Reasonable certainty in science and philosophy

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Abstract

It is argued that, as forms of knowledge, neither science is so safe, nor philosophy is as arbitrary as is often claimed. Mathematics and experimental science are founded on postulates that must be accepted axiomatically and cannot be justified with the rigor that is eventually expected from both disciplines. That acceptance entails the conscious or unconscious adoption of specific philosophical choices. The same can be said of other statements which enjoy so wide a consensus that their philosophical character is eclipsed. The ontological status is discussed of specific instances of such widely accepted assertions. It is concluded that, in the adventure of life, the elusive myth of sure knowledge must be replaced by the tangible prose of reasonable certainty. It is proposed that the necessary and successful vital bet on reasonable certainties that already enjoy a wide consensus may be extended to other philosophical spheres which so far have been perceived by some as the domain of the arbitrary.

Keywords: science, philosophy, knowledge, foundation, certainty, reasonableness.

1 Introduction

Within contemporary culture, science enjoys an unquestionable and well-deserved prestige. This positive image of science is sometimes distorted to the point of giving way to radical claims, typical of scientism, according to which science would be the only valid form of knowledge. In this intellectual context, one may also hear that philosophy is dead (Hawking and Mlodinow 2010) or that there is not a unique philosophical truth but rather a set of assertions forming a social consensus that evolves over time. The latter claim is typical of relativism (Baghramian and Carter 2016), a cultural current that extends even to the interpretation of science when, encouraged by the work of Kuhn (Kuhn 2006), the so-called social constructionists defend that science is more the product of a social agreement than of the discovery of an objective truth (Latour and Woolgar 1986). In this article we try to dismantle some of these clichés by arguing that scientific knowledge is neither so safe nor so conventional and that, on the other hand, philosophy is not so arbitrary. We will explain that even mathematics, that apparent ultimate bastion of epistemological certainty, is subject to some fundamental uncertainties. As a response to this set of uncertainties, we propose the reasonable bet on a constructive certainty which, in some cases, already enjoys such a wide consensus that it overshadows its own limited foundation. The awareness of the merely reasonable character of these widely shared certainties may stimulate the extension of this fruitful bet to philosophical spheres hitherto perceived by some as the domain of the arbitrary. To clarify the terms of the debate, we introduce some working definitions. We will understand by science the body of knowledge that, elaborated from observation and reason following the hypothetical-deductive method, satisfy Popper's falsifiability criterion (Popper 2008). This influential philosopher proposed that the characteristic essence of a scientific statement is its being open to the possibility of being refuted (proved false) by the outcome of a conceivable experiment. This definition is ideal for the great physical theories, but it is convenient to make it a little more flexible when applied to everyday science (Sols and Sols 2014). Even so, the criterion of falsifiability is always a valuable reference that reminds us of the ideal to which scientific work should aspire. In short, we will be referring to the usual science in its healthiest version, when it is far from both pure speculation and mere empiricism. Within scientific knowledge, we can include mathematics, which although as an autonomous discipline has its own methodology and is not governed by Popper's criterion, when applied to other fields it integrates perfectly into the landscape of science. Because of its formal independence from experience, mathematics is usually regarded as the last stronghold of safe knowledge. However, we will see that even this picture requires important nuances.

By philosophy we will mean the intellectual activity that attempts to be rational but to which the scientific method cannot be applied. We note that science can also be defined as the knowledge that can be attained using the scientific method (Andersen and Hepburn 2016). In other words, science is an intellectual discipline that is defined by its method. Thus, we will understand by philosophy any rational (or at least reasonable) discourse not reducible to experimental science or mathematics.

We will avoid here explicit references to the so-called ordinary knowledge, a very broad concept that constitutes the starting point for science and philosophy and therefore overlaps with both disciplines. We will note instead that the ontological status that one assigns to this basic knowledge is necessarily associated with the adoption, conscious or not, of concrete philosophical positions.

