; for example, the intrinsic legality of the world and the mathematical expressibility of its laws. Even the world of "classical" mechanics has not been immune to revisions; in order to fulfill its primary goal, which is to account for our experience of the world, "classical" science was constrained to change its picture of the world. Absolute space and time, for instance, which remained forever equal

[5] Husserl seems to be referring to quantum mechanics when he says that: "This means that no one, despite all these discoveries, really knows what nature truly is, in what consists precisely the sense of these discoveries, this sense that they establish as the complete truth about nature." Id. Ibid. p. 10 (p. 38).

to themselves in the old view, had to give place to relative space and time, whose determinations depend on the relative state of motion between observer and of the phenomena observed.[6] Theorizing and world-making are dialectically related, but perception, by delimiting the boundaries to which the dialectical process is confined, holds the power of vetoing.

Another intentional presupposition of science has to do with the infinity of the world as a domain of investigation, for although possibly finite in space and time the empirical world is forever open and infinitely renewable as a field of experiences. In the words of Husserl:[7]

> An infinity can only be given to the knowing subject as an indefinitely open horizon around the nucleus formed by the immediately given, and if this is a knowable infinity, it must be a horizon of unknown elements, but nonetheless accessible in the interior of an omni-containing totality.

That is, the *possibility* of a science of an infinite domain presupposes this is an *open* horizon domain of unknown elements extending beyond the immediately given which, nonetheless, if it is a knowable domain, is *in principle epistemically accessible* from within. In other words, the domain, albeit infinite, is not, in principle, beyond reach to the knowing subject departing from the *immediately* given. As Husserl noticed, this presupposition had already marked the turnabout of geometry in Greek hands, which, from a system of practical knowledge about *physical* space and geometrical constructions in *physical* space, became the

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[6] I mean, of course, the revisions imposed by Einstein's special theory of relativity of 1905.

[7] Id. Ibid. p. 32 (p. 60).

science of an *ideal* space conceived as "a rationally infinite totality of being systematically dominated by a rational science".[8]

This presupposition sets an *ideal* for science, namely, to disclose a hopefully *finite* set of fundamental or basic truths with which it is possible to *effectively* derive by purely logical, that is, purely rational means, the *totality* of truths of the domain. This is the ideal for which Euclid strived with his axiomatization of geometry, namely, to obtain a finite system of truths that contained *in itself* the totality of geometrical truths. By geometrizing empirical reality, as Husserl argued in *Crisis* (§ 9), Galileo imposed a similar change of meaning in the empirical world, no longer that which one can *perceive*, but an infinite geometrical domain *inaccessible to perception*, speaking the language of geometry and permeable only to mathematical rationality, submitted to laws and principles that could contain *in themselves* the totality of possible experience. Giving reality a new meaning was the revolutionary intentional action that made modern science possible and opened to it the immense arsenal of mathematical instruments of analysis, expression, calculation, and formal speculation.

The ideal of rationally mastering an infinite domain from within has a *logical* counterpart: ideally, a domain must be such that a system of fundamental truths exists so that *any* truth of the domain must be *logically derivable* from it. Husserl called such a domain a *definite manifold*, i.e., a manifold dominated by a *complete* system of basic truths or, in other words, a *definite system* or *definite theory*.[9]

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[8] Husserl 1970 § 8.

[9] See "The Imaginary in Mathematics", *Hua XII*, pp. 430-451. Incidentally, such a system of basic, axiomatic truths exists for Euclidean geometry, but not for arithmetic and most mathematical and

For Husserl, a domain is not yet a *world* if it is not supposed to be in principle capable of being completely mastered by a science and if it does not satisfy the following two requirements:

1) It must constitute a totality of elements that have to do with one another, so that, 2) "an ordered progression of knowledge can be prefigurated thanks to which *all truths* concerning these objects can *ideally* be thought as holding and being accessible in a systematic progression [...]." (Hua XXXII, p. 58, *Nature et Esprit*, p. 84. My emphasis). A world, that is, is a domain that is simultaneously an ontological and an epistemological *unity*.

