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Why Should Science Take Vagueness Seriously?

Syropoulos A*

Greek Molecular Computing Group, Greece

***Corresponding author:** Apostolos Syropoulos, 28 OKTOVRIOU 366A, Xanthi, Greece, Email: asyropoulos@yahoo.com

Essay

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Abstract

There are many things, ideas, and entities that we encounter every single day that can be described as vague, that is, one cannot precisely classify them as members of a specific class of objects. Although many hold the opinion that vagueness is either a deficiency of spoken languages or something that exists merely because we do not have all relevant details, a third group of people assume that vagueness is something real. This simply means that objects, including living beings, are vague. But if vagueness is a real thing, why do people ignore it when trying to explain a natural phenomenon, a syndrome, etc.? The reason is that people have a deep respect for pure, abstract objects with exact properties. But this has a negative effect on our understanding of our cosmos. Therefore, we investigate how vagueness really affects exact sciences and how the incorporation of vagueness will improve our understanding of our world.

Keywords: Vagueness; Spoken languages; Science

Introduction

People are tall or short. They may wear dress shirts that are light blue, gray, or green. They may look good or they may look like average persons. It is not uncommon that two or more people do not agree about the color of a dress shirt or the height of a person, even though they talk about the same shirt or person. This happens because we do not agree about which person is a tall person or which color is light blue or light green. Some may object to this because they would claim that a tall person is, well, a tall person. To see why this is not accepted by most people, consider a person whose height is 170 cm. Is this a tall person? If the person is a male, then we are not really sure, but if the person is a female, then it is definitely a tall person, especially if she is from some Mediterranean country. What about colors? We all know that there are ways to describe colors [1], but are they good?

Imagine that you are standing in front of a very beautiful and colorful landscape. You decide to take several pictures of it. Later on, you check these pictures on your personal computer and you realize that the colors are not those you expected. I am sure that this is not a science fiction scenario but rather a very frequent situation, and most people blame the quality of their cell phone or even admit that they cannot take good pictures. The real "problem" is that color is a physiological sensation and as such cannot be directly measured or described. So I can assure you that your cell phone or your digital camera are just fine! Since we need colors in documents, videos, etc., people have invented color models (i.e., a mechanism by which we can describe the color formation process in a predictable way) to represent colors and to use them in all possible ways. However, these models do not solve the subjectivity of colors.

In a nutshell, for color, height, and all such attributes, it is difficult to definitely say that an object has a particular property. In different words, the boundaries of these attributes are fuzzy and this is why we cannot easily say whether something is light green or not. The boundaries depend on context, on our view of things, etc.

Vagueness in Detail

The Sorites Paradox (σόφισμα τοῦ σωρείτη), which was introduced by Eubulides of Miletus (Εὐβουλίδης ὁ Μιλήσιος), is a typical example of an argument that demonstrates what are fuzzy boundaries. The term "σωρείτες" (sorites) derives from the Greek word σωρός (soros), which means "heap." The paradox is about the number of grains of wheat that make a heap. All agree that a single grain of wheat does not comprise a heap. The same applies for two grains of wheat as they do not comprise a heap, etc. However, there is a point where the number of grains becomes large enough to be called a heap, but there is no general agreement as to where this occurs.

In general, when we cannot agree whether someone or something has a particular property, then we say that this property is vague [see the introduction of Syropoulos [2] for a thorough introduction to vaguness]. Some advocate that since we lack crucial information that prevent us from properly categorizing a particular person or object, we "see" vague persons or vague objects. This is the *epistemic* view of vagueness. Others argue that since the languages we speak have intrinsic deficiencies, they prevent us from properly judging whether a shirt is blue or not, or whether a person is tall or not. This is the *semantic* view of vagueness. However, there is a third view of vagueness according to which objects, persons, animals, plants, etc., are really vague. This is the *ontic* view. In order to understand this idea l will present an argument that was put forth by Morreau [3]. Consider my dog Koula. She is constantly losing hair but at the same time new hair grows on her skin. Strictly speaking, Koula at 14:00 is not the same dog as Koula at 20:00. The reason? Koula during these six hours may lose hair, she may eat something or poop, etc. In the end Koula at 14:00 would be a slightly different dog from Koula at 20:00. A skeptical reader may object to these ideas and consider them nonsense. She may claim that it is the same dog based on the idea that the dog is *essentially* the same. But by following this train of thought we can conclude that an old and a young person are the same. They are not. Not to mention that people change in general.

