



Article

Contemporary Natural Philosophy and Contemporary *Idola Mentis*

Marcin J. Schroeder

Global Learning Center, Tohoku University, Sendai 980-8576, Japan; schroeder.marcin.e4@tohoku.ac.jp

Received: 6 July 2020; Accepted: 26 August 2020; Published: 1 September 2020



Abstract: Contemporary Natural Philosophy is understood here as a project of the pursuit of the integrated description of reality distinguished by the precisely formulated criteria of objectivity, and by the assumption that the statements of this description can be assessed only as true or false according to clearly specified verification procedures established with the exclusive goal of the discrimination between these two logical values, but not with respect to any other norms or values established by the preferences of human collectives or by the individual choices. This distinction assumes only logical consistency, but not completeness. Completeness (i.e., the feasibility to assign true or false value to all possible statements) is desirable, but may be impossible. This paper is not intended as a comprehensive program for the development of the Contemporary Natural Philosophy but rather as a preparation for such program advocating some necessary revisions and extensions of the methodology currently considered as the scientific method. This is the actual focus of the paper and the reason for the reference to Baconian *idola mentis*. Francis Bacon wrote in *Novum Organum* about the fallacies obstructing progress of science. The present paper is an attempt to remove obstacles for the Contemporary Natural Philosophy project to which we have assigned the names of the Idols of the Number, the Idols of the Common Sense, and the Idols of the Elephant.

Keywords: contemporary natural philosophy; *idola mentis*; scientific methodology; quantitative and qualitative methods; structural analysis; abstraction; complexity

*Dedicated to Gordana Dodig-Crnkovic
who proposed the idea of the Contemporary Natural Philosophy Project*

1. Introduction

Natural Philosophy or Philosophy of Nature has a long intellectual tradition with diverse ways of its identification as a style of inquiry and with the diverse interpretations of its role in the life of human collectives and in the individual reflection on reality. The presence of the qualification of Philosophy by the terms “Natural” or “Nature” does not make the concept easier to comprehend considering the long tradition of disputes about their meaning going back at least to Aristotle. Moreover, Natural Philosophy is the subject of this paper not so much because of its past, but because of its potential for the future of inquiry. This is the reason for the temporal qualification in the name “Contemporary Natural Philosophy” used in this paper and in the series of papers for which the present paper is intended. There is an increased interest in the revival and reconceptualization of Natural Philosophy as the means to adapt intellectual inquiries of reality to the challenges of complexity and of its consequences faced by science and philosophy [1,2]. Natural Philosophy emerged from the attempts to acquire universal knowledge of reality devoid of earlier divisions into separate realms of the Heaven and Earth consisting of separate essences long before the separation of the forms of this style of inquiry into the emancipated disciplines of knowledge. In this sense it can be considered a parent of the disciplines called Natural Sciences. Contemporary Natural Philosophy can be viewed as an attempt to reintegrate

the vision of reality fragmented by the overload of complexity into a domain overarching Natural Sciences, but going far beyond these disciplines, and challenging conventional disciplinary divisions.

This paper does not have any ambitions to analyze the entire variety of past and present conceptualizations of the Natural Philosophy, its revival in the form of the Contemporary Natural Philosophy or to advocate for any specific choice for its identifying principles. Instead, its objectives are to look for that which is common in the diverse studies, directly or indirectly associating themselves with the naturalized inquiry of reality and to identify the fallacies which have to be eliminated or avoided, if we want to make this type of inquiry effective. In fact, the latter objective is primary and the former just sets the stage for the study.

The present paper is motivated by the view that the Contemporary Natural Philosophy can and should play the leading role in the process of developing an integrated vision of objective reality built with the use of a self-regulated by the feedback control methodology. This process does not have to be limited to the integration of the existing forms of scientific inquiry or to the organization of their accumulated results.

Although the choice of the name “Contemporary Natural Philosophy” for this gradually emerging domain of inquiry is far from being of primary importance, it can be justified by the affinity with the loose but identifiable tradition associated with the name “Natural Philosophy” in the intellectual history of humanity and, on the other hand, by the need to avoid the confusion with the existing fragmented, lacking cohesion, and dominated by external values and norms field of human activities conventionally called science. Although, in this paper, this conventional term will be used frequently along with the expression “scientific method”, this is not an expression of the view that they refer to some clearly defined and uniform concepts, but rather a matter of convenience.

At present, Contemporary Natural Philosophy has the status of a project discussed in the series of papers presenting a wide variety of views and positions [1]. For this reason, its vision presented here is idiosyncratic and possibly temporary. However, no matter what its future shape will be, there is no doubt that its formation and development will require some adaptations and revisions of the methodologies which it inherited from Natural Philosophy and sciences. The present paper is intended as a preparation for these methodological transformations.

This is the actual focus of the paper and the reason for the reference to Baconian *idola mentis*. Francis Bacon wrote in *Novum Organum* about the fallacies obstructing science in its *statu nascendi*. The present paper is an attempt to remove obstacles for the Contemporary Natural Philosophy, categorized here, rather conventionally, as the Idols of the Number, the Idols of the Common Sense, and the Idols of the Elephant.

The reference to Francis Bacon does not mean an intention of the revival of Baconian philosophy of inquiry. It will become clear that the intentions of this paper are, in some cases, just opposite to those of Bacon. Its reason is the function of Baconian idols as a denouncement of the patterns and habits of human thinking which have to be eliminated for the purpose of achieving the authentic knowledge of reality. The function of the idols presented and discussed here is the same, but their specific characteristics are different and sometimes opposite to those in *Novum Organum*.

The triadic categorization of the Contemporary *idola mentis* which should be avoided in the development of the Contemporary Natural Philosophy is not intended to be comprehensive, exhaustive, or exclusive. It is as idiosyncratic as the vision of the new domain. After all, we are talking about the future domain of inquiry which is being discussed and developed. Possibly other idols will be identified in the future and they all may be re-categorized.

The selection of the three categories and of the examples of idols within these categories is dictated by my own experience from my mathematical-scientific research, from my teaching, and from my work on philosophical reflection. The main criterion for the inclusion of instances and types of fallacious reasoning into consideration in this paper was their hidden omnipresence in the present scientific, philosophical and educational practice, and their detrimental impact on this practice.

Their elimination is of great importance for the development of the methodology for the Contemporary Natural Philosophy.

The last statement can generate disbelief and criticism of my inflated expectations. How can I know that some topics will be of great importance for the Contemporary Natural Philosophy before it is born and matured? The answer will be given later, but at this moment, I can only give examples of the topics which are addressed in the description of the idols. The Idols of the Number address misconceptions regarding the distinction between quantitative and qualitative methods in scientific methodology. The Idols of the Common Sense address misconceptions regarding the relationship between the formal conceptualization of elements of reality and the way we perceive reality. The Idols of the Elephant address misconceptions regarding the relationship between structural divisions of reality.

The use of the term “misconception” puts some normative load in these descriptions. Does it mean that the subject of the paper is tracing errors in scientific methodology? My preference is to talk not about errors, but rather about fallacies. Errors are deviations from some standards of precision or correctness which are not always available or known, especially in the context of the domain of study which is still in the process of development. Fallacies are more general, as they may be of the type of formal fallacies where the deviation from some standards (i.e., they may be errors), but also of the type of informal fallacies, where the issue is not the deviation from some standards, but in not meeting declared expectations [3]. Certainly, the latter form of fallacies is relative to the expectations and therefore, it requires some context. All idols studied in this paper have the context of the Contemporary Natural Philosophy, although some are formal and can be classified as idols independently from any context. They have the common feature of being based on typically hidden divisions assumed to be obvious and absolute in their status or in their mutual relations. The expectation which serves as the evaluative (negative) criterion is the goal of an integrated view of reality. The idols studied here are obstacles in building this view.

2. Contemporary Natural Philosophy

As it was emphasized several times above, the role of the description of the Contemporary Natural Philosophy is to provide a context for the main part of the paper about overcoming obstacles in its development. The strategy in this description is to minimize the restrictions on its further evolution. The vision of the Contemporary Natural Philosophy presented here is not a summary of its discussions carried out in other contributions to the subject or the result of a consensus in these discussions. It is more a proposal of the framework in which the project can proceed.

2.1. Motivations for Contemporary Natural Philosophy

The problem of the fragmentation of human intellectual activity was studied in many different contexts and perspectives from the level of the modern civilization to internal divisions of scientific disciplines. This is not directly the subject of the present paper, but the claim of the need for reintegration of the view of reality may generate the question about its justification. Thus, the most prominent points of the discussions will be reported shortly.

The global scale disaster of the Second World War with its unprecedented atrocities led to the recognition of the consequences of the fragmentation of human intellect distributed among the highly specialized experts who lost the vision of reality as a whole in all its interrelated natural and humanistic aspects. This recognition became the subject of the common interest and multiple disputes all over the world after the publication of the 1959 book *The Two Cultures* by C.P. Snow [4]. Snow directly blamed the split into Two Cultures, that of the humanities and that of science and engineering for the degradation of intellectual elites willing to engage or at least tolerate war crimes committed by their own authorities.

Actually, the concern about the threats to the values of a free society caused by the spontaneous election of specialized individual curricula by students who had free choice of courses motivated the administration of Harvard University to form the Faculty Committee on General Education already in

1943. The famous so called “Redbook” on General Education, with the univocally approved by the entire committee report and recommendation of the policy, was published two years later [5].

The difference between the two publications, by Snow and by the Harvard Committee, was not in the diagnostic of the problem, but rather in their objectives. Both identified intellectual fragmentation as the main issue and both blamed the shortcomings of education for this fragmentation. Harvard Committee focused not only on the diagnostic, but also on the means to achieve the reintegration through the reform of the secondary and postsecondary General Education, which already existed, but which was ineffective in achieving its goals. Both publications promoted distribution of the subjects of study to provide graduates with sufficiently wide knowledge extending far beyond the subject of a more focused concentration of study. Recommendation from the Harvard Committee became the pattern for the entire American higher education, and both books influenced education in universities all over the world with some high and low levels of support through the decades. Whatever high or low points of General Education we can identify, it was clear that the goals of reintegration of Two Cultures were not achieved and that the cultures accelerated in their drifting apart.

Another form of the recognition of the problem of fragmentation together with the reflections on the methods of reintegration can be exemplified by the two books published by Edward O. Wilson, the first in 1998, *Consilience: The Unity of Knowledge* and the second in 2011, *The Meaning of Human Existence* [6,7]. Equally influential was the book *Mind and Nature: A Necessary Unity* published by Gregory Bateson in 1979 [8]. These are not the only books on the subject of the fragmentation of the scientific vision of reality and of the need for its reintegration, but the prominence of the authors generated a very wide resonance in the general public and among scientists and philosophers.

Not all works on the unification of science or its disciplines, such as physics, directly refer to fragmentation, but the fact that their focus is on the integration of subjects, methods or positions indicates that this fragmentation is problematic. For instance, Frank Wilczek, in his 2015 article, “Physics in 100 Years” does not lament lack of cohesion of physics, but considers different forms of the unification of physics as a most important aspect of the development of this discipline [9].

The discussion of the internal fragmentation of physics, apparently the most cohesive discipline of science, continued for years. It is generated and driven by the wide range of problems from the long chain of failures in the reconciliation between the Quantum Theory and the General Relativity Theory, through the failure to account for 94% of the universe mass and energy, popularly called the dark energy-matter, to more sensational, but not less serious problem of the failure to get clear judgment on the controversial work of the French brothers, Igor and Grigori Bogdanov, who at the turn of this century, defended their doctoral dissertations and published their papers in spite of the prevailing opinion that the content was pure nonsense expressed skillfully in scientific jargon [10]. In this last case, those who approved the degrees and accepted the papers and those who denounced them as fraud could not find the common criteria of evaluation.

Finally, an example of a comprehensive and in depth philosophical analysis of the issues related to the subject of fragmentation, but in the much more extensive context, can be found in the collective work of seventeen authors: *Stepping Beyond the Newtonian Paradigm in Biology: Towards an Integrable Model of Life—Accelerating Discovery in the Biological Foundations of Science INBIOSA White Paper* [11].

