Helmholtz, Du Bois-Reymond, and the Transcendent Difficulty of Explaining the Relation Between Sensations and the Physical World

Andrea Togni

FINO Consortium, University of Turin

According to Hermann von Helmholtz, sensations are *signs* (*symbols*) that external causes impress on our sense organs; those signs are then used by the mind to acquire knowledge of the reality. Helmholtz's work points out the difficulty of defining a notion of *causality* suitable for explaining the relation between sensations on the one hand and the physical world on the other. In fact, he states that: 1) Physical stimuli, understood as the causal origins of sensations, are unknowable in themselves; 2) There is no empirical evidence for the kind of causality from which sensations originate; 3) A transcendental causality is nothing but the urge of the intellect to know everything. It is necessary to keep in mind that Helmholtz is a committed *empiricist*: therefore, he believes that *all* knowledge originates from sensations. He tries avoiding commitments with any kind of pre-established harmony between the two sides of the causal relation. That is to say, sensible perceptions give us information about the peculiarities of the external world, but the relation between sensations and the reality should be explained and should not be taken for granted. In this paper, I study Helmholtz's struggles with providing a suitable explanation of that relation; in doing so, I also make use of Emile Du Bois-Reymond's work concerning the limits of human understanding, and in particular the transcendent difficulty of grasping the origins of sensations.

Keywords: Helmholtz, Du Bois-Reymond, sensation and perception, empirical and transcendental causality, realism, empiricism

Corresponding author's address: Andrea Togni, FINO Consortium, via Balbi 30, Genova, 16126, Italy. Email: andrea.togni@edu.unito.it.

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1. Introduction

The aim of this paper is to analyze how Hermann von Helmholtz understands the relation between the physical world and sensations. As a committed empiricist, he maintains that sensations are *signs* (*symbols*) that external causes impress on perceivers' sense organs, that those signs are used by the *mind* to achieve knowledge of the world, and that *all* human knowledge starts from sensations. His work is devoted, among other things, to finding out suitable justification for the reliability of human knowledge, to explaining how human beings can make use of qualitative sensations in order to achieve knowledge of the physical world, and to finding out a satisfactory theory of the causal relations between the external reality and the perceptual one. Helmholtz plays an important role in the birth of physical physiology in the XIXth century. The next section of this article deals with Helmholtz's understanding of the law of specific nerve energies, which was developed by Johannes Müller, his supervisor and mentor. The law of specific nerve energies states that sensations' qualitative character emerge from nerves' responses to external stimuli. Starting from Müller's work, Helmholtz tackles the problem of the relation between qualitative sensations and physiological events. The empiricist tradition rejects the idea according to which sensations resemble the physical world, and tries investigating that relation in causal terms. However, this strategy is not as straightforward as it appears. Emile Du Bois-Reymond, Helmholtz's friend and collegue, points out not only that we do not know why and how physical and physiological events give raise to qualitative sensations, but also that we will *never* know why and how that happens. Du Bois-Reymond's thesis will be studied in the third section of this article. The fourth part deals with Helmholtz's attempts to overcome the inadequacies in our understanding of the relation between the mental and the physical. His doctrine of unconscious inferences, his so-called experimental intercationism, and, especially, his revision of the Humean and the Kantian notions of causality will take the center of the stage. I analyze those theories in order to show that Helmholtz is well aware of the difficulties intrinsic to his own solutions. As we will see, his main goal is to give reasons for believing that the relation between the physical world and the perceptual one is lawful. Without a satisfactory understanding of that relation, even the commonsense theses that a mind-independent world exists and that our knowledge of it is reliable get in trouble. Indeed, if all knowledge starts from sensations, it is not easy to see how human beings can *know* that the world exists when nobody is perceiving it. Moreover, if we do not properly understand *how* our sensations present the physical reality, someone could cast doubts on the reliability of our knowledge of the world.