Let us forget about dogs and cats and their hair and let us think about geometrical objects like cubes and spheres. Everyone who has been taught some school geometry knows the properties of these objects. For example, a cube has 6 faces, 12 edges, and 8 vertices and all edges have exactly the same length. Now the question is: Are there cubes in the real world? In different words, are there such *crisp* (i.e., non-vague) objects in the world we live in? Surprisingly, the answer is that there are no cubes in the real world but they are objects that are approximately cubes. This simply means that the edges have approximately the same length and that the faces are approximately parallel. More generally, one can show that there exist only approximations of pure and abstract mathematical objects. But if exactness is not the norm, then why does science ignore this very important fact? It seems that people have a deep respect for pure, abstract objects with exact properties. Everything in between makes us feel uncomfortable. In fact, Richeson [4] quoted Plutarch who mentioned that

> For the art of mechanics, now so celebrated and admired, was first originated by Eudoxus and Archytas, who embellished geometry with its subtleties, and gave to problems incapable of proof by word and diagram, a support derived from mechanical illustrations that were patent to the senses. [...] But Plato was incensed at this, and inveighed against them as corrupters and destroyers of the pure excellence of geometry, which thus turned her back upon the incorporeal things of abstract thought and descended to the things of sense, making use, moreover, of objects which required much mean and manual labour. For this reason mechanics was made entirely distinct from geometry, and being for a long time ignored by philosophers, came to be regarded as one of the military arts.

Whether we like it or not, vagueness is here and in what follows I am going to present some manifestations of it in science. The discussion that follows is based on ideas presented in Syropoulos & Papadopoulos [5]

Vagueness in the Exact Sciences

When engineers and scientists built the first computers in the 1940s, they wanted to find a way to represent information inside them. Encoding dozens of symbols (or characters as they are called in computer lingo) is very difficult because one needs many distinct physical states to represent each character. However, it is possible to represent each character by a number through a mapping. This simply means that we can construct a table where characters are mapped to consecutive positive integers. This partially solves the problem because we now need 10 distinct states to represent the ten digits of the decimal system. However, the decimal numbering system is not the only one. In fact, there are many numbering systems and the simplest one is the binary numbering system that has two digits: the digit "0" and the digit "1". Encoding two digits in an electric system is easy: One could exploit the properties of electric current to represent these two digits. Indeed, the people who built early computing machines decided that when current travels along a wire, then we should assume that the digit "1" has just traveled along the wire. Similarly, when no current travels along a wire, we should assume that the digit "0" has just traveled along the wire. But how do we detect if current travels or not along a wire? We simply measure the potential difference between two parts of a circuit. More specifically, if the potential at some part of the electric circuits that made up the computer was, say, 3.5 Volts, then the early computer pioneers assumed that the digit “1” had just passed through this part. Similarly, if the potential at the same part of the circuit was, say, 0.3 volts, then they assumed that the digit “0” had just passed through this part. The problem here is that the potential is not always exactly 3.5 Volts or 0.3 Volts. Voltage fluctuations may happen because there are loose or corroded connections either at the house or on the power-lines, or because of bad weather or extreme heat, etc. Thus there are many reasons that can cause voltage fluctuations and this is why the measurements are approximate. In a nutshell, although computers are supposed to be very precise devices, they operate on imprecise power sources and thus they are vague by nature. Naturally, the early computer pioneers wanted their system to be able to compute abstract entities and so they did everything to get rid of the *extra features* of the power supply.

