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DOES AN OBSERVER BELONG IN PHYSICS?

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Abstract: In this paper we comment on the opinions of great philosophers from various epochs on the relationship between computers and the human mind. We ponder over whether we might be able to gain an understanding of the human mind and a perception of the world from the scientific point of view. We focus on the relationship between these two issues.
Keywords: computers; understanding; human mind; observer; natural processes.

Introduction

The title of the conference is "Computers, or pencil and paper?" As a theoretical physicist I am used to using both, so in my mind the question becomes: computer or "head"? Does relying on a computer mean that the "head" loses human qualities such as understanding and insight? Computers are becoming more and more capable—will they ever converge with the human mind? Will computers ever become, as Alan Turing (Turing, 1950) once dreamt, our equal partners?

Even this question is starting to appear to be a part of an even bigger problem: is it possible that in the future human beings will be understood and explained as a natural part of nature, fully subjected to natural laws, as we understand them in contemporary mathematics-oriented science?

These questions are not new and to gain a deep understanding of them would be a never ending task. Hence, I will concentrate only on four steps, as if I were walking through a gallery and have chosen only four key paintings. I would like to use them to demonstrate how the same problems reappear again and again, their essence unchanged, even though the technology is increasingly advanced.

The first stop: The senses and the mind

The first attempts to explain natural processes on the basis of particle physics and the formulation of the laws of particle behavior were undertaken by ancient Greek thinkers. Their efforts culminated in Democritus' teaching (Democritus A14, 1948), postulating that the world is composed of atoms which move within unlimited space. The interaction between these atoms causes everything else.

How can we know atoms exist and can our mind influence the way they move? Ancient Greek thinkers did not avoid this question. Lucretius' writing (Lucretius, 2011) is proof of this. His writing combines poetry, science, and philosophy in a way which could not have been achieved later. Lucretius states that everything in this world is connected to the law of cause and effect. Thus the question arises:

> Whence this free will for creatures o'er the lands,
> Whence is it wrested from the fates,- this will
> Whereby we step right forward where desire

Lucretius develops this theme of the free will of all beings in many intriguing scenes, and then he concludes succinctly:

> … this state comes to man
> From that slight swervement of the elements
> In no fixed line of space, in no fixed time.

Lucretius was using Epicuros' idea of trying to correct the original strict determinism of original atomic theory, which would have meant all freedom was an illusion. Even if the possibility of freedom emerges, we still do not know how to approach it. How can the movement and interaction of atoms which make up our bodies be transformed into a human perception of the world and how can we direct the randomness of these movements so that we can achieve our goals?

Five centuries later, Claudius Galenus (Galenos B 125, 1948) identified the problem of atomic theory:

Democritus, when he had run through the senses (saying "by convention colour, by convention sweet, by convention bitter: in truth, atoms and the void"), then portrayed the senses by speaking to the intellect as follows: "Wretched mind, do you take your evidence from us and then overthrow us? Our overthrow is your fall".

As all good doctors are, Claudius Galenus is capable of having a deep understanding of the scientific and human site of things. Through our senses we have access to knowledge, which is then processed by our mind. Our mind awakens a desire for unbiased knowledge, which should be expressed using scientific language and accessible to all investigators. We do not then trust data obtained by our senses that does not comply with these requirements. What will we be left with if, on the one hand, we set strict requirements of objectivity and, on the other hand, belittle the vague testimony of our senses? The mind without the support of the senses would become an isolated island, incapable of understanding its own existence and its destiny in the world, accessible only through senses.