2. Some troubles with the law of specific nerve energies

Given the centrality of the notion of sensation in Helmholtz's work, it is appropriate to provide his definition of the term. He states that

> our sensations are only effects which are produced by external agents upon our sense organs, and the way in which such effect is manifested, of course, depends essentially on the nature of the apparatus which is affected. As far as the quality of our perception gives us information about the characteristic nature of the external source of stimulation, it can be regarded as a symbol, but not as an image if this source. For an image some kind of identity with the portrayed object is demanded [...]. A symbol however does not have to possess any kind of similarity with the object which it represents. (Helmholtz 1878, 212)

As a committed empiricist, he claims that only one thing cannot be modified by experience: the qualitative response of sensory nerves to external stimulations (Helmholtz 1866, 182). Each sense organ responds in a peculiar manner when stimulated: the eyes perceive colours, the ears sounds, the nose odours, and so on. Sense organs' response is ruled by the law of specific nerve energies, which was established by Müller, and which is acknowledged as the starting point of contemporary physiology. Its main point is that we can be aware only of our nerves' responses and not of the world itself.[1] Ac-

[1] Given the importance of the law of specific nerve energy for our discussion, it is advantageous to report Müller's ten "axioms" almost in their entirety. The following version of the axioms is from Keeley (2009): 1. It must be kept in mind that external agencies can give rise to no kind of sensation which cannot also be produced by internal causes exciting changes in the condition of our nerves; 2. The same internal cause excites in the different senses different sensations—in each sense the sensations peculiar to it; 3. The same external cause also gives rise to different sensations in each sense, according to the special endowments of its nerve; 4. The peculiar sensations of each nerve of sense can be excited by several distinct causes internal and external; 5. Sensation consists in the sensorium receiving through the medium of the nerves, and as the result of the action of an external cause, a knowledge of certain qualities or conditions, not of external bodies, but of the nerves of the sense themselves; and these qualities of the nerves of sense are in all different, the nerve of each sense having its own peculiar quality or energy; 6. The nerve of each sense seems to be capable of one determinate kind of sensation only, and not of those proper to the other organs of sense [...]; 7. It is not known whether the essential cause of the peculiar "energy" of each nerve of sense is seated in the nerve itself, or in the parts of the brain and spinal cord with which it is connected; but it is certain that the central portions of the nerves included in the encephalon are susceptible of their peculiar sensations, independently of more peripheral portion of the nervous cords which form the means of communication with the external sense organ; 8. The immediate objects of the perception of our senses are merely the peculiar states induced in the nerves, and felt as sensations either by the nerves themselves or by the sensorium; but inasmuch as the nerves of the senses are material bodies, and therefore participate in the properties of matter generally occupying space, being susceptible of vibratory motion, and capable of being changed chemically as well as

cording to Müller, sensations are, one the one hand, nervous and physiological responses to physical stimuli; on the other hand, they have a qualitative character. Therefore, one of his main goals consists in individuating how the correspondence between external stimuli and qualitative sensations works. Helmholtz adds a further distinction to Müller's theory:

> Among the sensory perceptions there are two different distinguishable classes. The profoundest difference is the one between perceptions belonging to different senses, such as between blue, sweet, warm, and the pitch of tones. I have taken the liberty of calling this difference a difference in the *modality* of perception. [...] The second kind of difference, however, the less decisive one, is the one between different perception of the same sense. I reserve for it the designation of difference of *quality*. (Helmholtz 1878, 210)

Helmholtz expands Müller's law in order to let the differences between the operations of the various sensory modalities emerge. For example, human sight is defined by only three specific nerve energies, the ones associated with the three types of cones in the retina; by contrast, Helmholtz counts thirty-two hundred auditory energies, because of the particular structure of the cochlea and of the inner ear. While the eye "synthetizes" all colors starting from the three primary hues, the ear "analyzes" complex sound waves in conformity with Ohm's law.[2]

The main point of Helmholtz's philosophy of sensation is that the five sensory systems supply symbols of the external reality which can be used by the mind to represent the world. However, the fact that sensations depend more on the responses of the nerves than on their external causes threatens the reliability and faithfulness of perceptual representations. Helmholtz has to explain not only the differences between the responses of the various sense organs, but also the dissimilarities between the responses of sensory nerves on the one hand, and the responses of other kinds of nerves on the other hand. About this last problem, he reports an intriguing experiment:

> The French physiologists Philippeau and Vulpain, after dividing the motor and sensitive nerves of the tongue, succeeded in getting the upper half of the sensitive nerve to unite with the lower half of the motor.

by the action of heat and electricity, they make known to the sensorium, by virtue of the changes thus produced in them by external causes, not merely their own condition, but also properties and changes of conditions of external bodies [...]; 9. That sensations are referred from their proper seat towards the exterior, is owing, not to anything in the nature of the nerves themselves, but to the accompanying idea derived from experience; 10. The mind not only perceives the sensations and interprets them according to ideas previously obtained, but it has a direct influence upon them.

[2] On Ohm's law, see (Helmholtz 1863/1877, 393).

> After the wound had healed, they found that irritation of the upper half, which in normal conditions would have been felt as a sensation, now excited the motor branches below, and thus caused the muscles of the tongue to move. We conclude from these facts that all the difference which is seen in excitation of different nerves depends only upon the difference of the organs to which the nerve is united and to which it transmits the state of excitation. (Helmholtz 1867, 83)

In Helmholtz's view, sensory systems provide symbols (sensations) of the external reality which can be used for building mental representations of the world. However, given his endorsement of the law of specific nerve energies, and given Philippeau and Vulpain's experiment, he has to explain how faithful representations of the reality are obtainable. Helmholtz writes:

> All that we apprehend of the external world is brought to our consciousness by means of certain changes which are produced in our organs of sense by external impressions, and transmitted to the brain by the nerves. It is in the brain that these impressions first become conscious sensations, and are combined so as to produce our conceptions of the surrounding objects. If the nerves which convey these impressions are cut through, the sensation, and the perception of the impression, immediately cease. (Helmholtz 1867, 82)

Two metaphysical and epistemological problems stem from the quoted passage. Firstly: if, as empiricists like Helmholtz maintain, sensations are the source of all our knowledge, how are we allowed to *state* that the *reality* exists even when our nerves are cut through and sensations of that reality are lacking? Secondly: how sensible qualities as, for example, colours and odours emerge from electric discharges in the brain? What is the relation or the correspondence between the two?

It is now appropriate to examine the second problem. For instance, from a physical point of view, rays of light and rays of heat are both describable as electromagnetic oscillations: however, from a qualitative point of view, sensations of light are quite different from sensations of heat. Another example: if acoustic waves reach the skin in place of the ear, they may cause tactile sensations, not auditory sensations. Moreover, the same type of sensation can emerge from different physical stimuli: for instance, when the optic nerve is affected by electromagnetic, mechanical or electric stimuli, we experience sensations of light. A further example: in the metamerism case, "for any given object, of any given SSR [surface spectral reflectance], there will be an indefinite number of other objects with different SSR that nevertheless tend to look the same in a broad range of conditions" (Noë 2004, 151). All these facts show that it is compulsory to face a demanding question: how can we trust sensory symbols that transcribe different causes in the same way, and identical causes in different ways?

The break between physical causes and physiological responses can be expressed using the classic distinction between primary and secondary qualities. Gary Hatfield, whose works on Helmholtz are of remarkable importance, writes about this point:

> In conformity with the distinction between primary and secondary qualities, it was widely held that color sensations are mere signs of their causes and that there is no intrinsic connection between the phenomenal character of color sensation and its external cause. Nativists and empirists alike maintained that the phenomenal character of color sensations depends on some currently inexplicable property of the nervous system (a position that was formalized in the doctrine of specific nerve energies). (Hatfield 1990, 191)

To sum up. Helmholtz has to deal with the problem of finding a lawlike relation between physical causes and sensible effects. Moreover, he needs to find a way to emerge from the world of sensations in order to obtain a reliable knowledge of the external reality. In other words, Helmholtz needs to find a way to bridge the gap between the physiological and the mental.