There is a natural and legitimate question whether the solution of the problem can be found within the existing framework of science by simply reestablishing more naturalistic standards for all forms of inquiry.

The two main sources of problems in the naturalistic positions giving science its primary role in the inquiry of reality are an unavoidable specialization of domains, disciplines, theories and the use of common sense as a substitution for the methodology of their re-integration. The fragmentation of science (actually, of the entire human intellectual activity) is a natural consequence of specialization as a method to overcome the complexity of all subjects of study. No individual can achieve even basic knowledge of all disciplines of inquiry. Progress in science requires an engagement of the large, specialized collectives and the division of labor within them. However, without any structurally

organized system integrating the outcomes of specialized inquiry across the superficial disciplinary borders all scientific activities and the progress of work leads from the increasing complexity of the subjects of the study to the increasing complexity of the results of the study. This may be sufficient for solving more practical, technological problems which do not require a broad perspective; but without the large-scale integration, we cannot claim success in the conquest of complexity. For this reason, all philosophical discussions of naturalism and its relation to different forms of the scientific realism that refer to science or scientific method, understood as well-defined and consistent concepts or at least as clearly comprehensible ideas, are highly problematic.

At this point, a disclaimer regarding the negative impact of the fragmentation of science becomes necessary. The coexistence of competing approaches, conceptualizations, and results within science is its fundamental and necessary characteristic. Science is a discourse among diverse conceptualizations and hypotheses. The integration or reintegration of science is understood here, not as a process of achieving stable homogeneity, but rather as a dialectic and dynamic development of the common stage for this constant scientific discourse in the form of an overarching methodology for building a unified but evolving vision of reality. This vision has to evolve, as otherwise, we cannot expect any progress.

Traditionally, there was a common belief that this unification of the vision of reality can be achieved by the methodological reductionism to physics, considered to be the root of the tree of knowledge or by the ontological reductionism of reality to the subject of physical theories. Today, the positivistic view of sociology initiated by Auguste Comte as “physics of society,” giving this particular discipline of science its distinguished position, is just a historical curiosity and physicalism is largely abandoned. Although some disciplines continue suffering from so called “physics envy,” there are calls for the change of the “paradigm” through giving the priority to biology, cognitive science or some other domain of scientific inquiry, but they are not less naive than the other forms of the domain-oriented reductionism. The vacuum left by physicalism was never filled by a commonly recognized and rigorously developed methodology of integration. Moreover, physicalism remains in the scientific and philosophical discourses in the covert patterns of thinking, manifested openly only in the common and apparently devoid of any specific intentional use of the terms such as “physical reality” instead of reality, “physical space” in reference to the spatial aspects of reality, or “matter” understood as a synonym of mass. Instead of seeking a foundation for the integrated view of reality in the choice of a distinguished already existing discipline, a different approach was proposed in the series of Special Issues of the journal *Philosophies* [2]. This alternative approach of a comprehensive domain of study was given the name of Contemporary Natural Philosophy.

There is another issue which should be considered in the search for broadening the perspective of inquiries. From time to time, there are short-lived attempts to engage in the scientific discourse the alternative cultural traditions of inquiry. Probably the most prominent example is an explosion of discussions on the foundations of physics stimulated by the 1975 bestselling book, *The Tao of Physics* by Fritjof Capra [12]. The ideas adapted from the philosophical tradition of the East were used to provide a justification for formalisms such as that of bootstrap. The issue is that these encounters with alternative cultural conceptualizations of reality were just momentary, if highly amusing fashions and they never led to actual integration of the alternative methodologies of inquiry into scientific or philosophical methodology.

This intercultural intercourse is another, perhaps most difficult role of integration, which goes beyond the internal divisions of sciences. Even before any form of integration of the diverse cultural traditions within philosophical inquiry of reality is achieved or advanced, it is possible to utilize their experience for the purpose of a better understanding of the present scientific methodology, when it is viewed from the external perspective.

2.2. Philosophical Framework of Contemporary Natural Philosophy

No matter how the Natural Philosophy was understood in the past, it was always related to science in multiple roles of a predecessor, precursor, guide, or a tool for hermeneutics of scientific

disciplines and theories. This makes science a natural, although not necessarily exclusive context for the discourse on the Contemporary Natural Philosophy as an integrated study of reality. In the following, this postulated form of inquiry will be addressed as already existing, although its identity is a matter of the idiosyncratic projection of the desired characteristics on the already existing but diverse tradition of the Natural Philosophy.

The present paper is not intended as a clearly formulated program for the future Contemporary Natural Philosophy, but rather as a study of conditions necessary for its design and implementation allowing progress beyond the present status of scientific knowledge or its philosophical interpretation. However, the possible diverse ways of understanding the tradition of Natural Philosophy, and of its relation to the presented here program of a new domain of inquiry, make some more specific explanation necessary. Our objective is to eliminate fallacies which are relative to the goals of the Contemporary Natural Philosophy. It is important to avoid confusion regarding its role and goals, so we have to start from disambiguation.

Contemporary Natural Philosophy does not have a subservient role with respect to science, but rather, it is a design for its extension, revision and revival as a style of integrated inquiry capable of overcoming the limitations imposed by complexity of reality. This style of inquiry should avoid the generation of complexity of its results, preventing their unification into a consistent vision. The revision should not be limited to the saturation of science with philosophy or philosophy with science. It is true that philosophy has an important role in science and it is sad and symptomatic for the deficiency of its present state that this role has to be explained and defended, as, for instance, in the opinion paper, "Why Science Needs Philosophy," written by a group of researchers and philosophers about the instances of the influence of philosophy on recent important developments in life sciences [13]. The fact that it is necessary to convince anyone about the value of interaction between science and philosophy is alarming, but it does not explain much about the desired direction of transformations in the style of inquiry. This, of course, does not lower the value of the attempts to promote the intercourse between science and philosophy, such as that in the mentioned paper.

Contemporary Natural Philosophy is not an addition of the layer of a "second order science" postulated under the influence of the "second order cybernetics" [14–17]. At the first sight, someone can be convinced by the statements made by the proponents of the "second order science" and may believe that its objectives are very close to those of the Contemporary Natural Philosophy, such as an internal control of the methodology of inquiry. Certainly, this form of control requires a very thorough study of the hidden assumptions influencing the outcomes of inquiry and we can easily agree with its necessity. However, a closer look makes it clear that the concern in the "second order science" is not about the methodological aspects of science, but rather about psychological determinants influencing scientists. This is clearly stated by Michael Lissack,

The traditional sciences have always had trouble with ambiguity. To overcome this barrier, 'science' has imposed 'enabling constraints'—hidden assumptions which are given the status of *ceteris paribus*. Such assumptions allow ambiguity to be bracketed away at the expense of transparency. These enabling constraints take the form of uncritically examined presuppositions, which we refer to throughout the article as 'ucepts.' [. . .] Second order science reveals hidden issues, problems and assumptions which all too often escape the attention of the practicing scientist (but which can also get in the way of the acceptance of a scientific claim) [17].

The most important fallacy of this view is in the claim about the "hidden assumptions which are given the status of *ceteris paribus*." The method of abstraction, more frequently called the method of idealization expressed as *ceteris paribus* (everything else equal) is not hidden at all, at least from the time of Galileo. It is the central tenet of scientific methodology seeking the reduction of complexity. The idea of the internal mechanism of the methodological control in the Contemporary Natural Philosophy

is much closer to Heinz von Foerster's original concept of the "second order cybernetics" formulated in a much broader perspective of general systems [14].

Certainly, the intellectual experience of philosophy, including philosophy of science as well as the scientific studies in the subject of psychology and sociology of scientists and their organizations, or more generally, of human beings and their organizations, may be very useful in the Contemporary Natural Philosophy and its methodology, but they can contribute very little to the effort of reintegration of science. The studies of scientific activities of individuals or collectives in psychological or sociological perspectives are of great value for improvement of scientific organizations and they can contribute to the progress of science or inquiries in general. However, the greatest achievements in science and philosophy were frequently products of the work of exceptional, highly talented individuals who sometimes worked alone, removed from the influence of the mainstream intellectual trends or who rebelled against tradition. These individuals rarely could be analyzed in terms of the study of average members of human collectives. We can learn from their stories about creating the best conditions for fostering intellectual inquiries made by exceptionally talented individuals, but not about the desired directions of these inquiries.

More generally, Natural Philosophy is definitely not an equivalent of Philosophy of Science. They have very different methods and different objectives. The former attempts to study reality in a systematic way, engaging in some extent, the experience and methods of science; the latter has as its subject, science itself as a domain of human activity and its products. The central position of science in the project of Contemporary Natural Philosophy does not mean that science and its methods are of exclusive interest. Thus, while the naturalized epistemology of Willard Van Orman Quine is quite close to the spirit of the project, his famous and intentionally provocative statement, "philosophy of science is philosophy enough" [18] is very far from the vision of the new domain presented here.

Some parallels with Quine's thought or with the views of other philosophers should not be misleading. For instance, the present paper subscribes to the normative rule, "philosophy can, and should, make use of any of the forms of reasoning appropriate to scientific research," which is in perfect agreement with Larry Laudan's normative naturalism [19]. However, in the exact opposition to Laudan and his preference for "cognitive values" (scope, generality, coherence, consilience, and explanatory power) and "social values" (related to social processes of communication, negotiation, and consensus formation) over "epistemological values" such as truth, this paper defends the fundamental role of the concept of truth. Similarly, Quine's attempt to understand science exclusively from within the resources of science itself is too narrow to be acceptable as a principle for the Contemporary Natural Philosophy.

In agreement with the strategy to be as little restrictive as possible, there are only few characteristics of the Contemporary Natural Philosophy assumed here. Thus far, I presented more a "wish list" than actual description of the Contemporary Natural Philosophy. What would be the best description?

Contemporary Natural Philosophy is understood here as a pursuit of the integrated description of reality which is distinguished by the precisely formulated criteria of objectivity and by the assumption that the statements of this description can be assessed only as true or false according to clearly specified verification procedures established with the exclusive goal of the distinction between these two logical values, but not with respect to any other norms or values established by the preferences of human collectives or by the individual choices. Since the exclusive true-false distinction plays here a fundamental role, it has to be stressed that this distinction assumes only logical consistency, but not completeness. This means that completeness (i.e., the feasibility to assign true or false value to all statements which can be formulated) is desirable, but may be impossible.

Of course, Contemporary Natural Philosophy is a human product and as such, can be a subject of normative judgments at the level of meta-study. Moreover, its criteria of objectivity and its verification procedures evolve together with the collective experience of those engaged in the inquiries and of the state of the overall vision of reality produced within the Contemporary Natural Philosophy. Thus,

we can expect that the judgments of objectivity or truth from one stage of the inquiry may be reversed at a later time.

Additionally, the inquiries may involve the concept of probability in two ways. In one way, the probability of the truth of a statement in an inquiry can be considered as an expression of the epistemological use of the probability in inductive reasoning. This does not contradict the principle of the exclusive true-false logical values of acceptable statements, because the probability applies here to the knowledge of the logical status of the statements, not to the logical status itself. The other form of an engagement of probability theory can be directly in the statements about reality. In this case, the statement about the probability of some event within reality is about some aspect of reality and this statement can be assessed as true or false. Thus, here too, we do not have any inconsistency with the exclusive true-false values of the statements of inquiries. Some forms of the description of reality can have probabilistic form. The key point is whether this description is true or not.

It is easy to recognize the affinity of the Contemporary Natural Philosophy as presented here with Ilkka Niiniluoto's critical scientific realism [20], or with Michael Dummett's view of realism [21]. Both authors emphasize the importance of bivalence of truth-falsity as a necessary condition for realism, and this is in full agreement with the description of the Contemporary Natural Philosophy above. However, this paper is intended as a study of methods for a very broad and diverse direction of inquiry, and the emphasis on more specific understanding of realism or reality may defeat its purpose. For instance, the issue of the independence of reality from its human exploration (perception, cognition, empirical observation) is highly non-trivial and far from being established in the context of modern science, in particular of quantum mechanics, in which the state of quantum systems is not an observable and is dependent on the act of measurement. The only claim of the realistic doctrine acceptable here would be that the existence of any actual entity should be independent from our conceptualization of existence or from our will, but even this may require some qualification.