> Therefore, concerning the possibility of knowledge, it is *a priori* contained in the idea of an ontological domain the free possibility of accessibility of the infinite totality that the concept of the domain poses priorly as being and as object of knowledge. (Hua XXXII, p. 59. *Nature et Esprit*, p. 86)

The constitution of a world also requires, so Husserl thinks, a presupposition concerning the *identity* of the world in the changing *flux* of the *experience* of the world. In his words:[10]

> We see a thing and say that it now presents itself in perception; it has not just come into being. Then we go away and come back and have a new experience and say that it is the same thing, that it is still there, only unperceived in the meantime [...].

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axiomatized physical theories. My view that Husserl's concept of definiteness is equivalent of that of syntactic completeness is endorsed, among others, by Hermann Weyl (see Weyl 2009, p. 18).

[10] Hua XXXII, p. 61 (Nature *et Esprit*, p. 87).

Even movement and transformation presuppose *something* that is in movement and can reappear as *the same* in another time and place or transforms *itself* into something else, either partially or completely. The idea of transformation only makes sense in dialectical opposition to the idea of identity. If nothing is identical to itself, nothing can change.[11]

Presuppositions concerning space-temporality also figures preeminently in the intentional constitution of an empirical world submitted to a rational science. According to Husserl:[12]

> If, in a way or another, an individual world in itself must have a sense it must necessarily have a space-temporal arrangement, but also a space-temporal measure in this arrangement [...]
>
> An infinite individual totality, such as for instance a world, must be submitted to a unitary causal legality related to space-temporality".

Or still:[13]

> [*T*]*he most general and formal representation of a scientific domain* as a totality of objects in themselves knowable in the unity of a science harbors *presuppositions of meaning that can be unveiled* and from which one can discover formal conditions of

[11] One must, however, distinguish this from *essentialism*. The object maintains its identity in change *by being identified as the same* in *intentional acts of identification*. It does *not* hold its identity in virtue of some immutable essence, but by being *seen* as an indeterminate "something" perduring through changes, an "indeterminate X" capable of receiving ever new determinations. The "indeterminate X" is not a thing, a substance, but the objective correlate of an act of identification.

[12] Id. Ibid. p. 62 (p. 89).

[13] Id. Ibid. pp. 65-66 (pp. 91-92)

> great generality that such a totality must necessarily satisfy *a priori*. In a surprising manner we arrive then at a constructible "*space-time*" *form* as well as at a *universal causal legality*: it is thus the universal formal structure of our factual world that appears in great generality in this deduction as a '*transcendental* a priori'.

Husserl defines "constructible" thus:[14]

> [A] constructible manifold is one where "we can produce infinitely many multiplicities by systematic construction and thus give them the character of being-in-itself, precisely as formations that we can – and anyone can – produce again with evidence and knowledge of their identity in thought".

In other words, space-time, as the formal frame of the world of science, is supposed to be, according to Husserl, a *constructible* manifold in a sense analogous, I assume, to that attributed to physical space in the *geometrization* of reality carried out by Galileo, a space where *geometrical* constructions are possible whose products, however, stand as self-identical beings in themselves resurfacing *as the same* each time those constructions are set in motion anew. As I understand the notion, for Husserl, a "constructible" form is one in which the totality can somehow be "constructively" reduced to a manageable basis, a property one must presuppose of space-temporality if its infinity is to be epistemically manageable. I believe all this boils down to presupposing the *mathematical* manageability of the *formal* structure of the world, in which case Husserl is right, this is indeed a fundamental presupposition of modern empirical science. Moreover, with respect to its temporal aspects, as

[14] Id. Ibid. p. 65 (p. 91).

Husserl correctly notices, the world of science is presupposed to be submitted to strict *causality* – such that the future can be inferred from the past, and vice-versa – manifesting itself in *mathematical* correlations parametrized in time.

