We think, therefore we can be tricked

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Abstract
This review article concerns the human aspect of science. I describe (in a more or less interactive way) some flaws of cognition, biases, illogical reasoning, social validation—imperfections that also have an impact on a scientist’s daily work. This paper is based on the presentation given during the 2008 European School of High-Energy Physics.

1 Introduction
A prologue explains the title of this contribution and gives a brief introduction to the philosophical position regarding the attainment of certainty. The next part concerns some flaws of reasoning (biases), while the final part deals with the contemporary view of science as a mainly sociological phenomenon. Owing to the specificity of the initial presentation, this paper has no pretension to completeness on the topic.

2 Prologue
René Descartes (1596–1650) was searching for a solid base on which to build his world-view. Of course, so are all philosophers, but Descartes’ solution was new, because he found an answer linking ontology to cognition. Descartes thinks about the problem, so at least he is thinking. He cannot think without existing, so if he thinks, he exists. “I think, I am”, he concluded. Later on ‘therefore’ was added: “Cogito, ergo sum”. There was doubt about everything, but Descartes was sure about two things: (1) that he was thinking, and (2) that God Almighty had to be honest. An evil god could decide to trick Descartes and give him the impression that he was thinking. The method of rational doubt delivered certainty: Descartes had to acknowledge he existed. He came to this conclusion through deduction: merely in a rational way, without any reference to sensory perception.

It is the essence of philosophy to answer the question of what can we be certain. The sceptics as far back as the 4th century B.C. stated that no certainty could ever be obtained about anything, so the only adequate method of dealing with the world consisted in avoiding to judge (about matters beyond daily life). The only way to know something about the world was through sensory perception, but since (1) the senses could easily be deceived and (2) the senses can only tell us something about what can be perceived, it was common sense not to decide.

3 We are perfectible
We think, we see, and our brain lacks perfection. Neurological processes fail and make memory functions fallible. Our ability to solve problems is highly dependent on our working memory capacity [1]. Experiences that we think are ours, are imprinted [2]. We have recollections of things never before encountered: the phenomenon of reminiscence [3, 4]. Sense perception is inadequate: the world is in the eye of the beholder. We see things that are simply not there, because of processes that, again, fill in the gaps. Indeed, the imaging and recollecting of data ‘suffer’ from the same phenomenon and the combination results in the fact that we construct our ideas: “the intimate connection of perception and memory allows people to build elaborate episodes from simple stimulus events” [5]. Try to memorize the following words: thread, knitting, thimble, eye, sewing, pointed, sharp. Then say which of the following words appeared in the original list: door, sewing, stick, needle. Only the word ‘sewing’ was there, but
many say ‘needle’ too. It is a normal standard error which implies a normal functioning memory. But incorrect recollections such as this one are very frequently made [6].

Besides these shortcomings of the brain—some scholars find these not to be shortcomings at all, because they do give an evolutionary advantage to the species—many biases clog up our reasoning [7]. The confirmation-bias makes people look for positive results. Whatever confirms our ideas is noted, while contradictory information is neglected. Any affirmative conclusion is considered more valuable than a contradictory one. We want our hypotheses to be confirmed. We will continue to search for confirmation. We look for confirmations all day long. We want to hear how good we are. We are more susceptible to confirmations. It is difficult to acknowledge a contradiction. Confirmations are remembered easily, contradictions we tend to forget.

The base-rate fallacy focuses on the observation that valuable information is shielded by noise or not correctly taken into account. When people are confronted with the so-called taxicab problem, they give the wrong answer: they do not take the relative distribution of cabs into account: ‘A cab was involved in a hit-and-run accident at night. Two cab companies, the Green and the Blue, operate in the city. You are given the following data: (i) 85% of the cabs in the city are Green and 15% are Blue. (ii) A witness identified the cab as a Blue cab. The court tested his ability to identify cabs under the appropriate visibility conditions. When presented with a sample of cabs (half of which were Blue and half of which were Green) the witness made correct identifications in 80% of the cases and erred in 20% of the cases. Question: What is the probability that the cab involved in the accident was Blue rather than Green?’ [8]. Subjects say it was a Blue cab, while it is more probable that it was a Green one. Whatever the explanation for the fallacy might be (some psychologists do not agree [9]), the fact remains that we do not think logically at all times. Given that ‘Linda is 31. She had a cat and a dog, at the age of six. She always adored pets. She signed up with Greenpeace’, what do you think is Linda’s profession? Does she work in a bank or does she work in a pet store? There are more banks than pet stores (base rate), so it is more likely that she works in a bank (although most probably she does own a dog and/or a cat). We rather take stereotypes into consideration: somebody who adores cats and is a member of Greenpeace must be working in a pet shop.

Other experiments confirm our illogical thinking. Consider the following: ‘Linda is 31. She had a cat and a dog, since the age of six. She always adored pets. She signed up with Greenpeace.’ Order from more likely to less likely: (1) Linda is a veterinarian, (2) Linda works in a bank, (3) Linda is a veterinarian and a vegetarian. Most people will answer that Linda is probably not a bank teller, and most probably a veterinarian and a vegetarian. However, there are more people who work in a bank than are veterinarians, so it is more likely that Linda works in a bank (base-rate fallacy). It is difficult to know whether there are more veterinarians than veterinarians, but this does not matter: there are always more veterinarians than veterinarians that are vegetarians at the same time, since the set of veterinarians and vegetarians is a subset of all veterinarians. This is called the conjunction fallacy [10].

