Journal of Philosophy of Life Vol.6, No.2 (June 2016):51-58

[Essay]

Reality According to Language and Concepts

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Abstract

Science uses not only mathematics, but also inaccurate natural language to describe reality. The question is whether terms such as “beautiful” and “elegant” are applicable to describe physical laws and reality. The problem is that using such vague terms not only dilutes the description of reality, but also adds some attributes to it that may not exist, leading to greater ambiguity and illusions of understanding.

The reality perceived by a human being is based on the limited human senses and incomplete concepts generated by the mind. What one perceives is not reality itself, but an inaccurate and incomplete representation of reality, filtered by the senses and distorted by concepts and interpretations in the mind.

There are two main hurdles in human efforts to describe reality. First, humans can only understand reality through concepts and theories, which are always incomplete and provisional. Second, although linguistic and conceptual categories are necessary to provide a formal structure and the interconnectedness between the elements in the analysis, they also add additional layers of ambiguity to the understanding of reality. Natural language is imprecise and open to misinterpretation; and as a human construct for communicating common experiences, natural language has limits in expressing scientific concepts and describing physical phenomena. The dilemma is that one perceives reality with limited senses and interprets it with limited language.

Contemporary physics clearly demonstrates the inadequacy and incompleteness of any non-mathematical language to accurately describe the behavior of subatomic particles. The problem for describing physical reality outside of human experience relates to translational ambiguity from mathematical language to any other. In this context, for a non-mathematical description to have sufficient correspondence with the mathematical description

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and be comprehensible, special mathematical symbols, notations, and operations must be associated with physical quantities and interactions that can be conveyed by natural language. These problems are especially evident when one tries to assign certain linguistic terms such as “beauty” and “elegance” to scientific or physical descriptions of the elements and structures of reality. However, the notions of “beauty” and “elegance” are not scientific concepts. It is not possible to reliably measure beauty and elegance; they are subjective and vague human terms open to individual interpretation.

The human sense of beauty is derived from the observations of the world, some details of which appear agreeable, as they reveal such characteristics as symmetry, patterns and dynamic order. Humans desire to inhabit an ordered and harmonious world. Thus, individuals seek these characteristics, as they provide a pleasing background to life. The notion of symmetry is ingrained in the mind from observations that depict certain order and regularity in nature, so the mind has been conditioned to associate symmetry with beauty. Symmetry considerations play a key role in formulating physical laws and theories, and in simplifying mathematical equations and solving problems. The manifestation of symmetry in physical laws and equations leads to the tendency, by association, to view them also as “beautiful”.

Such aesthetic criteria as beauty and elegance have been often invoked in mathematics and physics. From Plato to Galileo to Bertrand Russell to Albert Einstein to Paul Dirac and many others, the association of beauty and elegance with the physical and mathematical description of reality appears to be a guiding principle. Some thinkers even value beauty over accuracy and truth. These thinkers were aesthetically attuned to symmetry and patterns and certain order in nature, and considered beauty as the overriding arbiter of truth. The question is whether terms like “beauty” and “elegance” are useful, or whether they diminish the clarity of human understanding.

Mathematical equations and physical laws expressed through specific equations are often perceived as “elegant”, which is a relative term and typically implies “simple” and “original”. But this simplicity is not based on the underlying character of reality, but relates to deliberate choices of symbols and notations to simplify description. Thus, by carefully selecting and defining symbols and notations representing variables and ideas, one can relatively easily manipulate these equations. What appears to be simple may in fact be very complex, with the seeming simplicity being related to the manner how these

symbols are defined and introduced. The apparent simplicity of equations could also be the result of an approximation, while more accurate mathematical equations could have a more complex form. Various combinations of symbols and mathematical operators, which represent complex ideas and information, can be compressed or expanded, making equations simpler or more complex. Mathematical operators are useful shorthand notations for more complex expressions, and these operators are introduced to simplify them. Otherwise, mathematical equations representing physical laws may in fact appear not simple and elegant, but long and complex. Real world applications of mathematics may not always be as elegant as those related to pure mathematical formulations. In addition, in perceiving mathematical equations and physical laws, like in the arts, there are individual preferences and emotional responses to symmetry and patterns. Thus, even if someone has a certain emotional response to what is interpreted as “beautiful”, it would have an aesthetic meaning only to the perceiver or interpreter. However, there are no universal criteria for beauty.

Mathematical equations can evoke a pleasant emotional response not because they are “beautiful”, but because scientists, who are constantly occupied with thoughts and ideas related to the physical aspects of reality, are able to reduce the complexity of the universe to relatively simple mathematical symbols and equations, and because they have the perception of understanding of the universe.