Even weaker forms of openly declared realism which do not refer directly to independence of reality from the inquiry may be too restrictive. The closest to the objectives of the Contemporary Natural Philosophy would have been the tenets of the realist liberal naturalism as presented by Mario De Caro:

The tenets of realist liberal naturalism are: (i) A liberalized ontological tenet, according to which some real and non-supernatural entities exist that are irreducible to the entities that are part of the coverage domain of a natural science-based ontology; (ii) A liberalized epistemological tenet, according to which some legitimate forms of understanding (say, a priori reasoning or introspection) are neither reducible to scientific understanding nor incompatible with it; (iii) A liberalized semantic tenet, according to which there are linguistic terms that refer to real non-supernatural entities that do not form part of the coverage domain of natural science and are not reducible to those entities which do; (iv) A liberalized metaphilosophical tenet, according to which there are issues in dealing with which philosophy is not continuous with science as to its content, method and purpose [22].

However, the references to the concepts of "non-supernatural entities" or "non-continuity of philosophy with science" make this description of realism questionable and not acceptable for the characterization of the Contemporary Natural Philosophy.

Therefore, the issue of how to understand reality can be studied in a much more suitable context of objectivity than that of the independence from human observer or human observation, where objectivity is understood as invariance or covariance with respect to transformations induced by the change of observer or a reference frame. Probably the most suitable for our purpose is the concept of realism as the doctrine that the existence is separate or independent from the conceptions of it, which avoids commitment to the independence of the observer and the observed. It is true that such independence is preferred or even expected, but only the feasibility of knowing objective reality is postulated. After all, if we establish some form of rigorously defined objective criteria for objectivity (understood as

invariance and opposed to subjectivity understood as the trivial invariance reduced to identity) [23], the definition of reality as that which satisfies these criteria is a simple consequence. While in the development of science (in particular physics) there was not much interest in the description of what reality is or what is real; the question about the criteria of objectivity was at the center of attention of scientific methodology, at least through the last four centuries.

Quite obviously, Contemporary Natural Philosophy is in direct opposition to Postmodernism and its denial of objective reality. For some contributors to the project, "Postmodern attack on Structuralism," which was probably the most important and most advanced attempt to reconcile natural sciences with the humanities, was a very strong motivating factor in the search for the revival of Natural Philosophy. From this point of view, Postmodernism can be used in the explanation of the ideas of the Contemporary Natural Philosophy as its antithesis.

In his 1979 metanarrative, *The Postmodern Condition: A Report on Knowledge*, Jean-François Lyotard initiated a crusade against metanarratives with the frequently repeated by others sentence: "Simplifying to the extreme, I define postmodern as incredulity towards metanarratives" [24]. The metanarrative against metanarratives is not the only self-contradiction of Postmodernism, but such contradictions seem not to bother the adherents of the revolt. The main topic of the book was a critique of metanarrative (or grand narrative) of science. Lyotard later admitted that his knowledge of science at the time of writing the book was negligible [25]. However, the critique, together with the commonly misunderstood Wittgenstein's idea of language-games (unfortunately, frequently interpreted without any basis in *Philosophical Investigations* that the use of the word "games" indicates that Wittgenstein dismissed any serious consideration for meaning) and with the openly expressed distaste for abstraction, led to the cult of the particular as opposed to general (power of individual event).

This confluence of ideas was promptly used against the ideas of Structuralism. This revolt against structuralism was deeper than just the anger generated by the perceived incomprehensibility and un-intuitiveness of scientific theories, and the limitation of the freedom of philosophizing by the requirements of the intellectual discipline imported from mathematics and science. Even stronger negative reactions were generated by the claims of the dismissal of apparently naturally existing chaos and disorder of the universe. Here, the opposition to the central ideas of Contemporary Natural Philosophy is the most direct and overt.

The irony of the intellectual history manifests here, once again. Lyotard's confession of his ignorance regarding science was sincere and his anti-scientific sentiment was very clear, but what he intended as a critique of science (e.g., of the lost commitment to the truth and the submissive conduct with respect to power and corporate interests) was actually an accurate critique of the social conditions in which scientific inquiry had to be conducted. Thus, the revolt was actually directed not against science, but against its corruption and ultimately, was in the name of science. There are some other points where the Postmodernist critique of science and scientific method could resonate among those who believe in the need for the transformation of science, however, the central tenet of the rejection of metanarratives in Postmodernism is irreconcilable with the fundamental commitment of the Contemporary Natural Philosophy to the search for the integrated understanding of reality.

3. From Baconian *Idola Mentis* to Contemporary *Idola Mentis*

The present revival of the interest in the Natural Philosophy reminds us of the situation in the past when Natural Philosophy started to emancipate from other forms of the philosophical inquiry and reflection at the beginning of the 17th century. This was the beginning of science before its fragmentation into specialized disciplines. At that time, it was necessary to reflect on the limitations of the Mediaeval Scholastic philosophical tradition and its sources in the philosophy of Mediterranean Antiquity. Baconian criticism of *idola mentis* was essentially nothing else but the "second order science" in the early 17th century format. Bacon was an equally adamant enemy of the involvement of abstraction or theory in the process of accumulation of knowledge, giving it only a secondary role of organizing the results in a more systematic way. This was an exactly opposite position to that

of Galileo, who wanted to read the book of nature written in the language of geometry and who avoided the use of inadequate instruments when logical or mathematical reasoning was sufficient. For instance, he preferred to conceive the thought experiment of two stones tied together with a string as a justification for equal speed of falling objects over the falsely ascribed to him observations of falling stones thrown from the Leaning Tower of Pisa.

Baconian method was still firmly rooted in the passive observation in which he was very similar to his nemesis Aristotle, who strongly believed that this is the ultimate source of knowledge. Aristotle did not restrict himself to his own observations but accepted, in some cases, the accumulated knowledge from the observations of our predecessors reflected and preserved in the language. For Bacon, this would have been unacceptable. In Baconian vision of inquiry, the engagement of an observer's action was only in the "artificial" arrangement of the observed phenomenon outside of the usual context, but the observation itself was understood by him as a direct pathway from the perceptions of senses to the mind without any mediation of a theory or abstraction.

Galileo was aware of the importance of instruments, their construction, and of the influence of their inadequate precision. For this reason, he frequently replaced direct observation (of, for instance, free fall of objects) with the experiments involving manipulation of the observed system by an experimenter accompanied with the theoretical analysis of the settings and outcomes (as in the experiments with the motion of minimal friction objects on the inclined plane). Probably these important methodological differences were the main reason why Galileo made such important contributions to physics, while those of Bacon were almost exclusively to the organization of science and to the promotion of the idea of empirical methods.

While the direct contributions of Bacon to science, in general, and to physics, in particular, were of negligible importance, and his insistence on direct observation purified of any form of abstraction or theory was misguided, his reflection on the conditions for the effective ways of inquiry are still valuable now as they were in his time—of course, when we translate them into the language of modern science and consider them in the modern context.

The original four *idola mentis* denounced by Bacon were introduced in the following Aphorisms of *Novum Organum* [26]:

"XXXIX. Four species of idols beset the human mind, to which (for distinction's sake) we have assigned names, calling the first Idols of the Tribe, the second Idols of the Den, the third Idols of the Market, the fourth Idols of the Theatre."

"XLI. The idols of the tribe are inherent in human nature and the very tribe or race of man; for man's sense is falsely asserted to be the standard of things; on the contrary, all the perceptions both of the senses and the mind bear reference to man and not to the universe, and the human mind resembles those uneven mirrors which impart their own properties to different objects, from which rays are emitted and distort and disfigure them."

"XLII. The idols of the den are those of each individual; for everybody (in addition to the errors common to the race of man) has his own individual den or cavern, which intercepts and corrupts the light of nature, either from his own peculiar and singular disposition, or from his education and intercourse with others, or from his reading, and the authority acquired by those whom he reverences and admires, or from the different impressions produced on the mind, as it happens to be preoccupied and predisposed, or equable and tranquil, and the like; so that the spirit of man (according to its several dispositions), is variable, confused, and as it were actuated by chance; and Heraclitus said well that men search for knowledge in lesser worlds, and not in the greater or common world."

"XLIII. There are also idols formed by the reciprocal intercourse and society of man with man, which we call idols of the market, from the commerce and association of men with each other; for men converse by means of language, but words are formed at the will of the generality, and there arises from a bad and unapt formation of words a wonderful obstruction to the mind. Nor can the definitions and explanations with which learned men are wont to guard and protect themselves in some instances

afford a complete remedy—words still manifestly force the understanding, throw everything into confusion, and lead mankind into vain and innumerable controversies and fallacies.”

“XLIV. Lastly, there are idols which have crept into men’s minds from the various dogmas of peculiar systems of philosophy, and also from the perverted rules of demonstration, and these we denominate idols of the theatre: for we regard all the systems of philosophy hitherto received or imagined, as so many plays brought out and performed, creating fictitious and theatrical worlds. Nor do we speak only of the present systems, or of the philosophy and sects of the ancients, since numerous other plays of a similar nature can be still composed and made to agree with each other, the causes of the most opposite errors being generally the same. Nor, again, do we allude merely to general systems, but also to many elements and axioms of sciences which have become inveterate by tradition, implicit credence, and neglect. We must, however, discuss each species of idols more fully and distinctly in order to guard the human understanding against them.”

We can find in Baconian idols the reflections of the earlier philosophical thought. The Idols of the Den are not very far removed from Plato’s Allegory of the Cave in his *Republic* which might have been the reason for their name. The similarity of Baconian Idols to the three centuries’ earlier Roger Bacon’s *offendicula* in *The Four General Causes of Human Ignorance (Causae Erroris)* forming Part I of his *Opus Majus* is very unlikely to be accidental [27]. Roger Bacon considered *offendicula* as the obstacles to acquiring real wisdom and truth, classified into four categories: (1) following a weak or unreliable authority, (2) custom, (3) the ignorance of others, and (4) concealing one’s own ignorance by pretended knowledge.

In turn, we can easily recognize in Baconian idols the precedents of some major philosophical and scientific themes. For instance, the Idols of the Tribe refer to the bias common to all human inquirers, and coming out of the features of human senses and the ways they present objects to the mind. The issue whether we can overcome this bias of mediation and in what degree we can know reality was prominent in philosophical contributions of John Locke, David Hume, and most famously, Immanuel Kant and his followers. Another evidence for the continuing interest in the matters considered by Bacon is in the fact that the Idols of the Market can be almost directly translated into the Sapir-Whorf Hypothesis of the culturally determined features of the language influencing human cognition and therefore, shaping the way we comprehend reality [28].

The threat of being deceived by Baconian idols and the directive to adhere to the straightforward use of induction as the only tool of inquiry had its reflection in scientific contributions very different from the vision of Bacon. Even Isaac Newton, whose most important work *Principia* was very close to the style of, and openly patterned on Euclidean *Elements* and therefore, saturated with the purely theoretical style of inquiry in its axiomatic form, capitulated in the face of the mystery of gravitational action on the distance with his famous declaration of *hypotheses non fingo*:

I have not as yet been able to discover the reason for these properties of gravity from phenomena, and I do not feign hypotheses. For whatever is not deduced from the phenomena must be called a hypothesis; and hypotheses, whether metaphysical or physical, or based on occult qualities, or mechanical, have no place in experimental philosophy. In this philosophy particular propositions are inferred from the phenomena, and afterwards rendered general by induction [29].

Most likely, this *hypotheses non fingo* was an expression of his desperation. It was the only point where the laws of motion proposed by René Descartes, in his posthumously published in 1664 *Le Monde*, were superior in the strict adherence to the interaction on contact, easily defensible by the straightforward induction [30]. In the confrontation with the competing approach to the laws of motion, Newton probably did not want to open his work to the criticism of using clearly empirically non-testable explanations and he could not find the testable ones.