3. Du Bois-Reymond and the impossibility of finding a sufficient reason to explain the qualitative character of sensations

Given the significance of the subject, it is necessary to investigate whether the difficulty of defining the nature of sensations, which swings between a phenomenological dimension and a physiological dimension, is contingent, empirical, and manageable with a deeper scientific understanding, or whether this difficulty is a matter of principle. In order to address this question, I refer to two presentations given in 1872 and in 1880 by Emile Du Bois-Reymond,[3] who is a friend of Helmholtz, and who was one of the founders of contemporary physical physiology together with him, Ernst Brücke, and Carl Ludwig. The two speeches deal with the limits of human understanding; one of those limits concerns the grasping of what sensations are and of their causal origins. Du Bois-Reymond starts his analysis from the mechanistic point of view and from the Laplace's demon hypothesis. Thus, he tries imagining a huge system of simultaneous differential equations from which it would be possible to deduce the origin, the direction of movement, and the velocity of every atom of the universe. It is interesting to pose a question: on the assumption that we obtained such a cosmic formula, would we be able to explain how sensations and sensible qualities emerge from nervous actions and physical stimulations? Du Bois-Reymond's answer is negative:

[3] The first speech was given to the Congress of German Scientists and Physicians, the second to the Prussian Academy of Sciences.

the origin of sensation is one of the problems that transcend human understanding, along with the essence of matter and forces and with the origin of movement.

Du Bois-Reymond's negative position is maintained not only because of empirical reasons, but as a matter of principle. It is appropriate to note that the inexplicability of the origins of sensations would emerge even if we could grasp the essences of matter and forces. Even if the Laplace's demon knew these essences (that seems to be, according to Du Bois-Reymond, a logical impossibility), he would be unable to explain how sensible qualities emerge from material structures. If this is correct, it seems not to be the case that the external reality is made with the sensible qualities that human beings perceive "in it": without nerve transductions, ruled by Müller's law, the coloured and noisy world in which we live would be obscure and silent (Du Bois-Reymond 1872, 22–23). The consequences for the notion of sensation are significant. If the world is obscure and silent, how can we maintain that sensations are symbols of this world? In order to claim the existence of a symbolic relation, it is necessary to discover at least a constant correspondence between the cause of the symbol and its effect.

Those troubles are known at least since Locke's works (**?**). Indeed, one of the distinctive characteristic of modern empiricism is the rejection of the notions of resemblance and of pre-established harmony between sensations and the physical world. Helmholtz takes this approach seriously, and gets rid of any resemblance between sensations and physical causes.[4] For this reason, he has to find an alternative explanatory paradigm. However, according to Du Bois-Reymond, that paradigm does not exist.

Du Bois-Reymond, in order to make bright his thesis about the transcendence of any explanation of the nature of sensations, proposes to meditate on some imaginary cases. In one mental experiment, borrowed from Leibniz, he asks to envisage a big machinery able to think, sense and perceive (Du Bois-Reymond 1880, 63–64). This machinery is supposed to be

[4] As a reviewer points out, the notion of "resemblance between sensations and the physical world" should be understood from a third-person perspective. Probably, this is one of the main reasons why the empiricist tradition, starting from Locke, takes advantage of physiological and psychological researches on perception. In the end, the empiricist tradition rejects the notion of resemblance, because it does not allow to explain *why* sensations and perceptions resemble the world in the first place. However, Helmholtz, during the second part of his career, endorses a temporal version of the notion of resemblance, according to which the same object in similar circumstances gives rise to the same sign (sensation). This theory is developed by Helmholtz in order to explain the *lawlike* relation between the physical and the mental. Unfortunately, it is not the aim of this paper to elucidate this point, which deserves an appropriate and dedicated space of discussion. However, Helmholtz's temporal analysis of the concept of resemblance is closely related to his analysis of the concept of causality, which I deal with in the fourth section of this article.

enlarged as if it were a mill, so that it would be possible for us to go inside it. According to Du Bois-Reymond, in this hypothetical situation we would find only mechanical collisions, but nothing suitable to explain the qualitative character of sensations. Du Bois-Reymond deduces a strong conclusion: *the psychic processes, and first of all sensations, that take place in our brains lack any sufficient reason* (Du Bois-Reymond 1872, 39).