To focus the discussion, we will concentrate here on the experimental sciences, ignoring all those intermediate disciplines that, without having the status of natural sciences, share some aspects of their methodology. We thus avoid the debate on the degree of rigor and reliability of social sciences such as economics, sociology, or psychology, a topic of great interest but different from that which we wish to address here.

In this article we will not refer to technology, since its essentially applied character makes the possible epistemological debate trivial. The concept of truth is very clear when we know that airplanes fly or do not fly. The aim of engineering is not so much to generate knowledge as to create useful products.

Nor will we discuss philosophical questions related to ethics and aesthetics. From the Platonic triad of truth, goodness, and beauty, we will focus on truth.

2 Some common clichés

To identify the poles of the discussion, we will list some statements that can often be heard. Also to simplify the discussion, we will present them in their most radical version. We assign a letter and a number to each statement. The letter will be C, F, M, depending on whether it refers to science, philosophy, or mathematics[1]. The number will be 1 if the statement is about the degree of certainty, which here we will correlate (but not identify) with the social consensus it gathers, and it will be 2 when it refers to the validity of the discipline as a form of knowledge.

C1: Science generates total certainty and universal consensus (on consolidated issues). C2: Science is the only valid form of knowledge.

F1: Philosophy is arbitrary (relativism) and incapable of generating a broad consensus. F2: Philosophy is not a valid form of knowledge.

M1: Mathematics generates total certainty and universal consensus. M2: Within its scope, mathematics is a valid form of knowledge.

In this article we will focus on statements related to science and philosophy (C and F) and make some very relevant considerations about mathematics (M).

Before starting the present study, I take a personal position and make some general comments. I subscribe to C1 and M1 but with important nuances that I will explain. I reject and will criticize statements C2, F1, and F2. On the other hand, I accept M2 without problems.

Statement C2 represents scientism in its purest form. The main problem with it is that it is not a scientific statement, in the sense of not being open to a falsifiability test. Therefore, it is a statement that disavows itself.

Those who defend C2 usually accept F2[2]. It is less clear whether those who hold F1 in turn defend F2 or not. In any case I have never quite understood why, in the field of philosophy, there are thinkers who defend C2 and F2 and yet do not engage in science.

We now turn to the central analysis of the statements on science and philosophy (C and F). As I have said, I subscribe to statement C1 but with the important reservation that science does not provide absolute certainties in the strict sense, although it can generate great certainties, so great that in practice they can be treated as absolute. Popper's criterion prevents us from proving a universal statement, since we would have to carry out infinite experimental verifications, but it reminds us that it can be refuted by a single experiment sufficiently verified that contradicts it.

[1]The letters C, F are taken from the initials of the Spanish terms for science and philosophy: "ciencia" and "filosofía", respectively.

[2]For example, see (Hawking 2010).

It may seem then that in science it is not possible to reach total certainty, and strictly speaking that is the case. We can never rule out that tomorrow an experiment may arise that forces us to revise a consolidated scientific theory. However, science allows almost total certainties that we could call "asymptotic" because confidence in a theory increases indefinitely over time as experiments continue to confirm it. Since, by definition, confidence can never exceed one hundred percent, we can say that, over time, consolidated science asymptotically approaches such limit of total certainty.

Among the paradigms of science about which we have practically total certainty we may mention, within physics, atomic theory, quantum mechanics, and the theory of general relativity. We are as certain about the validity of these theories, within their domain of applicability, as we are that the earth is round. It is important to emphasize the caveat of "within their domain of applicability". For example, we do not yet have a theory of quantum gravity that allows us to understand the behavior of space and matter in those situations where quantum effects are as important as gravitational ones. One requirement for a future theory of quantum gravity is that it must explain why quantum mechanics and general relativity work so well in their present domain of validity. That is, in the corresponding limits, the future theory must be able to reproduce today's accepted models.

In its clearly objectifiable aspects (genetic relationship, fossil record) evolutionary biology can be considered as well established as the physical theories which we have just mentioned[3].