While the description of the idols in the *Organum Novum* is too simplistic to be used for the present scientific practice, they can help us to identify modern idols understood as habits of thought which

can generate obstacles in inquiries of the Current Natural Philosophy, in particular, in its integrative role. There are three categories distinguished here: the Idols of the Number, the Idols of the Common Sense, and the Idols of the Elephant, if we want to follow Bacon's style of giving names to categories of transgressions. The three categories are not entirely independent among themselves and not entirely independent from Baconian idols. The division into the triad of categories is purely conventional and rather a matter of convenience than a reflection of some deeper universal rules of human fallibility in the search for truth. They refer to the three different distinctions which are commonly but erroneously assumed to be obvious and absolute.

4. The Idols of the Number

This category is related to the common forms of misunderstanding of the role of mathematics in scientific or philosophical inquiries. The most prevalent but almost never questioned misunderstanding is in the belief in the fundamental distinction between quantitative and qualitative forms of inquiry. The latter, typically considered inferior, primitive or less "precise" is associated with qualification, i.e., with the partitioning of the set of objects according to their possession of some properties (or qualities). The former, apparently superior and more precise, is associated with quantification, i.e., with the assignment of a magnitude expressed as a number qualified by an occasional restriction that it has to represent a measure or count. This seems to be an ultimate dream of a scientist, and nobody asks the question when actually we know, when we know it. The focus is on whether other, preferably "independent" researchers confirmed the values, not on what numbers actually tell us.

It takes some knowledge of mathematics to realize the close resemblance of many claims of the "scientific" achievement in establishing the values of some magnitudes to the answer "42" given by the computer Deep Thought to the Ultimate Question of Life, The Universe, and Everything in the cult novel *The Hitchhiker's Guide to the Galaxy* by Douglas Adams [31]. There are many levels of misunderstanding in the fascination with numbers as a core of science starting from the most elementary, where the sources of misconceptions are simple errors, and the lack of mathematical education to quite advanced produced by another manifestation of fragmentation, when even very famous contributors to one sub-discipline of mathematics make statements well known in another sub-discipline as elementary errors.

4.1. What Do We Know When We Know the Number?

Thus, starting from the most elementary level, we have to eliminate the confusion of numbers and numerals which are their conventional, symbolic representations. Neither the arithmetic of natural numbers, nor any other theory can tell us whether $2 + 2 = 4$, $2 + 2 = 5$, or $2 + 2 = 11$, unless we fix the convention of numerical representation. Thus, Max Tegmark's statement:

Modern mathematics is the formal study of structures that can be defined in a purely abstract way. Think of mathematical symbols as mere labels without intrinsic meaning. It doesn't matter whether you write 'two plus two equals four', ' $2 + 2 = 4$ ' or 'dos mas dos igual a cuatro'. The notation used to denote the entities and the relations is irrelevant; the only properties of integers are those embodied by the relations between them. That is, we don't invent mathematical structures—we discover them, and invent only the notation for describing them. So here is the crux of my argument. If you believe in an external reality independent of humans, then you must also believe in what I call the mathematical universe hypothesis: that our physical reality is a mathematical structure. In other words, we all live in a gigantic mathematical object [. . .] [32],

in which he tries to summarize his central idea of *The Mathematical Universe* published elsewhere in a more elaborate format, is a surprising mixture of contradictory statements.

The first statement is in exact agreement with the view presented here in this paper, although with the usual unfortunate assumption that the term "structure" is already known, while it is probably the

most frequently used but the least understood, and still lacking a sufficiently general definition concept in discourses on mathematics. It is followed by the statement involving " $2 + 2 = 4$ " which suggests that this equality is true, but which is not formulated in the abstract language of mathematics (arithmetic), free from the dependence on convention and therefore, it is just a matter of conventional choice whether it is true or not. For instance, the first and the third equality above are true but in different conventions (decimal and ternary numerical systems, respectively). Then suddenly, we learn that, "That is, we don't invent mathematical structures—we discover them, and invent only the notation for describing them."

Yes, in the case when we write " $2 + 2 = 4$ " we do not invent mathematical structures, but this is not writing a mathematical theorem. As Tegmark rightly stated at the beginning, "Modern mathematics is the formal study of structures that can be defined in a purely abstract way", and therefore, he admits that we define them, which for the purpose of simplicity of the language can be expressed that we create them or invent them. The statement "properties of integers are those embodied by the relations between them" is mysterious and difficult to analyze as it does not fit any standard use of the term "embodiment". Tegmark wrote earlier in the same article, "Here, I will push this idea to its extreme and argue that our universe is not just described by mathematics—it is mathematics" [32]. This pushing is definitely not very convincing but it demonstrates very well the dangers of the unfortunately frequent confusion of semantics with ontology. The fact that some statements have well-identified intentions, which is not exactly the case in the quoted passage where the meaning of some statements is unclear, does not entail their ontological status.

The confusion of numerals with numbers is only the first of many fallacies. To prevent it, statistical terminology of data requires that the main distinction between their quantitative type and qualitative type is that the former are expressed as numbers representing a count or measure, while the latter (possibly in the numeral form) represent the partition into disjoint classes (i.e., equivalence relations). The problem is that actually both types of data represent equivalence relations. In probability and statistics, it is clearly visible in the concept of a random variable when it is defined on a sampling space. The inverse images of the values of a random variable are simply classes of equivalence [33]. In the case of natural numbers (counts), this is more straightforward when we understand them as finite cardinal numbers defined by the equicardinality equivalence relation.

Thus, the engagement of numbers as values of counts or measures serves the purpose of the construction of equivalence relations on the set of objects of our inquiry, differing only in specifics from the qualitative analysis. This can be concluded from the casual reflection on physical magnitudes. They all have values expressed in conventional units, recently, mainly international SI units. The choice of the standard values is purely conventional and only the choice of fundamental magnitudes (called physical dimensions), although not free from some level of conventionality, is justified by physical theories. Here, it is easy to see that the particular value of the magnitude does not say anything about reality, but tells us about the equivalence class to which the outcome of observation belongs. Measuring the magnitudes is a tool to establish equivalence relations between the elements of reality. These equivalence relations in turn are involved in producing a wide range of mathematical structures such as partial order, topology, vector spaces, etc. At the same time, equivalence relations serve another purpose of lifting the level of abstraction when equivalence classes (subsets of the original set of objects) become the elements of the power set.

Finally, here is the key point of the methodology of the Contemporary Natural Philosophy understood as an integrative inquiry with the goal of reduction or elimination of complexity. Whatever is our understanding of natural or artificial intelligence, their most important feature is the ability to overcome the limitations imposed by the complexity of the environment. The primary tools for this purpose are the integration of information and abstraction [33–36].

The fallacies of the Idols of the Number do not discredit the importance of numbers in structuring our experience of reality. However, this importance has its source not in numbers themselves, but in structures which they form. At this point, it is necessary to refer to the next topic of the Idols of the Common Sense in which fallacies frequently arise from the illusion of obvious ideas.

Probably everyone (except mathematicians working in the number theory) believes that the concept of a number is obvious. School teachers sincerely believe that their introduction of the so called “real line” makes the concept clear and intuitive, when they draw on the blackboard a line, add to it an arrow on one side indicating the choice of one of the two possible choices of the linear order, mark two points indicating the location of 0 and the location of 1 and declare “To every real number different from 0 (we are done with it) corresponds exactly one point on the line which is on the right of point 0 if the number is positive, on the left if negative and which is in the distance from 0 equal to the absolute value of the number in consideration. Also to every point on the line corresponds exactly one real number identified as the distance from point 0 for points on the right side and its opposite for points on the left side of the line”. Kids are happy that they can understand real numbers well and teachers are happy that they could give students a precise conceptual tool. After all, all concepts engaged in the construction of this structure are precise, clear and, at the same time, they are very intuitive by the reference to the association number-point. We do not need these nasty Dedekind cuts to understand numbers, is that not right?

The answer to the question is obvious: Wrong! The distance can be understood properly, only after we conceptualize real numbers and there is nothing a priori which we can use in the general case to determine where is the point with given distance to the point associated with 0; moreover, there is no way to determine what is right and what is left. This illusion of understanding is reflected in the popular belief that the numbers (real numbers) are very well understood and therefore, they provide the magic key to the proper understanding of reality.

The history of numbers reflects the entire intellectual history of humanity, but we cannot elaborate on it in this paper. Some moments of this history can explain the complications of a special importance in this study. Originally, in the European tradition with its sources in Greek philosophy, numbers were understood as those which we now call rational numbers (expressible, but not uniquely as proportions of integers), with the very clearly stated relational character, as they were derived from the arbitrarily selected geometric unit segment through geometric constructions. Numbers were proportions between geometric objects. For this reason, neither 0 nor 1 were considered numbers. It was the proof that the length of the diagonal in a unit square cannot be described by a number (i.e., rational number) that prompted search for the extension of the concept of numbers. The outline of the idea was provided by Eudoxus of Cnidos in times of Plato, but only in the second half of the 19th century did Richard Dedekind introduce a well-defined concept of real numbers based on what now we would call the completion of the linear order of rational numbers in terms of a Galois connection (i.e., mentioned above “nasty Dedekind cuts”) [37]. By this time, the quantitative inquiry style was already established in the methodology of science, even if nobody really knew how to understand real numbers playing the central role in it. This should not be surprising, since even today probably less than 1% of people who use the quantitative methodology of science and who strongly believe in its superiority over the qualitative methods actually understand the concept of real numbers.

The importance of numbers as tools to describe the structure of order of the components of reality was already mentioned in the context of the extension of rational numbers to real numbers. However, it is only one type out of many structures which are generated by the association of numbers with the objects of reality. Moreover, in the text above, there was an emphasis on the recognition of the important distinction. The generation of the structures in the description of reality is not by numbers but by their structures. Theory of numbers is a theory of algebraic structures on sets of numbers. To appreciate the level of complexity and the importance of philosophical consequences of the structures of numbers, it is necessary to review some elementary mathematical facts.

4.2. Numbers and Their Structures

The presentation here will not require any previous knowledge of algebra beyond high school mathematics and the review is indispensable for the proper understanding of philosophical consequences of quantitative methodology. Apologies to mathematically educated readers who may

decide to skip the presentation and proceed to its conclusion. If they read it, they may notice some restrictions of generality for the sake of simplicity (for instance, the consideration of algebras with n-arity of operations limited to at most 2) which prevents an unnecessary increase of complexity.

Algebraic structures or more formally general algebras are understood as sets equipped with one, two or many, sometimes infinitely many, operations. We can restrict our attention here to algebraic structures (general algebras) with two, one or zero arguments producing the result. The formal terminology is that these operations are binary, unary or nullary, respectively. The addition of numbers is an example of a binary operation: $a + b = c$ which takes two arguments a and b and gives the outcome c . Taking opposite number is a unary operation corresponding to addition $a \rightarrow a_+^{-1} = -a$ with the traditional notation a^{-1} for the inverse coming from the fact that the inverse for a non-0 real number a is its reciprocal $1/a = a^{-1}$. The nullary operation does not require any choice of arguments as its value is independent from arguments and consists in the selection of some constant element, for instance, the choice of 0 or choice of 1 which both have special roles of the neutral element as defined below. Notice that to define an operation on a set requires that for all arguments there is an outcome of the operation.

General algebras form an informal, traditionally and logically justified hierarchy (usually) starting from the concept of a semigroup $\langle S, \bullet \rangle$ defined simply as a set S with a binary (i.e., two argument) operation \bullet understood as a function from $S \times S$ to S which is associative, i.e., $\forall a, b, c \in S: (a \bullet b) \bullet c = a \bullet (b \bullet c)$. Whenever this is not confusing, we can drop the symbol \bullet and write the juxtaposition ab instead of $a \bullet b$. The symbol \bullet will be used only when the symbol of the operation without its arguments is necessary. Notice that the binary operation does not have to be commutative, i.e., in general, we do not require that $ab = ba$.