The second stop: Machines, free will, and the mind

After thousands of years of lethargy, interest in a scientific understanding of nature is awakening again. Galileo Galilei outlines the major methodological principles:

> Philosophy [nature] is written in that great book which ever is before our eyes—I mean the universe—but we cannot understand it if we do not first learn the language and grasp the symbols in which it is written. The book is written in mathematical language, and the symbols are triangles, circles and other geometrical figures, without whose help it is impossible to comprehend a single word of it; without which one wanders in vain through a dark labyrinth. (Galileo, 1960, p. 237)

Galileo's attempts to postulate a comprehensive theory of natural phenomena is nicely summarized in the book *The Assayer*. These attempts may have been the main reason why the clergy were concerned—they were afraid people might conclude that God does not intervene in the world's affairs (White, 2007). Galileo writes

> To excite in us tastes, odors, and sounds I believe that nothing is required in external bodies except shapes, numbers, and slow or rapid movements. I think that if ears, tongues, and noses were removed, shapes and numbers and motions would remain, but not odors or tastes or sounds. The latter, I believe, are nothing more than names when separated from living beings, just as tickling and titillation are nothing but names in the absence of such things as noses and armpits. (Galileo, 1960, p. 277)

Galilei follows an approach similar to the one Claudius Galenus challenges in Democritus' teaching. Interestingly enough, and contrary to Democritus, Galilei does not include eyes and colors, or more widely, the perception of light, in his statement. He understands how important light is as a source of information and he suspects that light phenomena are more likely to be converted into shapes, numbers, and movements (later described in physics as waves, amplitudes, and frequencies).

The first calculating machines—mechanical calculators—were built in the 17th century. Surprisingly enough, one of their first designers, Blaise Pascal, organized their mass production for some time. In *Pensées* he devotes but a single, yet very serious, sentence to them (Pascal, 1958, Sec.VI/340, XXXII):

> The arithmetical machine produces effects which approach nearer to thought than all the actions of animals. But it does nothing which would enable us to attribute will to it, as to the animals.

René Descartes mentions a similar problem in his *Discourse on the Method*. He writes

> Machines which had organs, and the exteriour figure of an Ape, or of any other unreasonable creature, we should finde no means of knowing them not to be altogether of the same nature as those Animals: whereas, if there were any which resembled our bodies, and imitated our actions as much as morally it were possible, we should always have two most certain ways to know, that for all that they were not reall men. (Descartes, 1998, p. 114)

For Descartes, the boundary between minds that are able to think and minds that are not is located in a different place than for Pascal. According to Pascal people belong to the same category as animals, which Lucretius calls creatures. According to Descartes only people are able to think. Let us hear why Descartes thinks even machines that perfectly imitate human abilities would not be the same as humans

> The first of which is, that they could never have the use of speech, nor of other signes in framing it, as we have, to declare our thoughts to others… (Descartes, 1998, p. 115)

Today we would probably consider this argument non-valid since computers nowadays not only use words and characters, but they use languages too. But the second argument is still very relevant.

> And the second is, that although they did divers things aswel, or perhaps better, then any of us, they must infallibly fail in some others, whereby we might discover that they act not with knowledge, but onely by the disposition of their organs... (Descartes, 1998, p. 116)

According to Descartes, perception and will are not sufficient attributes of intelligence, only the intelligent mind as a universal tool is. The absence of perception and will results from the absence of an intelligent mind. We can complete Descartes' thought: creatures composed only of organs base their acts on the laws of nature, they have no mind of their own since they do not need one. If we consider machines or creatures from the standpoint of a scientist, then they became simple machines or things with no mind or will.

The third stop: Apparatus, measurement, observer

In his *Mathematical Foundations of Quantum Mechanics*, John von Neumann (1996) simply, but thoroughly, analyzes how essential the role of observer is in physics. He illustrates this using an example: When we measure temperature we can conclude the process by measuring the temperature of the air around the flask using mercury and state that the temperature was measured by the thermometer. We can include the length of the column of mercury and say that the length was recorded by the observer. We can add that the light traveled from the thermometer to the observer's eye and produced an image on the observer's retina. Given sufficient scientific knowledge we could research how the chemical signals traveled to the brain. But in any case, Neumann's conclusions (Neumann, 1996, p. 77) will still be true:

> That is, we must always divide the world, into two parts, the one being the observed system, the other the observer. In the former, we can follow up all physical processes (In principle at least) arbitrarily precisely. In the latter, this is meaningless.
>
> That this boundary can be pushed arbitrarily deeply into the interior of the body of the actual observer is the content of the principle of the psycho-physical parallelism — but this does not change the fact that in each method of description the boundary must be put somewhere, if the method is not to proceed vacuously, i.e., if a comparison with experiment is to be possible.