As Husserl shows, the world of science harbors many *transcendental presuppositions* without which science as we know it would be impossible. This world is definitely not a given and if it appears to the inquiring scientist as a mathematically structured manifold satisfying ontological completeness, self-identity, formal constructability, intrinsic legality, causal connectivity, epistemic accessibility, all the above-mentioned presuppositions, a sequence of *intentional acts* must be carried out that produces such a world from the raw material offered by the senses. As Husserl says, "between experience and physics intervenes idealization". (Hua XXXII, p. 73-4, *Nature et Esprit*, p. 100).

Idealization, however, is not the only or even the first stage in world making; the world object of the empirical sciences, which realists wrongly take as simply given, has many layers of constitution, idealization usually being the final. Let us examine this constitutive process from up closer.

a) *From sensations to perceptions*: Sensations and their content, sense data (*hyle* in Husserl´s jargon) are the *primordial matter* with which the empirical world is made. But for a world that science can fruitfully investigate to come out of sensations many layers of constitution are required, some intentional, involving consciousness and conscious acts, others infra-intentional, occurring at subconscious levels of subjective action. The latter are typically those responsible for organizing sensorial data into *perceptions* and giving sensation a *perceptual meaning*.

In their pure materiality, sensations are formless; they are not yet articulated in a world, much less an objective world. In their immediateness, sensations are accidents of the body that can only be read as signs of a world external to and independent of the body if *interpreted* as such, i.e., if processed as *perceptions*. Perceptions point towards something *outside* the perceiver´s body *causally* responsible for its sensations.

Our first task as world-makers is to sort out sensations that can be attributed solely to the body, bodily spasms so to speak, misfires of the sensorial system such as sensorial hallucinations, phantom sensations and like things, from those that can be interpreted as signs of an outside world, i.e., as perceptions proper. This "interpretation" is not a conscious operation, but an unconscious or subconscious process of sense-making carried out by built-in *perceptual* systems in charge of transforming bodily sensations into proper perceptions whose task is to *present* a world.

The question then imposes itself: how *faithful* is such a presentation? Of course, there is always the possibility of *misperception*, the "perception" of things "out there" that are not in fact out there. But this is not the sort of unfaithfulness I have in mind. The question is more consequent: is *faithful* perception indeed a window to a transcendent world as it *really* is?

Faithful perception is normal perception, resilient, stable perception that we normally take as having a presentational value. It would not be completely reasonable to suppose that they are *systematically* misleading, creating for us the illusion of a world outside, a world that causes them, if there is no such a world or there is one, but essentially and fundamentally different from that which we perceive.

After all, the sensorial and perceptual systems are products of evolution, and it is reasonable to believe that the best strategy for evolution is to endow us with the capability of perceiving the world as the world really is.

But it is not unreasonable either to suppose that perception may not need to give us access to the world as it *really* is or to *all* its aspects in order for us to survive until we procreate, which is all evolution cares about. A somehow "simplified" but still effective perceptual presentation of reality may be more economic and then preferable from the point of view of survival and evolutionary success.

It may even be the case that to interpret sensations as perceptions in ways that do not always correspond faithfully to things *actually* in the world may better serve the purposes of finding food or mates and escape predators than would more faithful presentations. Useful "illusions" may sometimes be better than crude reality. If I systematically avoid things that look like snakes, be they real snakes or coiled ropes that I systematically mistake for snakes, I will certainly find it more difficult to wrap my packages, but I will certainly be more protected from snake bites than normally perceiving people, for there is no chance I will ever touch a snake thinking it was a coiled rope.

This is indeed the case, for example, of colors and smells. Reality does not know them; it only knows light in different frequencies and different sorts of chemical substances. But our perceptual systems respond to light falling on the eyes and substances under the nose with the *perception* of colors and smells – to which we, moreover, associate emotional values – that helps us to distinguish the edible from the poisonous. This may also be the case of space and time, which some believe to not have transcendent reality

(although they certainly have transcendental reality, at least at certain levels of experience).