Thus, the only two conditions for a semigroup, below written in the simplified notation are:

- (no name as it is the universal condition for operation) $\forall a, b \in S \exists c \in S: ab = c$
- associativity can be written simply $\forall a, b \in S \exists c \in S: ab = c \forall a, b, c \in S: (ab)c = a(bc)$.

We define a neutral element e (the choice of letter is traditional) as an element satisfying the condition: $\forall a \in S: ae = ea = a$.

Semigroup with a neutral element e is called a *monoid*.

It is very easy to show that a semigroup can have, at most, one neutral element. Thus, we can say, "the neutral element e " when it exists. Both addition in real numbers (with the neutral element 0) and multiplication in real numbers (with the neutral element 1) define the structure of a monoid.

In a monoid with the neutral element e , we can define the concept of the inverse a^{-1} for an element a .

An element a^{-1} satisfying the condition: $aa^{-1} = a^{-1}a = e$ is called an inverse of a .

Once again, there is a very short and easy proof of a proposition: A monoid can have, at most, one inverse for each element. The respective inverses for addition in real numbers and multiplication in real numbers are for every a given by $-a$ and $1/a$, respectively.

This brings us to the most important general algebra in the entire mathematics defined as: A monoid in which every element has inverse is called a group.

The set of real numbers R with addition $+$ forms a group $\langle R, +, 0, a \rightarrow a_+^{-1} \rangle$. This group is called a commutative group, because for all real numbers: $a + b = b + a$.

There is a natural question: Is the set of real numbers R with multiplication a group? The answer is no, because 0 does not have a multiplicative inverse, since for every real number a $0a = 0$ and therefore $0a \neq 1$.

However, we can introduce the structure of a multiplicative group on the set $R^* = R \setminus \{0\}$.

The group $\langle R^*, \bullet, 1, a \rightarrow a_{\bullet}^{-1} \rangle$ with respect to multiplication \bullet on the subset $R^* = R \setminus \{0\}$ is commutative. Obviously, the subset R^* of R is closed with respect to multiplication, i.e., $\forall a, b \in R^*: ab \in R^*$ and $\forall a \in R^*: aa^{-1} = a^{-1}a = 1$ when $a^{-1} = 1/a$.

Now, we can consider an algebraic structure with two binary operations $+, \bullet$ on the set of real numbers R (for $+$) and R^* (for \bullet) $\langle R, +, 0, a \rightarrow a_+^{-1}, \bullet, 1, a \rightarrow a_{\bullet}^{-1} \rangle$ where $\langle R, +, 0, a \rightarrow a_+^{-1} \rangle$ is

its additive commutative group and $\langle R^*, \bullet, 1, a \rightarrow a_{\bullet}^{-1} \rangle$ is its commutative multiplicative group. This type of an algebraic structure is called a field if $\forall a, b, c \in S: a(b + c) = ab + ac$, i.e., multiplication is distributed over addition.

We can consider a general algebraic structure of a field $\langle K, +, 0, a \rightarrow a_+^{-1}, \bullet, 1, a \rightarrow a_{\bullet}^{-1} \rangle$ (if no confusion is likely, we will write shorter: $\langle K, +, 0, \bullet, 1 \rangle$) defined not necessarily on real numbers but on a set K , where $\langle K, +, 0, a \rightarrow a_+^{-1} \rangle$ is a commutative group (we say the additive group of the field) and K^* is a commutative group $\langle K^*, \bullet, 1, a \rightarrow a_{\bullet}^{-1} \rangle$ where $K^* = K \setminus \{0\}$ (we say the multiplicative group of the field). We combine these two groups with the requirement that multiplication is distributed over addition: $\forall a, b, c \in K: a(b + c) = ab + bc$.

We will talk here only about a very few instances of fields and only about infinite fields (there are infinitely many of finite and infinite fields (!)). The most frequently used in applications are the field of rational numbers $\langle Q, +, 0, \bullet, 1 \rangle$, the field of real numbers $\langle R, +, 0, \bullet, 1 \rangle$ and the field of complex numbers $\langle C, +, 0, \bullet, 1 \rangle$. They form a sequence of the field extensions or (in reverse) of proper subfields: $\langle Q, +, 0, \bullet, 1 \rangle \ll \langle R, +, 0, \bullet, 1 \rangle \ll \langle C, +, 0, \bullet, 1 \rangle$

The symbol \ll indicates that what is on the left is a proper subfield (substructure, i.e., subset closed with respect to all operations of whatever structure is on the right).

The algebraic structure of a field $\langle K, +, 0, a \rightarrow a_+^{-1}, \bullet, 1, a \rightarrow a_{\bullet}^{-1} \rangle$ (shortly written $\langle K, +, 0, \bullet, 1 \rangle$) can be found in many disciplines of mathematics and in many applications. The elements of a field K are what we call numbers or scalars, but this status is dependent not on individual elements but on the membership in the algebraic structure. It was already mentioned above that for the Ancient Greeks, numbers were elements of the field $\langle Q, +, 0, \bullet, 1 \rangle$ and it took more than two millennia to extend this field to the clearly defined field $\langle R, +, 0, \bullet, 1 \rangle$. For us, it is important that there are several important examples of infinite fields between the field of rational numbers $\langle Q, +, 0, \bullet, 1 \rangle$ and the field of real numbers $\langle R, +, 0, \bullet, 1 \rangle$, i.e., these fields form a chain of consecutive extensions or consecutive subfields of the field of rational numbers which in turn are subfields of real numbers.

Thus, the field of rational numbers Q is a proper subfield of the field of constructible numbers (numbers which can be constructed with the ruler and compass from the unit segment to the segment of the length equal to this number), which in turn is a subfield of the field A of real algebraic numbers (i.e., numbers which are roots of polynomials with rational coefficients), which is a subfield of the field of computable numbers, which in turn is a subfield of the field of definable numbers, which, finally, is a subfield of the field of real numbers R .

There was more technical reason for the further extension from the field of real numbers $\langle R, +, 0, \bullet, 1 \rangle$ to the field of complex numbers $\langle C, +, 0, \bullet, 1 \rangle$. This extension was dictated by the need to consider algebraically a complete field (i.e., a field in which arbitrary polynomial equations have solutions). The reason for the extension to complex numbers was more technical than conceptual, but it generates several philosophical questions. For instance, why do we accept only real numbers as values of physical magnitudes when, at the same time, we use most frequently the standard complex Hilbert space formalism in quantum mechanics? This is not a mathematical question which we can answer in a definite way as it is addressing intuitive preferences. However, the most likely answer is that the field of complex numbers loses the natural linear order of the field of real numbers. The field of complex numbers can be considered a two-dimensional vector space over the field of real numbers, and in two dimensions, we lose any meaningful linear ordering. The real number values of magnitudes introduce linear order in our description of reality. This feature is lost if we admit complex values.

All these fields $\langle K, +, 0, a \rightarrow a_+^{-1}, \bullet, 1, a \rightarrow a_{\bullet}^{-1} \rangle$ (in short $\langle K, +, \bullet \rangle$) in the chain considered above are defined on some proper subsets K of real numbers ($K \subseteq R$ and $K \neq R$) starting from the field of rational numbers Q . We can easily, and in the full agreement with our intuition, construct rational numbers forming the set Q from the integers in Z which in turn can be easily derived from the natural numbers in N . Of course, neither the set of natural numbers nor set of integers has the structure of a field with operations $+, \bullet$ as they lack multiplicative inverses. The field of rational numbers Q is the smallest field including all natural numbers.

Ancient Greeks thought that rational numbers are all numbers until they found that we need to look for an extension when we want to assign the length to the diagonal of a square with unit sides which today, we call the irrational number $\sqrt{2}$. The diagonal could be constructed with the use of ruler and compass, yet it was lacking the corresponding number. This deficiency of $\langle \mathbb{Q}, +, \bullet \rangle$ to represent geometrically constructible objects justified the need for an extension from the field $\langle \mathbb{Q}, +, \bullet \rangle$ to the field of what we call today, constructible numbers (more formally, the field of constructible numbers). Every number in this field can be associated with the length of the segment which can be constructed with the compass and ruler. However, there are also numbers like $\sqrt[3]{2}$ which are roots of polynomials with rational coefficients (real algebraic field) which are not constructible. For instance, $\sqrt[3]{2}$ is a solution of the equation $x^3 = 2$. Thus, when the elements of reality started to be considered in terms of equations, it was necessary to search for further extension. The next larger field is the field of computable real numbers which can be results of the work of a Turing Machine, i.e., the work of any computer. It is countable, so still much smaller than the uncountable field of the real numbers $\langle \mathbb{R}, +, \bullet \rangle$. The majority of real numbers are not computable. Even worse, the majority of real numbers are not definable. Between the field of computable numbers and the field of the real numbers, there is a countable field of the definable numbers. These are numbers which can be identified by a description in terms of logic and set theory. The uncountable majority of real numbers are not definable. There is no way we can identify non-definable numbers. They do not have any properties expressible in mathematical language which we could use to distinguish them.

The philosophical, e.g., ontological consequences of the recognition of these fields are enormous. It is difficult to accept the primary existence of the entity which does not have even, in principle, individual identity. Thus, how can we understand the identity of a real number which is not definable? Not only are these undefinable numbers in the majority of the set of real numbers, but the set of definable real numbers does not have a non-zero measure. Another question is: How to assess the school teachings about the real line which install in children the completely false sense of understanding of the real numbers and of the understanding of reality in terms of apparently superior quantitative methodology?

The Idols of the Number are not restricted to the fallacies related to numbers or to the fallacy of apparent distinction between quantitative and qualitative methodologies of inquiry. The name just refers to the most common fallacy involving numbers, but should apply to all forms of misuse, abuse and misunderstandings of mathematics as a tool of inquiry. The question of the ontological status of mathematical objects is not included in this category as it is of perfectly legitimate character. It is true that some contributions to this subject are biased by the Idols of the Number, but this should not prevent further studies of this subject.

4.3. Unreasonable Misunderstandings of Mathematics

There is one more type of fallacy, which at first sight, may look as clearly belonging to the Idols of the Number as they involve mathematics, but actually could be placed in the next category of the Idols of the Common Sense, in spite of the fact that they misguide not lay people, but highly respectable mathematicians or physicists. The example can be the naive reflection on *The Unreasonable Effectiveness of Mathematics in the Natural Sciences* by famous physicist Eugene Wigner [38]. Wigner mused on what he considered a mystery: "The first point is that the enormous usefulness of mathematics in the natural sciences is something bordering on the mysterious and that there is no rational explanation for it" [38]. He concluded his paper with: "The miracle of the appropriateness of the language of mathematics for the formulation of the laws of physics is a wonderful gift which we neither understand nor deserve. We should be grateful for it and hope that it will remain valid in future research and that it will extend, for better or for worse, to our pleasure, even though perhaps also to our bafflement, to wide branches of learning" [38].

The leitmotif of the paper is like a bewilderment of someone who, referring to his shooting skills, after watching the arrows in the center of the target's bull eye, forgot that the arrows were shot first and

only after this, were the concentric circles drawn. Wigner's surprise is one more piece of evidence for the fragmentation of science which started to be considered as the normal state. In the past, there was no separation of mathematics and physics, therefore, the work on physical theories was not different from the work on mathematical problems. There is no surprise (although apparently for Wigner there is) that informal, intuitive associations between different domains of scientists' activities acted as cross-pollination between mathematics and physics, even if, very often, the formal association might have been never considered or achieved. Mathematical theories frequently went much beyond the interests of physical theories and the connection was lost.

Wigner's article could have been just an amusing anecdote about an absent-minded famous physics professor who suddenly realizes that instead of doing his job in physics, he is doing mathematics. However, the sensational title of the paper and the Matthew effect caused a lot of damage by creating a frequently invoked false mystery. It is hard to believe that *Unreasonable Effectiveness of Mathematics* was written by the founder of the studies of symmetry and group theory in quantum mechanics, who received the 1963 Nobel Prize in Physics for his contributions to the theory of the atomic nuclei and elementary particles through the discovery and application of fundamental symmetry principles.