Du Bois-Reymond is not a weird idealist philosopher; rather, he is sympathetic with materialist thinkers as, for examples, Pierre Cabanis and Carl Vogt (Du Bois-Reymond 1872, 45–46). According to them, every faculty of the soul is a function of the brain, and there is a strict similarity between sensations and thoughts on the one hand and secretions like bile on the other: they are all objects of (neuro)physiological enquiry. However, Du Bois-Reymond claims that while it is possible, at least in principle, to gain knowledge of the material processes that underlie bodily secretions, the origins of sensations and thoughts are not comprehensible using only neurophysiological tools.

The state of affairs seems troublesome. According to the empiricist world view (endorsed by and large by both Helmholtz and Du Bois-Reymond), sensations are the source of all human knowledge; however, the best scientific model at that time available cannot provide explanations of them. Moreover, there are reasons to think that this is true also for contemporary scientific theories. As Nadia Moro (2015) points out,[5] even if we precisely knew the nature of the stimuli, the anatomy of our sensory systems and their physiology, it would be impossible to determine on those bases the qualitative character of the corresponding sensations. Albeit physiological, psychological and neuroscientific theories are always more refined, the gap between physical stimuli, neurophysiological interactions, and qualitative sensations is like a blank space not yet filled up. Furthermore, sensations are claimed to be signs of causes with which they have no necessary connection: in fact, it is possible that the very same stimulus cause different sensations, and that different stimuli cause the very same sensation. To the question of whether we could gain knowledge of the origins of sensations, Du Bois-Reymond answers: not only "Ignoramus" (we ignore), but "Ignorabimus" (we will ignore) (Du Bois-Reymond 1872, 47).

4. A sentimental-transcendental notion of causality

Helmholtz is well aware of the concerns expressed by his colleague. In order to overcome those troubles, he tries developing some solutions, among

[5] Among other topics, Moro's work deal with Kantian and post-Kantian philosophy and with XIXth century philosophical psychology and physiology.

which the psychological theory of unconscious inferences, what has been called "experimental interactionism," and a reformulation of the notion of causality. In what follows, I analyze those proposals.

The theory of unconscious inferences is coherent with the definition of sensation given above, which states that sensations are symbols that the *mind* uses in order to know the external world. The metaphysical and epistemological aims of this theory are clearly stated in the following passage: "It is obvious that we can never emerge from the world of our sensations to the apperceptions of an external world, except by inferring from the changing sensation that external objects are the causes of this changes" (Helmholtz 1866, 200). In addition, unconscious inferences are employed by Helmholtz to compose a unified picture of the mental life. Hatfield writes:

> Helmholtz regarded the dissolution of the sensibility-understanding distinction as one of the chief advantages of his theory of unconscious inference, equivalent to breaking down the distinction between *Kennen* and *Wissen*, that is, between phenomenal acquaintance with objects as opposed to propositional knowledge. The solvent performing these reductions was the notion that underlying the supposedly distinct operations that results in sensory perception on the one hand and judgments on the other is one kind of psychological operation—the association of ideas. (Hatfield 1990, 204)

The theory of unconscious inferences is one of Helmholtz's main contributions to the history of psychology. However, he sees that this theory does not provide sufficient tools to emerge from the world of sensible appearances and to reach the external world. Indeed, as the contemporary philosopher Michael Heidelberger underlines, Helmholtz's approach seems too close to the idealistic worldview:

> In conceiving of external perception as perception of one's own inner state (of nervous excitation conducted to the brain) Helmholtz, no matter how much he denied it, remained an idealist. For, as Kant noted, it is the mark of idealism to believe that the sole immediate experience is the inner one from which one only infers external objects. (Heidelberger 1994, 439)

Moreover, experience alone seems not to provide a constant criterion that associative processes can make use of to actively arrange simple sensations in complex perceptions, nor it seems to provide stable grounds for the generalizations required to form the major premises of the syllogistic-like unconscious reasonings.