Be as it may, it is not a self-evident truth that the world that perception creates for us is a 100% faithful presentation of a world out there, that it does not maybe fail to contain aspects that are irrelevant for our survival as individuals and as species, or that, contrarily, it does not contain aspects that the perceptual system *itself* produces. After all, built-in perceptual systems may not be completely passive, simply reflecting reality; they may very well be active systems operating in a way so as to optimize our response to sensorial stimuli.

A parallel can be made with our strategies of decision-making. Although the best strategy of decision making is to take into consideration *all* the relevant information concerning the issue at hand, complete information is often not available, and it would anyway take too much time to take into consideration all that should be taken into consideration before an informed decision is made. We then, pressed by insufficient knowledge and time, usually decide on the basis of generalizations based on insufficient information. Our prejudices, for this is the name such generalizations deserve, may not be factually true, but they can help us to decide quickly with a probability of acting correctly that compensates in the long run the wrong decisions such generalizations inevitably induce sometimes.

It is possible that efficiency in responding to worldly stimuli led evolution to choose not the perfectly reflective perception system, the one that provides the most faithful possible presentation of reality, but one that somehow selects, simplifies and organizes sensorial data in order to produce the most *efficient* interface between transcendent

reality and the subject *so as to maximize his chances of survival*.

After all, *evolution selected us to survive, not to understand*.

This is not, in fact, a matter of philosophical debate, but a truly scientific issue, and science, in particular, cognitive science, has amassed enough evidence for the belief that our perceptual systems are *active* in *producing* a reality, not simply passively presenting the one that is out there, that it contains a fair amount of contribution of the perceptual systems themselves. In short, *perceptual reality is a joint contribution of transcendent reality and perceptual systems*.[15]

So, *subjective* perceptual reality, the first level in the constitution of physical reality is already "contaminated" by the subject, it already bears the human stain.

b) *From subjective to objective perceptual reality*. Man confronts the transcendent world primarily with his body, his senses and the psycho-physical systems of sense-making nature endowed him with. These systems operate at a subconscious level, organizing and "interpreting" sense data *as manifestations* of an outside world. The encounter of the ego with the transcendent world (whose existence, let us keep it in mind, is a *metaphysical presupposition*) produces a *subjective* perceptual reality, the world "out there" from the perspective of this particular individual, a world whose center [*s*]*he* is. The subjective perceptual world is a system of objects endowed with properties and in complex systems of relations with one another. Among them, spatial and temporal relations and relations of magnitude. Things appear to the subject as close to or far from him, to his right

[15] See, for example, Hoffman 2019.

or to his left, above or below him, contiguous or separated from one another; events of the world happen simultaneously or one before or after the other; objects of the world appear equal, bigger or smaller when compared with one another, they have distinct forms, and so on.

To what extent these relations are out there in transcendent reality or are contributions of the perceptual system itself to perceptual reality remains an open question. However, be as it may, it is clear that the most basic presentation of the world, subjective perceptual reality, is already spatially-temporally and quantitatively structured. Two things however are worth emphasizing: 1) these structures may not be *transcendently real*, even though they are certainly *perceptually real*, and 2) regardless of whether they are real or not, the fact remains that they are not yet *mathematical*. Mathematical reality is the product of higher order intentional actions that take subjective perceptual reality as a given but go much further.

The next *necessary* step is the constitution of *objectivity*, the production of an *objective* perceptual reality out of a subjective one, or rather, out of many different self-centered subjective worlds. But, attention, objective does *not* mean here transcendent or subject-independent, but simply that which is *valid for all* and must then, necessarily, be constituted in *intersubjectivity*. An objective perceptual reality is then a reality which *any* normally constituted perceiver can *in principle* perceive. As Hermann Weyl observed, *only the subjective world is absolute, objective reality is by necessity relative*, for an objective world to be constituted, the other must be taken into account.[16] The

[16] "The immediate experience is *subjective* and *absolute* [...] Whoever desires the absolute must take the subjectivity and egocentricity into the

existence of a world that is common to all normally constituted subjects is a precondition of, first, *practical* communal life and then theoretical life. There is no science in the exclusively individual experience as there is no solid basis for communal life in the absolute indubitability and unchallenged validity of subjective experience.