The fact that we can never completely rule out that tomorrow a well-established theory will have to be revised, is no reason to claim that everything in science is ultimately uncertain. Some people use this provisional character of scientific theories to argue that in science the established knowledge results more from social convention than from the discovery of an objective truth. Planck's famous statement that new theories are accepted not because the defenders of the old ones change their minds but because the latter end up dying and giving way to a new generation accustomed to the new theories, is undoubtedly exaggerated and probably reflects a particularly bitter personal experience (Planck 2000).

In science there are heated debates because that high degree of certainty to which we have referred is only reached in some fields and after a great collective research effort. At the frontiers of science many ideas are discussed, sometimes passionately. But these debates are eventually settled when the experimental evidence clearly supports one thesis over another[4]. Although *stricto sensu* the scientific method only applies to the natural sciences, all intellectuals (philosophers, psychologists, pedagogues, economists, politicians) should learn from the rigor that is common in conventional scientific research and from the example of honesty and humbleness set by some great scientists such as John Bardeen, who knew how to rectify on time when they understood that the experimental evidence did not support their theory.

[3]However, for a demonstration that the absence or presence of finality in nature cannot be decided by the scientific method, see (Sols 2013, Sols 2014).

[4]There are countless examples of this intellectual dynamics. A particularly nice one, which occurred in condensed matter physics, was the debate between Josephson and Bardeen on the coherent transmission of electron pairs between two weakly connected superconductors (Donald 2001).

The virus of relativism in philosophy sometimes reaches the very interpretation of science. We have already said that, in some currents of thought, it is claimed that scientific consensus reflects more a social convention than proper knowledge of an objective reality. In my opinion, this type of assertion is defended by intellectuals with an apparent inferiority complex who try to lower the prestige of science. As we have just pointed out, it would be much more constructive if these conventionalists spent their efforts in trying to lead their professional community towards the highest levels of rigor that their discipline allows, something that is a daily practice in the field of natural sciences. Fortunately, the scientific community pays little attention to this fatuous relativism. Thanks in part to this, science continues to make steady progress, something that is difficult to claim for other intellectual disciplines, at least in what refers to widely accepted knowledge.

3 There is universal consensus on some philosophical questions

By universal consensus we will understand here a quasi-universal consensus, that is, one maintained by very broad majorities that include groups which radically disagree among themselves on other fundamental issues. We will ignore here exotic and clearly minority positions such as solipsism, a radical form of subjectivism according to which only the self exists or can be known[5].

We will now enunciate and discuss some assertions that enjoy an essentially universal consensus. It is very important to note that these statements are not scientific, in the sense that they cannot be refuted by experiment. They are philosophical statements that practically everyone accepts as valid, so much so that what is only reasonable appears as certain. With these examples we intend to illustrate that also in philosophy it is possible to reach total certainties accepted by all (always with the caveat of "practically").

Others have a subjective experience of consciousness similar to mine. The negation of this idea is solipsism, a marginal and exotic philosophical stance. We all have total certainty only of our own consciousness. We assume that of others. However, it seems *reasonable* to us to accept that we are not an exception and that others have an experience of consciousness similar to ours.

There is an objective material reality independent of us. This is the central claim of philosophical realism. If asked, some scientists may question realism, but they usually refer to those concepts that modern physics uses to describe objects that we cannot perceive as directly as, say, a table. With a snobbish attitude, a physicist may doubt the real existence of electrons but will hardly deny that the moon is there when no one is looking at it (or measuring it)[6]. We can affirm that it seems *reasonable* to us all to think that the moon is still there when no one is looking at it[7].

[5]Definition taken from the Oxford Dictionary.

[6]We are paraphrasing the title of the famous paper on realism in quantum physics (Mermin 1985).

[7]In this context, we would like to point out a confusion that is often perceived. The fact that a

There is such a thing as human design. When we see a car that works or an airplane that flies, we know that this object has been designed by someone, and we have this conviction for two reasons. The first is that we have never seen a natural process that spontaneously produces such a sophisticated object. The second reason is that we know that there are engineers and skilled workers who dedicate themselves to designing such objects[8]. When archaeologists and detectives look for signs of human intervention, they try to identify structures that can hardly be generated spontaneously. The recognition of an object as the result of human design may seem obvious on many occasions, but the reality is that there is no experiment that allows us to identify the design automatically. Abusing a little the language of quantum mechanics, we can state that there is no physical observable associated with design. However, there are many objects (e.g., any technological gadget) that we *can reasonably claim* to have been designed, even if we have not witnessed their manufacture.