An explanation of "[t]he miracle of the appropriateness of the language of mathematics for the formulation of the laws of physics [...]" can be found in the works of other giants such as Hermann Weyl [39] or the 1977 Nobel Prize in Physics laureate Philip W. Anderson [40], who gave the answers to the role of mathematics in physics and other disciplines exactly in terms of symmetry and group theory. The apparent miracle turns out to be just an expression of the identity of mathematical and physical theoretical inquiries as summarized in a sentence from Anderson's famous article "More is Different": "It is only slightly overstating the case to say that physics is the study of symmetry" [40]. Yet the title of Wigner's article became a meme which persists in confusing lay people. Whatever damage has been done, the case is an excellent example of the dangers of the Idols of the Number which include the belief in the reality of a strict demarcation line between mathematical and physical inquiries.

5. Idols of the Common Sense

It is again necessary to start this section from a disambiguation. Here, too, we have to be aware of the possibility of the confusion caused by equivocation. Common sense has two separate, although convoluted, traditions of study and associated with them are multiple ways of understanding this expression. Common sense in the understanding presented by Aristotle in *De Anima* is a capacity to identify shared aspects of things. Various expressions involved in the analysis of this capacity in humans and animals were later subsumed in the later translation into the "*common sensibles*" (and in modern psychological terminology called "binding"). Aristotle excluded existence of the sixth sense (although sometimes he addressed this capacity as the first sense), but rather considered the common sense a faculty by which *common sensibles* are perceived together as a single object.

Further evolution of this synthesizing faculty was long and too complex to be presented here, as this way of thinking definitely does not belong to the Idols of the Common Sense. Actually, it should be the subject of intensive studies within Natural Philosophy as a main tool for its integrative functions. An extensive study of common sense as the capacity to integrate information was published by the present author elsewhere [41].

There is another use of the expression "common sense" as a skill of using everyday experience common to all people from a more or less culturally homogeneous community in making decisions or normative judgments including judgments of the truth or falsity of statements. These type of skills are usually associated with "streetwise wisdom". Very often these skills are transmitted by language or learned by observation in the social environment. They may be of great practical value and they may be, in some situations, the only means to reduce complexity of the environment, i.e., they are necessary for everyday intelligent behavior. One of the main objectives of robotics and AI study is to develop in artificial systems the capacity of such common sense. Thus far, this objective has never been achieved.

Yet, we have to be careful about engaging both types of intuitive capacities in situations when the environment is very different from the environment in which intuitive skills have been acquired. Even more dangerous is mixing the intuitive and rational methods of inquiry involving higher levels of abstraction.

5.1. Beware of What Escapes Awareness

Idols of the Common Sense represent fallacies resulting from making conclusions based on individual, everyday experience, unaided by any systematic methods of critical thinking about the matters far removed from this experience. However, the origin of these type of fallacies is the result of the negligence of the recognition for both rational and irrational forms of inquiry and resulting confusions. When we ignore the role of the intuitive capacities as primitive and not deserving attention, they take over the functions of rational capacities and confuse them. In the presentation of the Idols of the Number, the central fallacious forms of inquiry were generated by the illusionary distinction between quantitative and qualitative methodologies of inquiry and the neglect of structural analysis accompanied by misunderstanding of mathematics and its role as a tool of inquiry. In the Idols of the Common Sense, the central confusion regarding the complex relationship between the rational and intuitive forms of inquiry, in mixing their analyzing and synthesizing roles is accompanied by the neglect of logic.

The distinction and relation between the rational and intuitive forms of inquiry was studied in my earlier publications [33,41,42]. For the purpose of this paper, it will be sufficient to consider the distinction between the inquiries involving the language-based reasoning organized and controlled by logic and the engagement of the human capacities to organize perceptions which escape linguistic and logical control. The most important capacity of the second type is our ability to integrate information into indivisible units which, in the rational form of inquiry, is called an “object”. The examples of the interaction between the two forms can be found in the presence of the word “thing” in Aristotelian writings, which he never tried to explain or to define, or in the struggle to conceptualize the notion of a set (Cantor, Husserl and many others) which ultimately was abandoned by giving the notion of a set the status of a primitive concept.

The further consequences of the Idols of the Common Sense are especially detrimental for the study of the complementary objective and subjective forms of inquiry leading to the belief in their opposition and in the dominant and exclusive role for the former. The distinction here was explained very briefly in Section 2.2 in the terms of invariance, but was extensively discussed in my earlier publications [23].

If we want to study Contemporary *Idola Mentis* for the purpose of preventing errors and fallacies in the Contemporary Natural Philosophy, we have to avoid unjustifiably rigid rules and exclusive restrictions to the existing methodology of science. There is nothing wrong in the study and development of methodologies engaging human intuition and its capacities. There were many highly recognized mathematicians and physicists (e.g., Henri Poincare) who openly declared the primary role of their intuition in their achievements.

Yet, the collective experience of mathematicians and physicists provides examples of the abuse of what was considered a systematic use of intuitionistic methodology, in particular, the refusal to accept the excluded middle rule of logic. The most notorious was the abuse by Leopold Kronecker, of his power of being the editor, to veto the publication of works submitted by the founder of set theory, Georg Cantor, on the grounds that this was not mathematics. We are not concerned here about the development of clearly formulated programs to modify logic or other tools of inquiry, as long as they follow the rules of evaluation of intellectual activity and are not just expressions of individual belief or personal preferences. So, the excesses of intuitionism, even if being harmful, do not belong to the Idols of Common Sense. For this qualification, it is necessary that the common sense deviation from logical or systematic, methodological rules is without any awareness of it. The actual Idols of the Common

Sense are the cases when the intuitive forms of inquiry developed in the familiar environment from everyday experience encroach on the functions of rational capacities.

The classical example of the fallacy belonging to the Idols of the Common Sense has its own name, “Linda the Bank Teller”. Amos Tversky and Daniel Kahneman, studying extensional and intuitive reasoning, created a story about a fictitious character called Linda for the participants in their research [43]: “Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations. Which is more probable? 1. Linda is a bank teller. 2. Linda is a bank teller and is active in the feminist movement.” More than 80% of participants in the research chose answer 2.

We should not be surprised at the above. Probability theory and logic are notoriously counterintuitive. This is a natural consequence of the differences between competences of the rational and intuitive capacities. It is significant that the most confusing for untrained people are problems related to conditional probability (in particular Bayes Theorem) and to inferences involving implication. However, even the use of simple connectives such as “and”, “or” turns out to be problematic for students, if they cannot use Venn diagrams (i.e., set theoretical representation).

5.2. Definition of the Definition

“Linda the Bank Teller” seems harmless, but actually, similar fallacies are surprisingly common in philosophical and scientific discourse, becoming a large obstacle in mutual understanding. This is a part of a larger problem in the context of much more serious misunderstanding of the concept of a definition and definability.

Once again, we can see the danger of equivocation, which can be identified as a main source of the Idols of the Common Sense. There are many different meanings of the word “definition” when it is qualified by some adjectives. Definitions always serve the identification of something. For instance, the dictionary definition serves the purpose of the identification of the standard use of words by finding their synonyms or synonymic expressions possibly with many words, typical paraphrases, or by providing contrast to similar words used in a very different way. Dictionary definitions are circular out of necessity, but also intentionally, as it is assumed that someone may know some words but not the others. Another example is an ostensive definition identifying objects by directly pointing at them.

There are multiple other “definitions” serving different objectives. However, in the context of philosophical or scientific inquiries, there is only one concept of a definition within formal logical methodology called genus-species definition. The tradition of this type of definition goes back to Socrates, but the works of Aristotle made it the central tool of philosophical methodology. Formal definitions of universals, i.e., terms with general meaning addressing multiple individuals, became necessary for the development of syllogistics as a methodology of reasoning. After Aristotle, the unqualified term “definition” always refers to genus-species definition. All other definitions, which are diverse forms of identification of a variety of objects or relations, require qualification.

Aristotelian concept of the *genus-species* definition referred to the partial order of universals according to their level of generality. The pair of universals was considered in the genus-species relation if every instance of the latter was an instance of the former. Thus, whenever we have that every A is B, A is species and B is genus. Of course, in the much later adopted biological taxonomy, the meaning of the terms “genus” and “species” changed as names of the specific consecutive levels of such order. In this partially ordered structure of universals, going in the directions of *species* was going in the direction of increasingly smaller classes of individuals, while going upward in the *genus* direction led to increasingly larger classes. Aristotle did not consider individuals being universals, but we could modernize the description of the structure of universals by considering individuals as atoms of the partially ordered set of universals.

To define a universal (*definiens*) we have to identify its *genus* (one of them, but preferably *genus proximus*, i.e., the nearest of all genera). Then we have to provide *differentia*, i.e., we have to provide

the difference between the universal which we want to define and all other species of this genus. The classical example of the definition was: A human (*definiens*) is an animal (*genus*) which is rational. Being rational was the differentia which made the distinction between humans and other animals. The genus and differentia formed the *definiens*. Of course, we have to be able to identify a genus before we can use it in the definition. Thus, we had to have its definition ready, or we have to give it the status of a category, i.e., primary, undefinable, universal identifiable only with the use of intuition. Aristotle selected his own categories and in the millennia to come, philosophers formed their own selections. The border between the rational and intuitive forms of inquiry is exactly at this point. The selection of categories is beyond our rational capacities and it is left to our intuitive capacities.

The only difference in the modern formation of a conceptual system is that we do not feel obliged to start from the selection of all categories, but for a particular theory, we choose its primitive concepts (which we do not define) and we formulate a set of axioms as a priori true sentences characterizing the primitive concepts. From the axioms, we derive the truth of all theorems of the theory using valid logical inferences. Of course, the truth of theorems is conditioned by the assumed truth of axioms. To reduce the complexity of the statements, which we want to prove, and give them the status of a theorem of the theory, we can (and actually we do) define derivative concepts using the process of the definition starting with primitive concepts as *genera*. Later we can use, in *definiendum*, already defined concepts as *genera* for consecutive definitions.

It is important that, in principle, we do not have to define additional concepts, and by the cost of extreme complexity of the statements, we could develop an entire theory using only primitive concepts. Here, we can recall another contribution of Eugene Wigner, this time to the Idols of the Common Sense, when, in his paper, "The Unreasonable Effectiveness of Mathematics in the Natural Sciences" mentioned in the context of the Idols of the Number, he wrote, "Mathematics would soon run out of interesting theorems if these had to be formulated in terms of the concepts which already appear in the axioms" [38]. Of course, in this case there is not much damage as a disproof of this false statement can be found in any introductory textbook to logic. This just shows the dangers of misconceptions which can make even laureates of the Nobel Prize victims of the Idol of Common Sense. This also provides the justification for the inclusion above regarding the elementary explanation of the concept of definition.

This does not mean that definitions do not have practical importance. Not only do they direct the attention of the philosophical or scientific community to a particular direction of research but also, they simplify both reasoning of the author and its reception at the other end of communication. There is a good analogy in the use of the higher level programming languages. Of course, in principle, every program can be written in the machine language, but in such form, it would be practically incomprehensible to other human programmers. Higher level programs use defined subroutines which have a short name easily comprehensible to human programmers, and when they use these names in programming, the reversal of the names to machine language is performed by the compiler.

Definitions are not true or false. They are conventional tools reducing complexity of the language, but they are still conventional. In arithmetic, we write 5, not $S(S(S(S(S(0))))))$, but without the convention of writing digits in some particular way, we cannot understand the meaning of 5 using only arithmetical theory, which describes the primitive concept $S(n)$ in terms of a recursive scheme.