Objective perceptual reality is a field where subjective experiences coherently coalesce, and perceptual conflicts are resolved. The subject-relative that is not objectively validated must then, deprived of objective value, recede into the private realm. Our communal *objective* reality is made of *objective correlates* of valid perceptions, i.e., *objects*, *systems of objects* in relations, and *phenomena* in *objective* time and space, all supposedly endowed with intrinsic properties and capable of eliciting valid perceptual experiences.[17] Perceiving is now *interpreted* as the *manifestation* of an objective reality that exists out there available in principle to all normally constituted individuals.

If I see a red spot here now, in order for this perceptual experience to have objective validity it must be confronted with other experiences, although obviously not as a purely subjective occurrence against other purely subjective occurrences, but as something objectively available to other subjects. To have a claim to objectivity, my subjective perceptions must point to a world outside me. In order to *interpret* my seeing of a red spot here now as an objective

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bargain; whoever feels drawn towards the objective faces the problem of relativity". Weyl 2009, p. 116.

[17] The subjective experiences of time and space (the experience of space being essentially that of certain types of relations among coexisting objects of perception), in order to be objectively validated, must also be objectivated through the choice of standard clocks and meters, subjected themselves to many presuppositions, such as the uniformity of beat for clocks and rigidity under spatial displacement for meters.

occurrence, I must first locate it in objective space and time. I then say that a flash of red light occurred at a certain point in space – where I saw the red spot – at a certain time – when I saw it. My perceptual experience stands now as a *sign* or an *effect* (of the said light into my visual system) of something objectively available and objectively verifiable (the flash of red light). *This* can now be checked against other objectively valid perceptions and validated or not, depending on whether other perceptual experiences admit the same objective interpretation.

Only by pointing to an objective world of objects, properties, relations and phenomena located in space and time, and possibly changing in time, available in principle to all competent subjects, can my perceptual experiences be objectively checked. Ideally, *objective perceptual reality* is the totality of objective correlates of in principle all valid perceptual experiences of all competent perceivers, an obvious idealization that is never actually available. We must then cope with an "incomplete" actual perceptual reality, to which we append presuppositions of a transcendental nature that predetermine to a certain extent the perceptual reality that is always beyond the horizon of actual perception. Once constituted, objective reality stands as the efficient *cause* of our valid perceptions and, conversely, valid perceptions stand as signs of its presence out there. Thus, *objectivity is born in intersubjectivity as the we-world produced by the relativization of absolute I-worlds*.

Since they must *prove* their reliability, subjective perceptions are a priori put under *suspicion*. My or anyone else's perceptions *can* be misleading for they may be illusory and can only be validated by confronting them with other perceptions. But, more importantly, even *validated* perceptions are forever *sub judice* for new perceptions are

constantly coming into the game. The constitution of objective perceptual reality is then always *open* and a completely constituted objective world is only a regulating *idea*. *The constitution of the world is an infinite task*. Correlatively, the task of the science of a world founded on perception is also, necessarily, only concluded ideally in a forever receding future and its conclusions forever suspicious.

c) *From objective perceptual reality to empirical reality*. But an objectively and independently existing world, or a world so *conceived*, cannot be reduced to what can actually or effectively be perceived. There is a gap between *perceived* reality and empirical reality, which albeit perceivable *as a matter of principle* is not necessarily perceivable *as a matter of fact*, that must be closed. *Intentional action* is again the bridge-builder. We, acting as *transcendental subjects*, must establish, totally *a priori*, what perception can *in principle* provide (every "in principle" betrays intentional action). And we do so by means of *transcendental presuppositions*, which are *not* merely hypothesizing, for hypotheses can be falsified, whereas the presuppositions we are alluding to cannot, since they play a transcendental role in the constitution of our conception of empirical reality (constitutive presuppositions can be canceled, but only when the constitutive process they are part of are also canceled; a world that does not comply with the presuppositions that go into the intentional constitution of empirical reality is not empirical reality until we change our conception of empirical reality in accordance with new presuppositions).