Helmholtz sees those problems, and looks for suitable solutions. One of his main goals is to hold realism and empiricism together. A way he tests in

order to achieve this goal is the so-called "experimental interactionism." According to Helmholtz, sensible impressions constitute a symbolic language that gives information about the external world. Human beings have to learn how to exploit this symbolic system, and this can happen only if they learn to distinguish the changes due to their voluntary and active movements from the changes independent of them:

> The meaning we assign to our sensations depends upon experiment, and not upon mere observation of what takes place around us. We learn by experiment that the correspondence between two processes takes place at any moment that we choose, and under conditions that we can alter as we choose. Mere observation would not give us the same certainty, even though often repeated under different conditions. (Helmholtz 1867, 128)

Helmholtz's idea is to study the correspondence between the physical reality and sensations as long as it is mirrored in experience and in perceivers' active engagement in the world. Experimental interactionism has at least three benefits that he can takes advantage of. First, it allows to underline the role of experience and practical experiments, thus strengthening Helmholtz's empiricist framework. Second, the possibility of constantly verifying the continuous existence of the reality seems to back up Helmholtz's realist inclination. Third, the first two advantages could cloud the difficulty of explaining the physiological relations between nerve fibers and sensations, between brains and minds. However, the possibility of performing experiments with our bodies is not sufficient to obtain an empirical criterion to organize sensations. Hatfield explains:

> The "feeling" associated with muscles movement is just one more element that enters into the mix of non-spatial sensations, out of which rules of spatial localization emerge. If the empiristic account is carried through consistently, it precludes the kind of innate "meaning" that would be presupposed in an active testing of spatial relations through voluntary motions that carry as part of their content an explication of a particular change, or any change at all, in the pattern of sensation. The initial help that was promised from the metaphor of "active testing" can be secured only by a violation of the project of resolving thought into associative learning. (Hatfield 1990, 207)

Helmholtz's psychological works aim to a unitary picture of mind. Art, scientific knowledge and perception are all ways to find universal lawfulness and invariants in natural phenomena. The problem is that laws of associations, unconscious inferences and experimental interactionism are not enough to achieve this goal, because they only deal with particular and empirical perceptions. Therefore, Helmholtz tries finding out if it is possible

to take advantage of some version of the law of causality in order to conceptualize the alleged lawfulness of nature and of perceptual processes. In particular, he works on the Kantian version of it. However, given that his empiricist attitude prevent him from using, in scientific explanations, any kind of pre-established harmony between mind and nature, and given that he maintains that sensations are symbols, not images, of the external world, it follows that he struggles with fully endorsing a transcendental and a priori notion of causality, because it seems too close to the *modus explicandi* of nativism and pre-established harmony. Albeit he is sometimes guilty of an unfortunate confusion between nativism and Kantian transcendental philosophy, he does not lack a deep understanding of what "*a priori* causality" means. His resistance to that notion depends on contemplated reasons.

Helmholtz states that human minds can understand only those natural phenomena which are ordered in a lawful way. Together with this Kantian principle, he supports the Humean idea according to which there is no empirical evidence for empirical causes. It is necessary to investigate how Helmholtz tries conciliating these two approaches. Until now, two kinds of empirical regularity have been identified: the regularity due to the actions of external objects, and the regularity due to the experiments performed with our own bodies. Given that, according to the law of specific nerve energies, what is immediately perceived is the physiological response of the nerves and not the physical stimuli, the best way to recover the external reality is, according to Helmholtz, to carry out inferences starting from the double regularity just mentioned. However, this paradigm needs a well-refined explanation of what causation is. This, for a number of reasons: 1) Qualitative sensations are, according to Helmholtz, the outcome of processes that involve physical, physiological, and psychological events; it is necessary to take into account all of them; 2) Helmholtz has to deal with the transcendent difficulty of bridging the gap between nervous actions and sensible qualities; 3) He has to face the charge of psychologism, that is, the charge according to which he has investigated only the empirical side, but not the properly epistemological side, of the process of knowledge.