The typical problems arise when the process of defining concepts, which is a syntactic procedure, is confused with semantics. The fact that we provide a definition of a concept does not tell us anything about the relevance of this concept, even if it is formulated in a perfectly correct way. We did not create anything new. We just eliminate a concept by reducing it to other concepts. This is actually an expression of the two main conditions for proper definition called "eliminability" and "noncreativity" [44]. Herbert Simon writes about them: "These criteria stem from the notion, often repeated in works on logic, that definitions are ('ought to be') mere notational abbreviations, allowing a theory to be stated in more compact form without changing its content in any way" [45].

There is extensive classic literature on the modern logical theory of definitions and definability with the particularly highly respected and renowned contributions of Alfred Tarski and Patrick Suppes [44,46]. The form of a logically correct definition is very well established and does not require much more study. The actual subject of the theory of definitions and definability is the transition between deferent theories developed in not necessarily the same conceptual framework of primitive concepts and axioms. This subject is beyond the scope of the present paper. After all, the most important lesson from logic about the concept of a definition is that Humpty Dumpty was right in his teaching Alice about the meaning of words: “When I use a word, ‘Humpty Dumpty said, in rather a scornful tone,’ it means just what I choose it to mean—neither more nor less” [47].

The idol which Linda the Bank Teller manifests is a quite frequent form of unintended and undesirable restriction of the scope of the concept by adding either additional differences or by adding additional axioms for the axiomatic theories based on the primitive concepts. Very often, authors who are not satisfied with the too narrow scope of the existing definition add to it additional conditions or comments, not realizing that this will never make the concept more general, but usually the effect is exactly opposite.

The logical definitions may not be sufficient for the purpose of theories describing a part of reality in terms of active engagement of observers. In this case, very often, operational definitions are used. They describe, for instance, how to construct the object of study through practical manipulations of the environment. This, of course, is very different from the presented before theoretical definitions. However, the difference can be eliminated if we include a theory of these operations into the more comprehensive theory of the studied fragment of reality. Once we have a theory of operations (for instance, empirical procedures) the operational definition can be formulated in the purely logical form.

Francis Bacon wanted to eliminate the intervention of theoretical reasoning in the form of theoretical description of experimental system, but in the perspective of modern science, his dream is impossible. Even if we could avoid the use of any experimental equipment (we know that we cannot) and restrict all inquiries to direct human observation based on sensory experience, our body is an experimental system and the functioning of our senses cannot be ignored.

The importance of the process of the formulation of the definitions for the concepts forming the conceptual reference frame can be seen in the eternal disputes on subjects, formulated as a question “What is...?” For instance, the concept of culture has been discussed since the 19th century by anthropologists, linguists, scholars of intercultural communication, etc., without ever reaching consensus. Already in 1952, Alfred L. Kroeber and Clyde K.M. Kluckhohn summarized, in a critical review, 164 earlier definitions, adding their own [48]. Arthur Lovejoy, in 1927, studied 66 ways in which the word “nature” has been understood in the context of aesthetics [49,50]. Raymond Williams based on the variety of definitions for nature, called it “perhaps the most complex word in the language” but he was not aware that no philosophically non-trivial concept has commonly accepted unique meaning [51,52]. Even the concept of meaning has diverse meanings. The classical book of Charles Kay Ogden and Ivor Armstrong Richards, *The Meaning of Meaning* published in 1923, distinguished 16 different ways in which meaning is understood [53].

There is nothing wrong with the diversity of definitions. Actually, this diversity is just an evidence for the relevance. The problem is that the vast majority of so called “definitions” are not definitions at all from the point of view of logic. Quite a typical fallacy is that establishing of a quantitative magnitude is sometimes considered a definition of a concept.

The classical example of this fallacy of taking the definition of a mathematical formula for some magnitude as a definition of the concept is “Shannon’s definition of information” which supposedly was written by Claude Shannon in his famous 1948 paper, “A Mathematical Theory of Communication” later published together with Warren Weaver in book format [54]. Shannon claimed to be interested in the fundamental communication problem of reproducing, at one point, either exactly or approximately a message selected at another point. In his paper, he formulated a mathematical concept of entropy

characterizing probability distributions and wrote in Section 6, with the title, Choice, Uncertainty and Entropy: “Quantities of the form $H = -\sum p_i \log p_i$ (the constant K (omitted in the formula, m.j.s) merely amounts to a choice of a unit of measure) play a central role in information theory as measures of information, choice and uncertainty” [54] (p. 20). There is not much more directly about information in this historical paper, yet it is considered that Shannon defined here “information”. It is clear that the two idols, of the Number and of the Common Sense, are responsible for this opinion. The former prompts people to believe that something expressed as a number giving value to some magnitude must be an entity. The latter idol just obscures the meaning of the definition as a concept.

Even when all definitions of some diverse attempts to define a concept are correct, the Idol of the Common Sense may prevent their effective use. The disputes on the definitions are often performed as if it was a matter of truth or falsity or of correctness. The definitions of concepts (if correctly formulated) can be evaluated exclusively on the adequacy of the theory which they serve, not by the form or content of the definition. If the theory (i.e., its syntactically true sentences or claims) describes objects of reality in the way which can be empirically confirmed, then we can consider the definition useful, but, of course, not true.

Another possible criterion of the evaluation of a definition can be formulated through the analysis of its conceptual framework (concepts involved in the *definiendum*). If a definition gives a wide range of relations with other relevant concepts, then this gives the evidence of its potential value, but this, too, can be assessed only by the analysis of the theory and its consequences. We have to remember that a definition of the concept is basically a selection of already defined or primitive concepts, something which metaphorically we could describe as a “conceptual system of coordinates”. The same way as coordinate systems may be convenient or not is less important than finding the rules which govern phenomena framed by the coordinate system.

6. The Idols of the Elephant

The Idols of the Elephant can be easily recognized because of a well-known parable of “The Blind Men and an Elephant” accompanying many threads of Indian philosophical tradition, and going back before its first historical appearance in the Buddhist texts more than two millennia ago. The parable is now well known all over the world. A group of blind men tries to learn what a large object is, in their way. They use their tactile sense, but without having ability to see, they cannot compare and synthesize their individual experiences derived from touching small portions of the object. This may look like a too simplistic metaphor of the fragmented vision of reality provided by science. Certainly, the parable is of high relevance for Natural Philosophy as an integrated system of knowledge of entire reality, as it suggests that we should look for some form of sense of sight (or insight) to achieve integration.

Actually, not all the Idols of the Elephant are as obvious as that represented by the ancient parable. The other idols which prevent us in achieving our goal of integrated vision may not be like that in the parable, where the men are aware of their handicap. As in the cases of other idols, we may not be aware of our handicaps.

The division into the types of idols is not exclusive and not straightforward. In the description of the Idols of the Common Sense, the central fallacy was related to the relationship between the rational and intuitive forms of inquiry which have consequences for the relationship between objective and subjective forms of inquiry. However, this distinction can be associated with the Idols of the Elephant, too. Objectivity can be viewed as intersubjectivity, i.e., invariance with respect to the transition between the different human knowing subjects rather than the different, more general and not necessarily human observers or reference frames.

Let us change the parable and let all blind men touch at the same time, the same part of the elephant. Why should we expect that their reports should be the same? Each of the men has a different experience in touching the object of their environment. They may have different levels of sensitivity in tactile perception. Finally, they may have different skills in expressing their perceptions. Thus, we have to avoid oversimplified one-dimensional conclusions about the value of the collective inquiry.

The danger here is in the habits perpetuated by the language, promoting the view of the complementary objective and subjective forms of experience and inquiry falsely considered as exclusive, contradictory, competing, and requiring the dominance of one form over the other. The priority is usually given to the former, objective form. This can be seen in the normative character of the terms, “objective” (good), “intersubjective” (neutral) and “subjective” (bad) in everyday language.

Usual studies of objectivity are focused on preventing bias coming from the conflict of interest present in social life or from psychological determinants such as the trait ascription bias exhibited in a tendency to describe own behavior as flexible, adapting to the situational factors while the behavior of others is by ascribing fixed dispositions to their personality. Objectivity of science is expected to be achieved by the requirement of the judgment of many disinterested and independent reviewers. Sometimes, objectivity is considered in more abstract terms of independence of the evidence from that or whom it serves. Peter Kosso considers more general description “Objective evidence is evidence that is verified independently of what it is evidence for” [55].

We could see in the discussion of the Common Sense that misunderstanding of the concept of definition may generate difficulties in coordination of individual inquiries and formulation of a consistent vision of reality. However, this looks like a matter of communication between the blind men in the parable—but is the deficiency of communication the main problem? The problem is rather in the lost sight, i.e., missing tool of integration at the level of the acquisition of knowledge.

Certainly, it is very important to establish social mechanisms eliminating the influence of external factors and interests on the inquiries and their outcomes. Equally important is to foster good communication coordinating and integrating collective forms of inquiry. However, the most dangerous Idols of the Elephant are highly non-trivial and difficult to identify and control. They may not be related to the problems of coordination of inquiries performed by different individuals. They may put the obstacles on the path of inquiry of an individual inquirer.

In this paper, only one example of such non-trivial form of the Idols of the Elephant will be considered. This is a tendency to avoid the recognition of the hierarchic character of reality or in the attempts to giving, without any justification, the privileged status of reality to one particular level of this hierarchy. The blind people in the parable experience separate parts of reality (the elephant) in this parts’ geometric separation. Each of the blind men is touching different parts of the surface of the elephant. It is still quite easy to reassemble the picture of the animal by gluing together fragmented images. We can consider yet another version of the parable of the (rather science fiction) ability to penetrate the body of the elephant to different depths. Once again, their reports will be different.

Reality can be analyzed from another perspective of having multiple levels of the collections of its components. In the mathematical language of the set theory, these levels can be constructed with the concept of a power set. We start from some set S which forms the first level of the hierarchy. Then we consider the set of all its subsets, which is called the power set of set S . Of course, we can form the power set of power set and the constructions can continue forever. On the other hand, all (usual) set theories do not have any separation of sets and elements. All objects of these theories are sets (no matter how strange it may seem to non-mathematicians). The concept of an element is relative. One set, let us say, set x , can be an element of another set y , which for the purpose of simplicity is expressed as “ x is an element of y ” ($x \in y$), but it does not give x and y different status. It is just an expression of the relationship between sets. This gives us the possibility of the infinite downward hierarchy.

We already know from physics that moving from one level of this hierarchy to another requires some change of the conceptual tools for the study of the collective phenomena which do not have any meaning at the lower level. We have examples of emergent phenomena whose description or prediction cannot be derived from the lower level. These are well-known ideas. Little less known or recognized is the fact that for the description of symmetry, the most important concept in many disciplines of science and humanities, we have to consider three levels of this hierarchy. If we want to consider higher order symmetries, we have to consider more levels [23,56,57]. Thus, there is no reason to think or to believe that these levels are just a creation of the human mind. At least, we should consider this hierarchic

structure of reality a central subject of study and we should assess its ontological status based on the results of this study.

Now, the Idols of the Elephant appear here because there is a consistent tendency in many domains of inquiry to flatten the vision of reality. Traditionally, this tendency was expressed in reductionist forms of physicalism. In this position, we can only consider as real, one level of the hierarchy. Originally, this distinguished level was a stage of the set of points of space-time in which atoms or point masses were actors. Later atoms were replaced by elementary particles and the empty stage of points was equipped with the assigned to them vectors of the fields. All collectives of the higher level were just abstract creations of our inquiry without any right for independent existence.

Both the physicalist and reductionist position have lost attractiveness and are currently retreating, mainly under the influence of the reflection on the forms and mechanisms of life. However, the tendency of flattening reality remains, for instance, in the form of a variety of doctrines of structural realism initiated by John Worrall in 1989 [58]. The change in this direction consists in giving exclusive or, at least, primary existence to the second level instead of the first. Whichever level we choose, it may be the perspective of an individual blind man. To avoid this type of the Idols of the Elephant, we should wait for giving the priority to any particular level. If (for some unlikely reason) there is a reason to prioritize some levels over the other, this has to be justified by an empirically testable explanation and justification. In the absence of this justification, the hierarchic architecture should be retained until demonstrated otherwise.