So, we presuppose that the empirical world exists in itself, that it is not a mere correlate of perception (*esse*, at least as the empirical world is concerned, is not conceived as *percipi*); things and facts can exist "out there" that are not

perceived or even effectively perceivable (although nothing can exist in empirical reality that is in principle unperceivable). We also presuppose that empirical reality is identical to itself and presentable as the same in renewed acts of perception (although, possibly, in different states of itself) and consistent with itself, so that valid perceptions cannot ever contradict one another. Empirical reality is also conceived as ontologically (or objectively) complete, so that any possible situation in it is decidedly either a fact or not a fact, in which case the complementary situation is a fact (a situation being *possible in principle* if formally and materially meaningful).

These presuppositions are constitutive of the conception of reality of the "common man" as well as the "learned man", the empirical scientist. They are, moreover, the presuppositions on which our thinking and reasoning about reality are based. Incidentally, the presuppositions of self-identity, consistency and ontological completeness of the world *justify* the basic principles of world-logic, respectively, identity, non-contradiction and tertium non datur. It is worth emphasizing the presupposition that empirical reality is *in principle* accessible to perception, that no aspect of it is a priori out of reach of perceptual experience, directly or indirectly, with the bare senses or through sense-enhancing instruments, even if we do not know how to put ourselves in a position to actually experience it (except, of course, those aspects of the world that involve it as a whole and must be transcendentally presupposed) and that it is up to us to find ways of experiencing reality properly. This presupposition has a theoretical or epistemological equivalent, the principle of epistemic optimism so clearly voiced by Hilbert on which the project of science depends: we must know, we will know.

But, although presenting spatial and quantitative aspects, reality is not, yet, a mathematical manifold. Spatial objects have shapes and forms, and magnitudes such as distances and time lapses are quantitatively comparable, but the spatial and quantitative forms of the world are not yet properly mathematical, they do not have the ideality and exactness characteristic of mathematical forms. However, as it might be expected, the proto-mathematical forms of the world elicit practices in the world – counting, measuring, weighting, gauging – that in due time, when theoretical interest imposes itself, will give origin to mathematics proper. Geometry and arithmetic were the first mathematical sciences to appear, concerned respectively with spatial and numerical forms and their mutual relations considered in abstracto and ideally.

Since it was born out of practices of the lifeworld, mathematics was naturally required as an instrument for science as soon as empirical reality became an object of scientific interest. Quantity is one of the categories under which the world is perceived and any empirical science that takes the quantitative aspects of reality under consideration will naturally invite a mathematical treatment. The first such science was probably astronomy, in which measurements of time lapses and the relative position of physical bodies in space, planets, stars and the like, are essential. Measurements, of course, are expressed as numbers, and the science of astronomy amounts to nothing more than finding interesting or useful relations among these numbers. But not until Galileo said it explicitly, no one dared to see perceived relations among numbers representing quantitative aspects of reality as mere *approximations* to *proper* mathematical relations lying at the core of reality and inaccessible to perception. For this, further intentional elaboration was required.

d) *From empirical to mathematized empirical reality*. Valid perceptions are the only *adequate* means of access to perceptual reality, and will remain so forever, but *not* to the *mathematical* reality that modern science (science since the time of Galileo) has substituted it by. The intentional constitution of the reality object of mathematized empirical science has degraded perception as a means of access to reality. My perception of a red spot here now, a perfectly valid piece of information about the world if objectively validated, can only count as information about *mathematized* empirical reality if related causally to an objectively real flash of light at a certain objectively singularized point in space (here) at a certain objectively singularized point in time (now) in principle accessible to other individuals whose frequency can in principle be objectively verified (by in principle any individual) as being in the red band. The color perception has now been completely reduced to a mathematical, quantitatively measurable electromagnetic disturbance of which the perception is a *necessarily imperfect* manifestation. What is really real now is the electromagnetic phenomenon, whose intrinsic nature is purely mathematical; perception is only an epiphenomenon.