Helmholtz is well aware of what is at stake in his attempt to adjust his theory of sensation and in his attempt to reconcile realism with empiricism. During his early career, he maintains a both mentalistic and scientific realist view: in his first work on Goethe (Helmholtz 1853), he states that, given that it is impossible to perceive forces and causes and that we perceive only their effects, we have to depart from the sensible world in order to explain natural phenomena. Thus, physics is supposed to discover the concealed mechanisms which work behind the perceivable scene. However, such a position is described, in other works, as the Icarus' flight of metaphysical reasoning

(Helmholtz 1877, 548). According to the committed empiricist Helmholtz, the senses are unavoidable means by which figure out what happens in the world: naïve mentalism and naïve physicalism are not compatible with this framework. In the end, Helmholtz acknowledges the point and chooses the empiricist side.

However, he is also aware of the limits inherent to empiricism, in particular with regard to the notion of causation, which is obviously fundamental to the definition of sensations as signs. From the second half of the Sixties, he tries merging his empiricism with the Kantian and transcendental paradigm of causality. In order to understand properly this move, it is useful to pay attention to Helmholtz's own words. In some passages, he seems to endorse a transcendental notion of causality:

> The law of causation, by virtue of which we infer the cause from the effect, has to be considered also as being a law of our thinking which is prior to all experience. Generally, we can get no experience from natural objects unless the law of causation is already active in us. (Helmholtz 1866, 201)

If the law of causation is given a priori, then, by definition, experience cannot provide evidence for it:

> The causal law really is given *a priori*, it is a transcendental law. It is impossible to prove it from experience. As we have seen, the first steps of experience are not possible without inductive conclusions, i.e., without the Causal Law. Even if previous experience taught us that everything observed thus far has taken place according to law—which as yet we are not justified in asserting—it could only follow as an inductive conclusion, i.e., the assumption that the Causal Law may follow, that the Causal Law will be valid also in the future. (Helmholtz 1878, 228)

According to Helmholtz, the law of causality is a logical law (in the Kantian sense). However, the fact that it cannot be proved by experience involves some after-effects. In the following two long passages, Helmholtz struggles with giving the transcendental notion of causality a full endorsement. In the first, he writes:

> The law of sufficient basis amounts simply to the requirement of *wishing to understand everything*. The process of our comprehension with respect to the natural phenomena is that we try to find generic notions and laws of nature. *Laws of nature are merely generic notions* for the changes in nature. But since we have to *assume* the laws of nature as *being valid and as acting independently of our observations and thinking*, whereas as generic notions they would concern at first only the method of our thinking, we call them causes or forces. Hence,

> when we cannot trace natural phenomena to a law, and therefore cannot make the law objectively responsible as being the cause of the phenomena, the very possibility of comprehending the phenomena ceases. However, we must try to comprehend them. There is no other method of *bringing them under the control of the intellect*. And so investigating them must be proceed on the supposition that they are comprehensible. Accordingly, the law of sufficient reason is really nothing more than the *urge of our intellect* to bring all our perceptions under its own control. It is not a law of nature. *Our intellect* is the faculty of forming general conceptions. *It has nothing to do with our sense-perceptions and experiences, unless it is able to form general conceptions or laws*. Those laws are then objectified and designated as causes. But if it is found that the natural phenomena are to be subsumed under a definite causal connection, this is certainly and objectively valid fact, and corresponds to special objective relations between natural phenomena, which we express as being their causal connection, simply because *we do not know how else to express it*. (Helmholtz 1866, 202, italics added)

The transcendental law of sufficient reason (that is, in this context, another name for the Causal Law) is based on nothing more than the *desire* to know everything. Natural phenomena's conformity with causal laws cannot be taken for granted; worse, it is not empirically demonstrable. Helmholtz's reference to transcendental causality seems more a last resort than a strong justification for the reliability of human knowledge. In other words, it seems a *sentimental* urge, the "urge of the intellect to bring all our perceptions under its own control."