Science, art, and religion, which engage with reality in different ways, are major preoccupations of the human mind. Among these, art and religion are laden with emotional responses that are subjective, whereas science is intended to provide an accurate and objective description of reality. In this context, a clear definition of things is essential to avoid ambiguity. Science relies on empirical evidence, rather than opinions, in the search for truth. Physics and mathematics offer insights about certain order, patterns, symmetry, and coherent relations between things, which are some of the main principles of aesthetics. However, what is perceived as “beautiful” or “elegant” is subjective and has no direct correspondence with reality.

Human beings experience a colored representation of a colorless world. Color sensation, or perceived color, is a result of light interacting with receptors of different spectral sensitivity in the eye, followed by the brain’s interpretation of the eye’s input. Color does not exist in the outside world; it is not an intrinsic characteristic of waves and objects. In reality there is electromagnetic radiation

of various wavelengths or wavelength ranges. It is a combination of the human visual perception and brain processing that interprets these wavelengths as colors. The human perception of visual reality is fraught with optical and cognitive illusions that result in a distorted view of reality. As human visual experience of reality is limited to a narrow range of electromagnetic radiation in the visible region of the spectrum, the actual perception of reality is also limited and thus one cannot experience many attributes of the physical world. On the other hand, because of a colored representation of the physical reality, the subjective image of the world in the mind includes additional attributes, such as color, that do not exist in reality.

Although the outside world is colorless, a colored perception of the world gives a distorted impression that there is more to nature than it actually is in reality; that there are these notions of “beauty” and “elegance” associated with the universe, which is in fact dark and silent, and full of repeating cycles of creation and annihilation processes on different scales. Both a colored representation of the otherwise dark universe and the perception of beauty of a colored reality in the brain are perceptual and experiential illusions that influence the conceptualization of reality. For the human observer, it appears that one has direct experience of complete reality, but in actuality it is a distorted representation of only a fraction of reality in the mind.

The same applies to other senses, such as hearing and touch and taste and smell. In fact, one never experiences the physical world directly, but rather through these senses and the corresponding information processed in the brain. Although one could conclude that the human perception of reality is an illusion, since it is not an accurate representation of the outside world, this representation is nevertheless real for an individual. It becomes an illusion when one mistakes this distorted representation for objective reality, or if one thinks that what is perceived is a direct experience of reality. One may also conclude that any judgment, based on senses, on the aesthetic qualities of the world does not relate to reality itself, but to the multi-sensory virtual representation of reality constructed within the brain from firing patterns of neurons. And as each individual’s brain is different, so is the perception of reality generated in the brain. Thus, what is perceived as beautiful is not in fact related to reality itself, but to its distorted representation in the brain. The perception of beauty reflects on the perceiver rather than the perceived.

As most of the natural processes on all scales are inaccessible to the unaided

human senses and cannot be visualized directly, various scientific instruments are used throughout a wide range of scales, from the microscopic to the macroscopic and cosmic levels. For example, various microscopes are used to study the atomic-level structure, whereas various types of telescopes are used to explore distant galaxies and deep space. In all these cases, the images obtained are distortions of reality, especially when using false colors depicting the universe on different scales, from atoms to galaxies, as a tranquil and beautiful place. Such images are typically altered by making arbitrary choices of color and contrast using computer software to enhance the details of the image, thus generating false-color images and altering what is perceived as reality. In fact, everything in the universe on all scales is in constant motion and change. The distorted representation of reality may influence the interpretation of the observed phenomena and aesthetic experiences, including the perception of beauty.

The pursuit of scientific simplicity and elegance is also directed at formulating a Theory of Everything, which in the case of physics would require unifying all known physical theories into a single theoretical framework. But what is the basis for stating that a theory, and especially one related to everything, must be simple or elegant? Because of the preoccupation with simplicity and elegance, it is assumed that the whole of physics can be unified under a single formalism; but perhaps there is no single unified theory, as possibly there is no single reality with fixed laws. The laws of physics may even differ throughout the universe. Humans can hardly observe four percent of a presumably “knowable” universe, as its mass is in the atoms that make up human beings and planets and stars and galaxies, which can be observed and measured. The remaining ninety-six percent of the universe is hypothesized to include “dark matter” and “dark energy”, which cannot be detected by conventional methods. The inevitable question is whether there are fundamental limits to what is knowable about the universe.

Scientists are involved with increasingly complex and challenging concepts and theories, such as quantum mechanics and string theory and multiple universes, or multiverses, which are beyond common sense and experience. Quantum reality appears indeterminate, probabilistic and nonlocal. It is incomprehensible from the common-sense perspective of the macroscopic world. What humans cannot understand, they typically refer to as “mysterious” from the biased and limited perspective formed on the basis of observations and

reasoning about the human-sized world. From the perspective of classical physics, it would be more appropriate to refer to quantum mechanics as counterintuitive.