Before being objectively validated, subjective perception is under suspicion as a means of accessing empirical reality for it may, at times, be deceptive or illusory. But even objectively valid perception, a reliable means of access to empirical reality, loses its power when we move to mathematized reality. It is, although still relevant, necessarily inadequate, for mathematical reality is, *by constitution*, inaccessible to adequate perception.

The mathematization of empirical reality goes back to the aurore of modern science, to Galileo, Descartes, Kepler,

Newton, and was *motivated* by the convenience of mathematics as a language for expressing those aspects of perceptions that naturally invite mathematical expression, the quantitative and the space-temporal. Instead of merely to an objective world of *physical* objects, events and processes, perceptions point now, albeit imperfectly, to a perfect world of mathematical forms, relations and equations.

As just said, two aspects of perception stand out as particularly prone to mathematical "translation", the quantitative and the space-temporal. Magnitudes in the world appear to us in perception as affected by quantity and capable of quantitative variation. It was then natural to express quantities and quantitative relations of perceptual experience in terms of numbers and numerical relations, since these entities were originally created precisely for this end. Bodies in space and movement in space and time, *once abstracted of their material elements and mathematically idealized*, can be seen as geometrical forms is space (points, lines, surfaces, bodies) and chrono-geometrical forms in space-time (trajectories, velocities, accelerations).

Giving the empirical world a mathematical expression obviously requires certain adjustments in it. After all, quantities and quantitative relations of *experience* are not exact and precise whereas numbers and numerical relations are, and if the latter are to represent the former, this must be taken with a grain of salt: this is not and cannot be a faithful representation. The arithmetization of the quantitative aspects of experience serves a *methodological* purpose, namely, to approximate real relations of quantity by ideal arithmetical relations so as to use arithmetic as a means of disclosing quantitative relations not so easily accessible perceptually. The standard example is the use of arithmetic algorithms for counting instead of actually counting.

But now an important reversal takes place, instead of simply accepting the mathematical "translation" as an overkill, we take experience itself as an underachiever. We *presuppose* that *only* mathematics has the power to reach into the hidden core of reality where perceptual experience cannot go, not even in principle. Thus, the idealized mathematical representation of perception, wrong by efficiency (excessive exactitude), is subtly reinterpreted as the exact counterpart of inexact perception, which is wrong by deficiency (lack of exactitude).

As Husserl observed (*Crisis*, §9) this is even more radical than original Platonism, for it is no longer simply a matter of participation (méthexis) of the real in the ideal, but the positing of the real world *itself* as ideal. This is not Platonism, but the ascension of empirical reality *itself* to Platonic heaven. Such is the *mathematical* idealization characteristic of the constitution of empirical reality as the object of the modern mathematical sciences of nature.

That the objects of the world appear to us perceptually in space and time and related to each other in spatial and temporal relations is a fact. Whether space-temporality is an attribute of the transcendent world or only of the empirical world, the world of perceptual experience, is irrelevant and probably unanswerable; whether the objects, properties and relations of perception are transcendentally real or simply an efficient way of organizing our sensorial impressions, and then a sort of image, is also irrelevant and possibly unanswerable, the brute fact is that the perceptual world is *our* world, the world in which we live our practical lives and the only one we are scientifically concerned with. The rest is metaphysics.

Bodies appear to us in perception as near or far, close, contiguous or separated, still or in movement, faster or

slower; based on our perceptual *experiences* with rigid bodies (of which the standards of measurement of distances are particularly important instances) and their displacements in space we develop, first, a *technology* for dealing with spatial relations, relations of relative position as well as quantitative relations, and later a *theoretical science* of these relations, geometry. Geometry had already been used with great success in astronomy when Galileo extended it to encompass space-temporal relations between bodies in general, thus inventing kinematics. But, also, instead of simply seen geometry and kinematics merely as contexts of *idealization* of perceptual spatial and space-temporal relations, as useful falsifications, so to speak, Galileo took geometry and kinematics as describing reality as reality *really* is at its hidden core and perception as a necessarily imperfect, but ever perfectible, approximation to reality. Thus, space and time, together with quantity, were idealized and mathematics made into the adequate context for expressing certain formal aspects of reality.