A similar attitude is expressed in the following passage:

> Every inductive conclusion is based on the *confidence* that a regular behavior hitherto observed will prove to be valid also in all cases not yet observed. This is a *trust* in the lawfulness of all occurrences. And conformity to law is the condition of intelligibility. *Trust* in the lawfulness of nature is the same *trust* in the intelligibility of natural phenomena. If we *suppose* however that the understanding will be complete, then we will be able to establish one last final cause for observed changes. Our cognition is responsible for terming this rule principle, The Causal Law. We may say that it expresses our *trust in the complete intelligibility of the world*. Understanding, in the sense in which I have described it, is the method by which our reasoning accepts the world, arranges the facts, and predetermines the future. It is one's right and duty to extend the application of this method to all that takes place, and it actually has yielded great returns in this manner. *We have no other guarantees however for the applicability of the causal law but its success*. (Helmholtz 1878, 228, italics added)

The principle of causality seems grounded more in our trust and beliefs than in transcendental objectivity. Indeed, Helmholtz provides no guarantees of its validity but its (empirical) success. The law of sufficient reason is described by him as a sentimental urge to *believe* in (or to *trust*) the complete intelligibility of the world. Desire, trust, belief, urge, assumption, supposition: Helmholtz's notion of causality seems not to provide the desired universal and necessary foundation of our knowledge of the external reality.

5. Summary and conclusion

In this article, I analyzed Helmholtz's struggles with explaining why and how the physical world causes the sensations we have when it impinges our sense organs. The starting point was Müller's law of specific nerve energies, according to which what human beings perceive are the responses of their nerves to the external stimuli and not the external stimuli per se. Helmholtz's reflections on this law, combined with his empiricist attitude, show his urgency to justify the commonsense believes that the external world exists independently of the perceivers and that human perceptions and knowledge of that world are trustworthy. The complexity of achieving this goal is made explicit by Du Bois-Reymond's claim that it is impossible to individuate sufficient reasons to explain how the physical world causes the emergence of qualitative sensations.

Helmholtz's doctrine of unconscious inferences does not provide the tools to overcome those problems, mainly because it states that the world is only indirectly grasped by human perceptions. His experimental interactionism is not conclusive either, because it relies on merely empirical grounds. Helmholtz, a committed empiricist, sees the difficulties implied by the empiricist paradigm, in particular with regard to the notion of causality. In fact, he states that physical stimuli, understood as the causal origins of sensations, are unknowable in themselves, and that there is no empirical evidence for the kind of causality from which sensations originate. This is why Helmholtz turns his head towards Kant and his transcendental philosophy: they promise a universal and necessary foundation for human knowledge. In the end, in order to make sense of our insuppressible desire to gain knowledge of the world, he endorses a sentimental-transcendental notion of causality. However, the arguments he provides for this notion lie more in the "trust in the complete intelligibility of the world," or "in the urge of the intellect to bring all our perceptions under its own control," than in rational reasoning.

If this is the case, skeptic philosophers that do not have faith in the complete intelligibility of the world can make use of the very same argument provided by Helmholtz, just in the opposite direction. In order to avoid a non-

fruitful impasse, it is necessary to ask why Helmholtz's work leads toward this unsatisfactory conclusion. My suspect is that the crucial difficulty lies in Helmholtz's definition of sensations as signs of the external world. This definition is so problematic that Helmholtz points out the urge to emerge from the jail of sensations to recover the external reality that causes them. After investigating a number of way outs, the most promising solution he finds to reach the goal consists in empowering the *intellect* and in declaring his *trust* in the lawfulness of the relations between the external world and perceivers. However, Helmholtz would probably admit that this solution is not powerful enough for philosophers and scientists who do not share that trust. This is hardly only Helmholtz's problem: in contemporary philosophy and psychology, the same need to escape from the jail of sensations is widespread. Helmholtz has done much for our understanding of human sensations and knowledge, especially because he pointed out the shortcomings that stem from his own views. The moral of this article is that the philosophical and the scientific communities should follow and go beyond Helmholtz work in order to achieve a better understanding of what sensations are, of their relation with the physical world, and of the knowledge that that relation is supposed to make possible.

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