Nature follows regular laws. A fundamental element in the development of modern science is the hypothesis of induction. If we observe that a behavior is repeated many times, we decide to postulate that it is always repeated, i.e., that it is a stable law of nature[9]. A very unsophisticated example is the following: if we catch a stone in our hand and, when we drop it, we observe that it falls to the ground, and we see that the same phenomenon is repeated many times and in very varied circumstances, we conclude that it is a regular "law" of nature: whenever a stone is dropped, it falls to the ground. This step that takes us from repeatedly observed singular facts to a postulated universal statement is the hypothesis of induction. This act of generalization plays a central role in Popper's criterion of falsification, for while the singular can be proved, the universal can only be refuted (falsified). Are we absolutely sure that the hypothesis of induction will always work? No, but by virtue of accumulated experience, it is *reasonable* for us to believe that the known laws will continue to be fulfilled[10].

Nature follows intelligible laws. A working hypothesis that has proved to be very effective throughout the history of science is the idea that the laws of nature are intelligible, that is, objective, rational, and understandable by human reason. It should be emphasized that without this hypothesis science is impossible. In fact, science may well be defined as the intellectual program generated by the notion that there is order in nature. It has

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microscopic object subject to the laws of quantum mechanics, such as, for example, an electron, does not have a perfectly defined position, does not mean that its position is "perfectly undefined". For example, an electron in a molecular orbital between two atoms may not have defined which of the two atoms it is closer to, but there is certainty that it is in the molecule, not very far from either of the two atoms. That is, the degree of definition of the position of a quantum particle depends on the length scale in which we are interested.

[8]We are not talking here about intelligent design, whose possible role in evolutionary biology is controversial.

[9]For a discussion of the validity of induction, see the article in this same volume (Sols 2016).

[10]Quantum indeterminism is compatible with the regularity of nature. One only must admit that, on a very small scale, nature obeys the rules of quantum mechanics, one of which is the indeterminacy in the measurement of a physical variable that is previously not well defined. Quantum mechanics allows us to calculate very well the probability distribution of possible outcomes in an indeterminate process.

been argued that the belief in an intelligent, rational, and good God who has created an ordered world has been a decisive factor in the development of modern science, which, not by chance, began in culturally Christian Europe (Jaki 1978, Gonzalo 2000). Regardless of how explicitly aware people may be of this cultural heritage, the reality is that the belief in the rationality of nature is firmly rooted in modern culture. We are not absolutely certain that all the laws of nature will be rational, and even less certain that they will be comprehensible to the human mind, but by virtue of past experience, it is *reasonable* for us to believe that nature is potentially intelligible.

Mathematics is consistent. There may be a radical skeptic who questions some or even all the above statements. If such a person exists and is in good mental health, his or her position is more likely to be the result of a desire to stand out than of real conviction. But regardless of the reasons that may lead to defend such an exotic point of view, the reality is that it will be very difficult to find someone who doubts the consistency of mathematics. A system of axioms is consistent if it never leads to contradiction, that is, if a theorem and its negation can never be deduced from it. If that were to happen, that system of axioms would have to be thrown away, since from an affirmation and its negation any other affirmation can be derived. Everything would be true and false at the same time; it could be a relativist's dream. No one believes that this will happen with mathematics. The axioms of mathematics are a set of truths that we consider self-evident and that include the very rules of logic. Even for the most skeptical, mathematics is the last bastion of cognitive certainty. Well, even that conviction lacks scientific or mathematical demonstration. As Gödel demonstrated at the end of the first third of the last century, a finite system of axioms cannot prove its own consistency. That is, we cannot prove that present mathematics will never lead to a contradiction. However, given the self-evident character of its foundations, to which we can add the efficiency shown so far in its applications, it seems *reasonable* to us all to think that current mathematics is consistent.