Conclusions

There is, admittedly, a problem in the effectiveness of mathematics in science, which Wigner famously qualified as "unreasonable".[18] Not only because we can use mathematics to express facts of empirical reality capable of mathematical representation (such as, more conspicuously, quantitative, spatial and space-temporal relations), to predict the outcome of future experiences, to invent empirical concepts, but also, somewhat surprisingly, to discover, for we can also use mathematics as an instrument to discern possible *formal* properties of reality before they materialize phenomenally,

[18] Wigner 1960.

i.e. we can use mathematics as a heuristic instrument of *formal* exploration of reality.

Realism explains and justifies some of these uses as direct consequences of the supposed fact that empirical reality is, at its core, mathematical. After all, as Galileo has also famously said, the book of Nature is written in mathematical characters and no one ignorant of this language can read it. So, there is a priori no mystery in the fact that mathematics is so effective in empirical science as a language to express facts of the world, a calculus to compute and infer consequences of known mathematical facts with empirical content, and a conceptual system to invent new empirical concepts with or without empirical content (these are the theoretical terms, which in general play only an auxiliary role in the mathematical schema, but that can in principle also denote real entities of the world).

But things are not as simple as they appear. If mathematics lying at the heart of reality – without, supposedly, having been put there by human action – is identical or similar to that which appears in the most *adequate* scientific theories of reality, as it is to be expected, if successful scientific theories *reveal* and *bring to light* the mathematics hidden at the core of nature, how to explain the *fact* that most of mathematics used in science was *not* discovered in the investigation of nature, but completely independently of science by mathematicians usually preoccupied with other problems? How to explain that *man-made* mathematics lies hidden at the core of *man-independent* nature? Ruling out pre-established harmony and divine Grace, I cannot see an explanation.

More embarrassing for realists is the heuristic role of mathematics in empirical science. How can the mere manipulation of mathematical symbols, *often symbols*

without material meaning, i.e., *without a representational value in empirical reality*, can help us discover *new* facts about nature? Is nature somehow *predisposed* towards human intellectual efforts?

These disturbing questions can, however, be answered and the mysteries disappear as soon as we abandon the realist tenet that nature is a *given* that is *in itself* already mathematically structured at its most fundamental level, accessible only to mathematical reason and which perception can only vaguely discern, if at all.

Empirical reality, so claims phenomenological transcendental idealism, is an *intentional construct* brought about in many steps. Even at a pre-conscious level, that of perception, man is already actively, even if not consciously, at work constituting a world out of his sensations. The resulting perceptual world, be it that of a single ego or that of the collective ego, is, therefore, already stamped with human ways of perceiving, which explains its pre-mathematical traits. *Abstracting* from the empirical world (a further intentional elaboration of the objective perceptual world) its quantitative, spatial, space-temporal *forms* and associating to material contents mathematical forms that act as their scientific representatives (sense of heat to temperature, color to electromagnetic frequencies, etc.) in an *idealized* manner, an ideal mathematical world is obtained that is given to science as its object of study; *this* is the world of science. No longer simply given, the world is *expressly* constituted so mathematics can be used as a *methodological* tool.

The world of science, the highly mathematized modern physical science, is a *mathematical* manifold that *substitutes* for methodological reasons the empirical world. By being a mathematical manifold, reality can be mathematically

investigated as any other mathematical manifold, and as successfully. The heuristic effectiveness of mathematics in science, in particular, is no more mysterious than the effectiveness of mathematics in mathematics, which boils down to the fact that formal properties of a mathematical manifold can be investigated by investigating different mathematical manifolds that maintain with the original one relevant formal-mathematical connections.[19]

Besides offering a more elaborate, less naïve image of the world of science and how it comes to be, transcendental idealism seems in a much better position compared to metaphysical realism to explain and justify the effectiveness of mathematics in science.

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[19] For details, see da Silva 2017.

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