Although not fully understood, quantum mechanics describes atomic and subatomic phenomena remarkably well and provides exact and consistent predictions of observable outcomes of experiments. Quantum mechanics offers a mathematical description of reality at the subatomic level, but it does not provide a clear understanding of that reality. The wave function, which is a fundamental quantity of the quantum mechanical formalism, relates to the probability of the outcome of a measurement, such as finding a particle in space; but this wave function has no corresponding reality in the physical world. Nevertheless, for some scientists, who adhere to the view of instrumentalism (theories are only instruments for predicting observable phenomena), the quantum-mechanical description is sufficient, as it makes experimental predictions.

There are several interpretations of quantum mechanics, which remain controversial, and all of them assume the existence of unobservable entities. The prevailing but nevertheless controversial interpretation of quantum mechanics has been the Copenhagen interpretation, according to which a quantum system's wave function, representing its probability amplitude, "collapses" into a determinate state when observed or measured by a classical apparatus. However, the term "collapse" is not defined or understood. It is not clear how the transition occurs from probabilities to definite outcomes, as the boundary between the quantum and classical domains is fuzzy. It is also not clear how the macroscopic measuring apparatus can provide information about subatomic entities. The deeper philosophical implications of this interpretation are that there is no objective reality, as entities seemingly become real only when observed.

Thus, the ordinary words and language cannot accurately portray the quantum world, which can be described by the mathematical formalism of quantum mechanics. But this formalism cannot adequately explain the reality of the quantum world.

Mathematical concepts and models do not necessarily represent reality or truth, but are rather attempts to describe reality. A case in point is the conjectured eleven-dimensional string theory, known as M-theory, which aspires to be the Theory of Everything. But this is basically a mathematical model,

rather than a physical theory, and it appears to be untestable. Nevertheless, this mathematical model is considered by some to be so “beautiful” and “elegant” as to be almost inevitably true. According to this superstring theory, extremely tiny strands of energy vibrating at various frequencies in eleven dimensions give rise to various forces (weak and strong nuclear, electromagnetic, and gravitational) and elementary particles, such as quarks and electrons. In this case, the concept of a “string” is used as a familiar image, a mental representation, which can be assigned with some analyzable attributes and properties, but non-existent in reality. This theory, which attempts to unify general relativity and quantum mechanics, is modeled from mathematics rather than physics and reality. In addition, it requires the existence of unobservable extra dimensions, and it also postulates a very large number (ten to the power of five hundred) of universes ruled by different laws. This is neither beautiful, nor simple, and nor elegant.

In the absence of evidence, it is hard to tell whether string theory and multiverses are sound concepts, the products of unrestrained imagination, or just mathematical possibilities detached from reality. It seems that the deeper one explores reality, the more illusory it appears. Without experimental verification, such theories will remain metaphysical illusions. Nevertheless, debates on such abstractions are so commonplace that their existence appears almost real. One cannot fully accept or reject these concepts. However, one must remember that mathematical models are not reality.

As physics explorations go beyond observable and measurable phenomena, it can stray into metaphysics. The failure to recognize the transition from physics to metaphysics can result in misleading conclusions about the subject of inquiry. This transition has begun with the formulation of quantum mechanics and its interpretations, which assume the existence of unobservable entities, triggering questions about the human incapacity to understand reality in its entirety and the limits of human knowledge.

Quantum mechanics and string theory deal with unobservable entities and thus do not provide certainty of knowledge about reality. This also includes such concepts as multiple universes and higher dimensions. Scientific instruments can detect or infer the existence of subatomic particles leaving tracks in a bubble chamber, but humans cannot see or perceive them as what they truly are. This leads to a realization that scientific conclusions and truths are not only uncertain and incomplete, but also to a certain degree illusions ingrained in the mind and in what is perceived as knowledge.

The human brain not only constructs a colored representation of a colorless world, but the human mind also assigns vague linguistic terms such as “beauty” and “elegance” to the elements and structures of reality that elicit certain emotional response. The human perception of beauty is an illusory construct of the mind. Humans not only distort what they perceive, but also impose on reality what does not exist and what they wish it were.

The limits of human understanding may lead to either humility or scientific hubris. Humility is born out of the recognition of the limits of human understanding, and the hubris stems from the idea that humans are capable of devising some kind of Theory of Everything that is presumed to be “beautiful” and “simple”. Believing that such a goal is reachable and trying to assign such a subjective human construct as “beauty” to the elements of reality is not only scientific hubris, but also an illusion.

Being a human endeavor, science uses not only mathematics and incomplete concepts but also imprecise natural language to describe reality. The resulting linguistic vagueness may further exacerbate illusions of understanding of reality. Instead of clarifying and simplifying the scientific description of reality, such vague terms as “beauty” and “elegance” can dilute the description of reality and add some attributes to it that may not exist. It is a human desire to imbue nature with aesthetic values and assign notions of beauty and elegance to physical laws and reality itself. But using vague linguistic terms to describe reality does not help understanding; it only adds another layer of ambiguity to the already imprecise description of reality.

There are notions of equating beauty with truth. However, beauty is not necessarily truth, and truth is not always beautiful; and if one has to choose between truth and beauty, the commitment of the scientist is to truth.