Unfortunately, these extra features are also a fundamental problem of quantum mechanics (i.e., the study of the world at the atomic and subatomic level). In fact, there are factors that prevent us from knowing exactly both a particle’s position and its momentum. This simply means that we may choose to ignore these extra features in order to achieve purity.

At school we learnt that elementary particles are something like little spheres and atoms have a nucleus consisting of little spheres (protons and neutrons) while other little spheres (electrons) orbit the nucleus. Admittedly, this is a very simplified if not totally wrong picture of the atom. In fact, each electron is something like a cloud and it can be in any position within a *specific* space but we have no way to exactly predict its position. Thus the position of an electron within an atom is a vague concept. In addition, the electrons, and more generally elementary particles, are not spheres but have an indefinite shape. Similarly, we are taught that planets, satellites, and stars are globes but not spheres. Thus the laws of physics that govern the motion of these objects are approximate since we are not dealing with perfect geometric objects. This, again, implies that we should take the laws of physics with a pinch of salt. But one may ask: If nothing is precise how do we manage to send space probes to distant planets and asteroids and get important information about these worlds? First of all, one must have one mind that there have been many failures and many space probes have failed miserably. On the other hand, it is true that many space probes have successfully completed the tasks they had designed for. However, a space probe when compared to a comet, a little planet like Pluto, etc., is really a very small object. Thus we can approximately calculate the trajectory of a space probe by making a number of assumptions. If everything goes well (that is, if we are lucky enough), the space probe will reach its destination sound and safe. As should be obvious, here we are not talking about idealistic science where everything is smooth and there are no unexpected events or phenomena. This is real science that assumes the world is vague, imprecise, and unexpectable.

Because of the COVID-19 pandemic most people got to know a lot about viruses, bacteria and all these tiny “living” things. What was a big surprise for most laypeople is that the scientific community is divided to tell for sure whether viruses are indeed living things.[1] In fact, we could say that viruses are living things up to some degree. This automatically classifies them as vague entities. But vagueness is prevalent in life sciences and even the definition of a species is manifestation of this. Typically, a species is assumed to be the largest group of organisms that have common characteristics and are capable of interbreeding. This vague definition leads even a person without formal training in biology to conclude that it is quite possible that some individuals might at the same time be members and not members of some species. But vagueness can be seen also in medicine and veterinary medicine.

In many cases, a person may exhibit specific symptoms yet it is very difficult to make a safe diagnosis. For example, ulcerative colitis (an inflammatory bowel disease) and cytomegalovirus colitis (inflammation of the inner lining of the colon due to cytomegalovirus infection) exhibit similar symptoms and so it is difficult to tell whether a person suffers from the first or the second condition. In addition, gastroenterologists cannot easily differentiate between an acute ulcerative colitis flare and true cytomegalovirus colitis. But colitis goes down to cells and viruses where chemistry plays a very important role. Naturally, the next question is: Is chemistry vague?

Let us take prebiotic chemistry. A widely accepted definition of this field is that prebiotic chemistry is the study of the chemical steps that lead to the first living organisms. One obvious problem is that there is no unambiguous and universally accepted definition of living organism. Of course, this does not prohibit biologists from doing excellent work. Similarly, physicists do not really know what time or space is, but this does not prevent them from discovering secrets of our physical world. Going back to the problem of having a definition of living organisms, a natural question is this: How can we tell whether a robot is a living organism? And if we can create “living” robots, does this make us humans some sort of gods?

Conclusions

Clearly, there are many other examples of vagueness

1 See https://www.scientificamerican.com/article/are-viruses-alive-2004/ for discussion of the status of viruses.

in science. But my intention was not to present all possible expressions of vagueness in science. Rather, I wanted to show that vagueness exists in science and in many cases it is ignored. I think this is a rather unfortunate practice. One can use vagueness to better understand how things work in real life situations. In addition, as the various approaches to vague computing have revealed, it is possible to get better results and have systems that operate smoother than their counterparts that completely ignore vagueness.

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