The “flattening” tendency can be identified not only in natural sciences, physics, or philosophy. In some sense, it can be identified in mathematics, too. The shift in mathematics with some analogy to the shift in philosophy towards structural realism can be identified, for instance, in the category theory. In the admittedly oversimplified summary of the category theory, it can be described as an attempt to eliminate the first level. We give the priority to morphisms acting on objects. In the traditional perspective of set theory, both objects are sets of elements from the first level and therefore, morphisms are elements of the second level. This can be considered as a highly efficient way to deal with complexity by lifting the level of abstraction. Such an argument would have been convincing, if we had only two or, at most, a few levels of the hierarchy. However, the hierarchy is infinite, so lifting or lowering by one level is irrelevant. This does not preclude the fact that the category theory and its easy diagrammatic representation may have multiple good contributions to mathematics and its applications.

Funding: This research received no external funding.

Acknowledgments: The author would like to express his gratitude for the encouragement, criticism, and helpful comments from the reviewers and the editor.

Conflicts of Interest: The author declares no conflict of interest.

References

1. Dodig-Crnkovic, G.; Schroeder, M.J. (Eds.) *Contemporary Natural Philosophy and Philosophies, Part 1*; MDPI: Basel, Switzerland, 2019; Available online: <https://www.mdpi.com/books/pdfview/book/1331> (accessed on 30 June 2020).
2. Dodig-Crnkovic, G.; Schroeder, M.J. Contemporary natural philosophy and philosophies. *Philosophies* **2018**, *3*, 42. [CrossRef]
3. Fallacies. *Internet Encyclopedia of Philosophy*; American Library Association: Washington, DC, USA, 1995; Available online: <https://iep.utm.edu/fallacy/> (accessed on 16 August 2020).
4. Snow, C.P. *The Two Cultures*; Cambridge University Press: London, UK, 1959.
5. Conant, J.B. *General Education in a Free Society: Report of the Harvard Committee*; Harvard University Press: Cambridge, MA, USA, 1946.
6. Wilson, E.O. *Consilience: The Unity of Knowledge*; Vintage Books: New York, NY, USA, 1999.
7. Wilson, E.O. *The Meaning of Human Existence*; Liveright Publishing: New York, NY, USA, 2014.
8. Bateson, G. *Mind and Nature: A Necessary Unity*; E.P. Dutton: New York, NY, USA, 1979.

9. Butler, D. Theses spark twin dilemma for physicists. *Nature* **2002**, *420*, 5. [CrossRef] [PubMed]
10. Wilczek, F. Physics in 100 Years. Available online: <http://frankwilczek.com/2015/physicsOneHundredYears03.pdf> (accessed on 17 August 2020).
11. Simeonov, P.L.; Smith, L.S.; Ehresmann, A.C. Stepping Beyond the Newtonian Paradigm in Biology: Towards an Integrable Model of Life—accelerating discovery in the biological foundations of science, INBIOISA White Paper. In *Integral Biomathics: Tracing the Road to Reality*; Simeonov, P.L., Smith, L.S., Ehresmann, A.C., Eds.; Springer: Berlin/Heidelberg, Germany, 2012; pp. 319–418.
12. Capra, F. *The Tao of Physics*; Shambhala Publications: Boulder, CO, USA, 1975.
13. Laplane, L.; Mantovani, P.; Adolphs, R.; Chang, H.; Mantovani, A.; McFall-Ngai, M.; Rovelli, C.; Sober, E.; Pradeu, T. Why science needs philosophy. *Proc. Natl. Acad. Sci. USA* **2019**, *116*, 3948–3952. [CrossRef]
14. Von Foerster, H. (Ed.) *Cybernetics of cybernetics: Or, the Control of Control and the Communication of Communication*, 2nd ed.; Future Systems: Minneapolis, MN, USA, 1995.
15. Umpleby, S.A. Second-order science: Logic, strategies, methods. *Construct. Found.* **2014**, *10*, 16–23.
16. Müller, K.H. *Second-order Science: The Revolution of Scientific Structures*; Echoraum: Wien, Austria, 2016.
17. Lissack, M. Second order science: Examining hidden presuppositions in the practice of science. *Found. Sci.* **2017**, *22*, 557–573. [CrossRef]
18. Quine, W.V.O. Mr. Strawson on logical theory. *Mind* **1953**, *62*, 433–451. [CrossRef]
19. Laudan, L. *Science and Relativism: Some Key Controversies in the Philosophy of Science*; The University of Chicago Press: Chicago, IL, USA, 1990.
20. Niiniluoto, I. *Critical Scientific Realism*; Clarendon Press: Oxford, UK, 1999.
21. Dummett, M. Realism. *Synthese* **1982**, *52*, 55–112. [CrossRef]
22. De Caro, M. Naturalism and Realism. In *A Companion to Naturalism*; do Carmo, J.S., Ed.; Dissertatio's Series of Philosophy; University of Pelotas: Pelotas, Brasil, 2016; pp. 182–195.
23. Schroeder, M.J. Invariance as a tool for ontology of information. *Information* **2016**, *7*, 11. Available online: <https://www.mdpi.com/2078-2489/7/1/11> (accessed on 15 June 2020). [CrossRef]
24. Lyotard, J.-F. Theory and history of literature. In *The Postmodern Condition: A Report on Knowledge*; University of Minnesota Press: Minneapolis, MN, USA, 1984; Volume 10.
25. Anderson, P. *The Origins of Postmodernity*; Verso: London, UK, 1998; pp. 24–27.
26. Bacon, F. *Novum Organum or True Suggestions for the Interpretation of Nature*; Devey, J., Ed.; P.F. Colier & Son: New York, NY, USA, 1902; Available online: <http://www.gutenberg.org/files/45988/45988-h/45988-h.htm> (accessed on 7 June 2020).
27. Bacon, R. *Opus Majus of Roger Bacon: Part I*; Kessinger Publishing: Whitefish, MT, USA, 2002.
28. Whorf, B.L. *Language, Thought, and Reality*; Carroll, J.B., Ed.; MIT Press: Cambridge, MA, USA, 1956.
29. Newton, I. *Philosophiæ Naturalis Principia Mathematica, General Scholium*, 3rd ed.; University of California Press: Berkeley, CA, USA, 1726/1999; ISBN 0-520-08817-4.
30. Losee, J. *A Historical Introduction to the Philosophy of Science*; Oxford Univ. Press: London, UK, 1972.
31. Adams, D. *The Hitchhiker's Guide to the Galaxy*; Pan Macmillan Books: London, UK, 1979.
32. Tegmark, M. Shut up and calculate. *arXiv* **2007**, arXiv:physics/0709.4024v1.
33. Schroeder, M.J. Crisis in science: In search for new theoretical foundations. *Progress Biophys. Mol. Biol.* **2013**, *113*, 25–32. [CrossRef] [PubMed]
34. Schroeder, M.J. Structures and their cryptomorphic manifestations: Searching for inquiry tools. In *Algebraic Systems, Logic, Language and Related Areas in Computer Science, RIMS Kokyuroku*; Adachi, T., Ed.; Kyoto Research Institute for Mathematical Sciences, Kyoto University: Kyoto, Japan, 2019; p. 10.
35. Schroeder, M.J. Equivalence, (crypto) morphism and other theoretical tools for the study of information. *Proceedings* **2020**, *47*, 12. [CrossRef]
36. Schroeder, M.J. Intelligent computing: Oxymoron? *Proceedings* **2020**, *47*, 31. [CrossRef]
37. Schroeder, M.J. Logico-algebraic structures for information integration in the brain. In *Algebras, Languages, Computation and Their Applications, RIMS Kokyuroku*; Shoji, K., Ed.; Research Institute for Mathematical Sciences, Kyoto University, Kyoto: Kyoto, Japan, 2007; Volume 1562, pp. 61–72. Available online: <http://www.kurims.kyoto-u.ac.jp/~{}kyodo/kokyuroku/contents/1562.html> (accessed on 20 June 2020).
38. Wigner, E. The unreasonable effectiveness of mathematics in the natural sciences. In *Communications in Pure and Applied Mathematics*; New York University: New York, NY, USA, 1960; Volume 13.
39. Weyl, H. *Symmetry*; Princeton University Press: Princeton, NJ, USA, 1952.

40. Anderson, P.W. More is different. *Science* **1972**, *177*, 393–396. [CrossRef] [PubMed]
41. Schroeder, M.J. Concept of information as a bridge between mind and brain. *Information* **2011**, *2*, 478–509. Available online: <http://www.mdpi.com/2078-2489/2/3/478/> (accessed on 1 June 2020). [CrossRef]
42. Schroeder, M.J. Towards cyber-phenomenology: Aesthetics and natural computing in multi-level information systems. In *Recent Advances in Natural Computing*; Ser. Mathematics for Industry 9; Suzuki, Y., Hagiya, M., Eds.; Springer: Tokyo, Japan, 2015; pp. 69–86.
43. Tversky, A.; Kahneman, D. Extensional versus intuitive reasoning: The conjunction fallacy in probability judgment. *Psychol. Rev.* **1983**, *90*, 293–315. [CrossRef]
44. Suppes, P. *Introduction to Logic*; Van Nostrand: Princeton, NJ, USA, 1957.
45. Simon, H.A. The axiomatization of physical theories. *Philos. Sci.* **1970**, *37*, 16–26. [CrossRef]
46. Tarski, A. Some methodological investigations on the definability of concepts. In *Logic Semantics, and Metamathematics: Papers from 1923 to 1938*; The Clarendon Press: Oxford, UK, 1956.
47. Carroll, L. *Alice's Adventures in Wonderland*; Pan Macmillan Books: London, UK, 1865.
48. Kroeber, A.L. Culture: A critical review of concepts and definitions. In *Papers of the Peabody Museum of American Archaeology and Ethnology*; Harvard University, Peabody Museum of American Archaeology: Andover, MA, USA, 1952; Volume 42.
49. Lovejoy, A.O. Nature as aesthetic norm. *Mod. Lang. Notes* **1927**, *7*, 444–450. [CrossRef]
50. Lovejoy, A.O. Some meanings of 'nature'. In *A Documentary History of Primitivism and Related Ideas*; Lovejoy, A.O., Boas, G., Eds.; Johns Hopkins Press: Baltimore, MD, USA, 1935; pp. 447–456.
51. Williams, R. Ideas of nature. In *Problems in Materialism and Culture: Selected Essays*; Williams, R., Ed.; Verso: London, UK, 1980; pp. 67–85.
52. Williams, R. *Keywords: A Vocabulary of Culture and Society*, rev. ed.; Bennet, T., Grossberg, L., Morris, M., Eds.; Blackwell: Malden, MA, USA, 2005; pp. 235–238.
53. Ogden, C.K.; Richards, I.A. *The Meaning of Meaning: A Study of the Influence of Language Upon Thought and of the Science of Symbolism*; Harcourt Brace Jovanovich: San Diego, CA, USA, 1989.
54. Shannon, E.C.; Weaver, W. *The Mathematical Theory of Communication*; University of Illinois Press: Urbana, IL, USA, 1949.
55. Kosso, P. Science and Objectivity. *J. Philos.* **1989**, *86*, 245–257. [CrossRef]
56. Schroeder, M.J. Hierarchic information systems in a search for methods to transcend limitations of complexity. *Philosophies* **2016**, *1*, 1–14. Available online: <http://www.mdpi.com/2409-9287/1/1/1> (accessed on 15 June 2020). [CrossRef]
57. Schroeder, M.J. Exploring meta-symmetry for configurations in closure spaces. In *Developments of Language, Logic, Algebraic System and Computer Science, RIMS Kokyuroku*; Horiuchi, K., Ed.; Kyoto Research Institute for Mathematical Sciences, Kyoto University: Kyoto, Japan, 2017; pp. 35–42. Available online: <http://www.kurims.kyoto-u.ac.jp/~kyodo/kokyuroku/contents/pdf/2051-07.pdf> (accessed on 1 June 2020).
58. Worrall, J. Structural Realism: The best of both worlds? *Dialectica* **1989**, *43*, 99–124. [CrossRef]



© 2020 by the author. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).