Before the end of the 19th century, the observer was almost never considered to be of any importance. It was assumed that the analysis of a physical process ends with reading a measuring device and that this reading is not dependent on the observer. With the gradual perfection of scientific devices and the statistical evaluation of data we come ever closer to this reality.

Thanks to the theory of relativity and quantum theory, the word "observer" appeared frequently within the science of physics during the 20th century. But these two examples are very different. Using "observers" makes the concepts of the theory of relativity much easier to explain, and observers could easily be substituted with measuring devices. When objects travel in high velocity and great amounts of energy are involved, the results of measurements are considerably different than one would expect given the classical teachings (distance contraction, time dilation). The situation is even more complicated in quantum theory and has yet to be successfully clarified. Let us consider an excerpt from Landau and Lifshitz's famous *Course of Theoretical Physics* (Landau & Lifshitz, 1977, pp. 21-24):

> We consider a system consisting of two parts: a classical apparatus and an electron (regarded as a quantum object). The process of measurement consists in these two parts' coming into interaction with each other, as a result of which the apparatus passes from its initial state into some other; from this change of state we draw conclusions concerning the state of the electron.…The classical nature of the apparatus appears in the fact that, at any given instant, we can say with certainty that it is in one of the known states.…We see that the measuring process in quantum mechanics has a "two-faced" character: it plays different parts with respect to the past and future of the electron. With respect to the past, it "verifies" the probabilities of the various possible results predicted from the state brought about by the previous measurement. With respect to the future, it brings about a new state (see also §44). Thus the very nature of the process of measurement involves a far-reaching principle of irreversibility.

The authors avoided talking about the observer directly. Observers can choose what they are going to measure. Their decisions and preparations concerning the experiment are not subject to physical analysis. As soon as the experiment is set up, the observer is there only to record the data. He/she cannot influence nature's answer to the question.

Unlike in classical physics the answer to this question cannot fundamentally be predicted. Quantum physics formulas describing the changing status of quantum objects can only predict the probable condition of a classical instrument in interaction with quantum objects. These formulas do not explain how the instrument selects from different conditions—reduces data. There is no clear definition of "classical". Classical physics is not an extreme case of quantum theory, but it is a fundamental condition necessary to prove quantum theory.

Now the question arises as to whether the seemingly haphazard reality detected by measuring was created by the measuring or if it existed beforehand and somehow predetermined the outcome. Einstein and his coworkers defended the second opinion in their dispute with Bohr. The importance of the work they conducted in 1935 was recognized much later, when it lead to the definition of quantum entanglement (Einstein, Podolsky, & Rosen, 1935).

We are dealing with the relationship between data obtained in different locations where there is no possibility of one measurement influencing the other—for instance if superluminal speed (which is impossible in terms of modern physics) was involved. This connection could exist if the objects measured shared a mutual history. If I discover I have packed only my right shoe, it is pretty obvious that the shoe I left at home is my left shoe. To the eccentric philosopher who would object that I can only be sure that the shoe is the right one after I have looked at it (Berkeley's "esse est percipi"), I can argue that if my wife sees the shoe I left at home, I can predict with certainty that she will see my left shoe, even though my looking at my right shoe could not have influenced what she sees. The shoe was a left shoe before my wife looked at it; likewise my right shoe was a right shoe before I looked at it.

Einstein and his colleagues tried to point out that quantum theory is unsatisfactory when applied to quantum objects that are entangled by their common history. They assumed that physical interactions travel at a finite speed. So despite the fact that the measurement taken of an object at location A cannot influence the measurement of an entangled object at location B we can predict the outcome of measuring at location B on the basis of the measurement at location A. Einstein concludes that an "element reality" localized in space exists and predetermines the outcome of measuring at location B.