4 Reasonableness criterion

We have just reviewed some statements that are almost universally accepted even though, in the strict sense, there is no scientific or mathematical certainty about them, so much so that they can be considered philosophical propositions. But then, why are they so widely accepted? We have noted here that the reason is that such statements seem very reasonable to us all. But what does reasonable mean? We can turn to the dictionary and consult the definition of reasonable, rational, reason, and other related words. Invariably we will arrive at a circular argument. To avoid that *impasse* we will define "reason" here as the faculty of thinking in a way that seems to us to be self-evident, logical, and orderly, and that, when applied to practical situations, works well[11].

We can understand that a discourse is "rational" when all its statements make explicit

[11] For example, we can use reason to deduce the Pythagorean theorem and then check it experimentally by measuring the sides of a right triangle.

use of reason in an evident way[12]. The adjective "reasonable", which appears in the title of this article and which we are using frequently, is more difficult to define. It may be understood that reasonable is what is in accordance with reason, or compatible with reason, but this meaning does not seem very determinant when, ultimately, reason in turn is defined in an intersubjective (we agree that a sentence is in accordance with reason) and pragmatic way (in practical situations, exercising what we understand by reason is useful, it works). In some cases, a criterion of "reasonableness" can be specified, but this will never cease to be a roughly useful and more or less "reasonable" proposal.

Why is it more reasonable to think that the laws of Nature are regular? Ultimately, we have to settle for justifications of the type that it seems so to many of us and that, moreover, thinking this way in practical situations tends to work. Strictly speaking, we cannot go much beyond the well-worn cliché: when I hear something reasonable, I recognize it. We all find it more reasonable to understand that the planets move according to regular laws that we have come to discover, than to think that they move without any regularity but in such a way that, by chance, they always end up following elliptical orbits[13].

Of course, in a Christian conception of the world, everything fits together quite easily: there is a good and intelligent God who creates an ordered world that can be understood with our reason. In that vision, reason is the faculty with which God has endowed us to be able to discover and understand truth, understood here according to the classic definition of "adequacy of the intellect to reality", whether we are dealing with material reality in its quantitative aspect, the object of experimental science, or with the material and spiritual realities that are the object of philosophy and theology. But when we are trying to identify a body of knowledge as the object of universal consensus, accepted by believers, agnostics and atheists, we cannot invoke concepts characteristic of the Judeo-Christian worldview. At most, with the permission of the relativists, we can introduce the concept of truth and recognize reason as the mental faculty that allows us to discover such truth or reality starting from elementary observations.

5 Betting on reasonableness

The epistemological panorama we have just described may produce a feeling of unease in those people who would only be reassured by absolute certainty. The fact that such absolute certainty does not exist in philosophy does not seem very surprising. But here we have argued that even positive experimental science cannot provide absolute certainties. More surprisingly, not even mathematics, the apparent last redoubt of cognitive certainty, can provide us with the comfort of total certainty.

[12] It is worth noting a nuance here. In both science and philosophy, there are many statements that are not "self-evident" in the sense of obvious. However, they are usually arrived at after a succession of logical steps that, taken individually, are "self-evident" to a person of adequate intelligence. Often, the final conclusion of a reasoning is not obvious if it is directly compared with the initial premises, ignoring the details of the rational argumentation that leads from the premises to the conclusion.

[13] A systematic study of the philosophical assumptions implicit in scientific research can be found in (Artigas 1999).

The situation is not so serious if we take the step of changing the utopia of absolute certainty for the realism of *reasonable certainty*. We must accept that total cognitive certainty is not possible but that we can live satisfactorily with many reasonable certainties, some of which, as we have already argued in specific cases, may enjoy a practically universal consensus.