How many animals did Adam put in the Ark? Attention! This question concerns the number of animals of a particular kind and not the total number of species. So what is the answer? None, because Adam is not Noah. We focus on what is conspicuous; we focus on what we are focused on. By the way, ‘two’ is also wrong, because according to Genesis, chapter 7, you have to ‘take with you seven of every kind of clean animal, a male and its mate, and two of every kind of unclean animal, a male and its mate, and also seven of every kind of bird, male and female, to keep their various kinds alive throughout the earth.’ We are gullible. If we are asked to connect five dots prefiguring a house, to draw the house, and subsequently to connect nine dots (three rows of three in a square) by drawing four straight lines that need to be connected, we are indoctrinated by the former task and it is hard to succeed in the latter, simply because we cannot think beyond the apparent square. However, nobody said that we had to draw a square!

A conclusion reached without considering problem-free instances is called pseudo-diagnostic [7]. This kind of irrationality has been pinpointed as the reason for the Challenger accident on 28 January
1986: because NASA did not take the problem-free flights into consideration (flights where there were no problems with the parts identified as not functioning correctly and designated as the culprit for the explosion), the correct correlation between outdoor temperature and O-ring failure was not found [11].

When an audience is asked at what time one went to sleep the day before (At ten? Eleven? Midnight?), subsequently whether anybody had sex during the previous weekend, and finally who looked around before answering the first two questions, it becomes clear what ‘social validation’ leads to. We want to inform ourselves about what others did in order to make up our own mind.

When we read texts, look around, hear messages, we can not be sure we will draw the correct conclusions. Even if we read the following attentively—‘Finished files are the result of years of scientific studies combined with experience of years’—and are asked to count the number of times the letter f is printed in that sentence, some count only three, four or five letters, while there are actually six f’s present. Several explanations can be given (only a small part of our sight is sharp, short words are read as holes, etc.), nevertheless it is quite clear that we can easily be tricked. So many illusions confirm this [12]. Give consideration to the following text: “Acocdrnig to an Elgnsh unviesity sutdy the oredr of letetrs in a wrod dosen’t mttaer, the olny thng thta’s iopmrantt is that the frsit and lsat ltteer of eevry word is in the crect ptoision. The reet can be jmnbued and one is stil able to raed the txet wiohtut dclftfyiuy.” No problem reading it?

What if a scientist has to count the number of basophilia when looking through a microscope? Can she be misled? What if she is so eager to find many? (Confirmation bias) What if the situations in which the basophil count remained insignificant were not taken into consideration? (Pseudo-diagnostics) What if she was influenced by the group dynamics and said she found as many as her colleagues? (Social validation) Her work could result in the confirmation of the thesis that water has memory; and it did. All researchers of a centre were misled by themselves (and a bit by the head of the centre). A team of other scientists (led by Nature’s famed editor John Maddox) and an illusionist, James Randi, could falsify the claim [13].

4 Scientists and laymen alike

For years philosophers of science focused on the disciplines to figure out what science is all about. Before Thomas Kuhn’s The Structure of Scientific Revolutions, normative studies ruled (philosophers saying what scientists should do) and afterwards the descriptive way took over (how does science actually develop?). Only during the last three decades did it become clear that the human aspect had an impact on scientific development; scientists themselves became worth studying. Psychologists and sociologists showed interest.

With Bruno Latour and Steve Woolgar [14] the anthropologist’s approach was introduced. How do scientists interact? What do they actually do? Scientists would be studied as if they were members of a newly discovered tribe, without prejudice, nor cultural and philosophical presuppositions. Their conclusion was that scientific facts are actually made by a network of scientists. Science might be a very special kind of activity, but it remains a human activity. Because, evidently, individual humans are involved, all the above-mentioned influences need to be ruled out—as far as possible. In contemporary philosophy of science the position is taken that science is to a great extent a social activity, and, as such, is extensively influenced by everything that determines human behaviour [15]. According to Latour, for example, science needs to acknowledge the many social actors that make it happen. In the end, everybody contributes to science. It is the grand scale of the enterprise that renders scientific knowledge trustworthy [16].

Some scientists were not pleased with what they heard. Those sociologists, psychologists, philosophers of science… those philosophers all needed a lesson! So Alan Sokal, a mathematician, wrote a hoax paper and submitted it to Social Text (a respected journal in the humanities). Sokal’s paper [17] was published and as soon as possible the blunder was brought into the open. Of course, it is a fact that a few
sociologists, philosophers, and psychologists do use scientific concepts illegitimately or uncritically—the postmodern psychoanalyst Jacques Lacan used $i \sqrt{\sqrt{-1}}$ as a symbol for the phallus—but these scholars are a minority, whose theories are received with scepticism by the rest. The so-called ‘war of the sciences’ began—and is still ongoing. The only way to end it is to respect each other’s work—remaining sceptical at all times.

5 Conclusion

Scientists are men and women like everybody else. The scientific enterprise makes it possible to eliminate to a great extent the human shortcomings (biases, flaws, etc.) that govern thinking. However, people make facts, people make science, and the scientific enterprise is, according to the contemporary philosophy of science, an endeavour with clearly irrational aspects. Scientists, a fortiori, think; therefore they can be tricked by reality.

References