Even though the quantum mechanics uncertainty principle holds that the values of two variables cannot be predicted at the same time, they can both be predicted. So the "element reality" which is outside the scope of quantum mechanics, exists for each of them even before it is measured. John Bell's theoretical reflections and his associated experiments showed that the world is not governed by Einstein's assumptions. By comparing measurements of entangled objects it could be shown that reality and location, in the sense Einstein understood them, are irreconcilable.

It seems that the outcome of an interaction between a quantum object and a classical measuring instrument is not preceded by any predetermining reality. On that basis we can legitimately ask if the reduction is carried out by the instrument or the observer's mind.

The fourth stop: Towards a Theory of Everything

During the last few decades the dream many great physicists have had of the possibility of formulating a universal theory of physics explaining all relationships among all physical phenomena has come to fruition. This Theory of Everything is usually understood as encompassing all four known interactions: strong, weak, electromagnetic, and gravitational. The main obstacle seems to be that the theoretical foundation for explaining gravity is the general theory of relativity based on classical concepts, and it is very difficult to connect it to quantum theory, which is applicable to the remaining interactions.

The "Theory of Everything" might even have greater ambitions—it could include systems of considerably larger complexity, including the human brain. That is how Roger Penrose, among others, understands this theory. In his books (Penrose, 1989, 1994) he points out that the main obstacle to formulating a universal theory is not only the fact that the general theory of relativity occupies an isolated position among the other theories, but he also points out the contradictory character of quantum mechanics, which does not allow a satisfying bridge to be constructed between quantum and classical physics. Only once the bridge is built will we be able to understand brain processes and incorporate consciousness and the intelligent mind into physics.

From that point of view, Penrose asks to what degree can modern computers actually "think" (Penrose, 1997). He argues, and provides examples, that computers cannot understand and comprehend the world the way humans can. Let me give you at least one example: a computer program called Deep Thought capable of winning against champions. The program chooses a simple winning move connected with material gain, because the catastrophic outcome would have surfaced after dozens of moves and the program would not have calculated its moves that far. But even when a computer wins over a human being it does so through "brutal force"—a computer can only do what people following instructions would be able to do if they were not held back by their inability to act faster.

According to Penrose, the conscious mind can never be substituted by computing—when an algorithm is followed. The fundamental attribute of the conscious mind is non-computability and Penrose believes that the theories capable of overcoming the contradictions of quantum mechanics will have the same attribute. But computability is not the same as mathematical science or determinism, and so it is potentially possible (according to Penrose) to understand the conscious mind within mathematical science.

> I simply do not see any room for conscious mentality within our present-day physical world-picture - biology and chemistry being part of that world-picture (Penrose, 1997, p.146).

Conclusions (which I do not wish to force on anyone)

Computers can execute our programs, but they cannot think for us. What computers and people excel in is complementary, to some degree, and therefore it is important to combine these strengths. We should always keep developing strengths that can never be replaced by the computer: our intuition, ability to estimate, our understanding, and empathy. It is still good to know how to calculate integrals and solve differential equations, even though a computer can do it much faster.

Pascal's thoughts and the second of Descartes' reasons are still true. There is no evidence that even the most powerful computers have any will of their own and that they have anything that people could not understand (as is the case with human conscience and the mind).

Galen's words are still valid: if we rid the world of everything subjective we will have an incomprehensible world.

Reflections on non-computability might lead to an understanding of conscious mind, but like Lucretius' element deviations—they do not really show us how to approach this problem.

I would like to try to answer the question: "Does an observer belong in physics?" Well, on the one hand, yes, and on the other, no. Without an observer there would be no physics, but physics does not explain the observer (now and maybe for ever). Perhaps we can say that an observer forms the boundary of physics.

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