We will say that we "bet" on an idea when we accept it as true and assume it to such a degree that it is natural for us to identify it as part of the routine landscape of reality. In some cases, the commitment to a notion can be internalized to the point of conditioning our behavior and our perception of reality[14]. This attitude can be unconscious or conscious. The former is perhaps more frequent, but only the latter is the fruit of the reflective maturity that leads the individual to become aware of the vital and philosophical options that he or she has freely chosen.

The conclusion is that, in the absence of absolute certainties, we have to settle for reasonable certainties; we have no other choice. But in this adventure of life we all bet: believers, agnostics, and atheists. There are people who like to perceive themselves as hard skeptics who only accept self-evident truths, preferably if these are reached by applying mathematics or the scientific method. Here we have argued that, whether conscious of it or not, such people also must give up on absolute certainties and in practice accept philosophical assertions that can only be described as reasonable. Many of these people embrace the idea that religious faith is based on blind adherence, ignoring that they also firmly accept many philosophical concepts that are only reasonable. It is also often ignored that such a level of acceptable certainty can be found in religions with a stronger intellectual tradition, and perhaps this explains why the list of believers among the scientists and mathematicians who have contributed decisively to the development of science and mathematics is so long (Gonzalo 2000).

6 The unity of philosophical experience

The title of this section is taken from the famous book by Gilson (Gilson 1973), who argued that the right use of reason can generate and has generated agreements that he interprets as a manifestation of the possible unity in the philosophical experience, even -we add here- if that consensus is not as universal as that described above.

In this article I hope to have contributed in a very modest way[15] to reinforcing the idea that unity in philosophy is an attainable ideal, or at least an ideal to which we can come increasingly close. Proof of this is that, in fact, such unity has already been achieved on numerous issues whose purely philosophical nature is obscured by the broad consensus they enjoy. In this article I have described several examples of statements that are considered valid on a virtually universal basis, despite the fact that they cannot take refuge in the absolutely certainty supposedly provided by the scientific method and

[14]For example, the acceptance that others have a conscious experience similar to our own is more likely to stimulate altruism than the solipsistic view that perceives life as a big video game.

[15]It cannot be otherwise coming from a physicist only interested in philosophy.

mathematical reasoning. I have pointed out in particular that even the foundations of the scientific and mathematical activity fall outside this supposed ideal of total cognitive safety. The working hypotheses underlying scientific and mathematical work are based on certainties that are not absolute but that can be, and in fact are, reasonable, so reasonable that they come to seem obvious to us. This picture of obviousness, reinforced by the experience of a broad cultural consensus, can overshadow the character of intellectual and vital bet involved in the assumption, conscious or unconscious, of concrete philosophical hypotheses.

It is a fact that in life there are very few absolute certainties, Descartes' *cogito ergo sum* and little or nothing else. However, this realization needs not lead to unease or solipsism. The challenge of living is inseparable from the audacious bet on philosophical conceptions in whose validity we can have great confidence. The elusive myth of absolute certainty must be replaced by the tangible prose of reasonable certainty. In fact, consciously or unconsciously, we are all making a daily existential bet on a set of truths that we perceive as almost self-evident even though they are beyond the reach of the scientific or mathematical discourse and which include the very foundations of that discourse.

It does not seem right to seek the refuge of relativism in some cases on the grounds of a scarce cognitive safety that in other less controversial contexts is considered totally sufficient. It would be desirable that awareness of these fundamental but bearable epistemological limitations should stimulate the broadening of the range of certainties that are widely shared and whose internalization makes it easier for us to live fully and coherently.

7 Dedication

This article is dedicated to the memory of Professor Mariano Artigas. I became interested in the topics of science and faith when, while a university student, I read the books of Planck, Heisenberg and, most importantly, Jordan (Planck 1969, Heisenberg 1972, Jordan 1972). In time, Don Mariano's books were decisive in consolidating my interest in questions of science and faith and of philosophy of science. His books are the first texts that I recommend to anyone interested in these subjects[16]. I was able to greet don Mariano on one occasion, when he was introducing a speaker to whom I had come to listen. I remember him as kind, serious, and profound. I hope this article can be considered a worthy reflection of his legacy.

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[16]For example, (Artigas 1985).

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