Our philosophical science correspondent
Massimo Pigliucci asks:

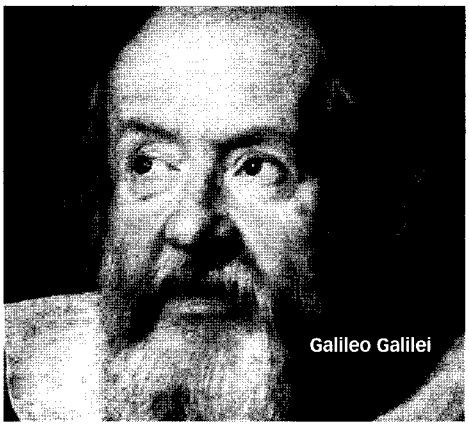
What is a Thought Experiment, Anyhow?

Science

Philosophers are often accused of engaging in armchair speculation, as far removed from reality as possible, inside the proverbial ivory tower. The quintessential example of this practice is the thought experiment, which many scientists sneer at precisely because it doesn't require one to get one's hands dirty. And yet scientists have often engaged in thought experiments, some of which have marked major advances in our understanding of the world.

Just consider the famous example of Galileo's thought experiment demonstrating (rather counterintuitively) that two objects of different weight must fall at the same speed. (Contrary to popular belief, Galileo never actually climbed the leaning tower of Pisa to do this experiment – he didn't need to.) Galileo knew Aristotle would have predicted that a heavy body (H) would fall faster than a lighter one (L). But, the Italian scientist reckoned, suppose we connect the two bodies by a string, thereby making the compound object H+L. Following Aristotelian physics, one would predict that H+L should fall faster than H by itself because of the compound weight: therefore H+L > H. However, it's also possible to use the same logic to claim that the compound body should fall at a *slower* pace than H because of the drag created by L, so that H+L < H. But this yields a contradiction, which means – by *reductio ad absurdum* – that really H = L = H+L. Neil Armstrong, the first human to set foot on the moon, dramatically showed the whole world that Galileo was right when he let go of a hammer and a feather in the absence of atmospheric friction while standing on our satellite, and, sure enough, they hit the Moon's surface at the same time. Such is the predictive power of thought experiments!

Then again, some thought experiments can lead to misleading conclusions – as in the case of Lucretius' 'demonstration' that space must be infinite. In the *De Rerum Natura* he reasoned that one might walk up to the boundary of the universe and throw a spear (there were no weapons of mass destruction in Roman times). If the spear flies through the alleged boundary, then it is no boundary at all, and we conclude that the universe is infinite. But what if the spear bounces back? Then there is a boundary; but by definition if there is a boundary then there must be something beyond it – which again leads to the conclusion that the universe is infinite. The problem with this is that today's mathematics and physics show us how a universe can be *both* finite and unbounded (it's like a toroid, ie a donut).



Galileo Galilei

These and other thought experiments are discussed in an elegant paper by James Robert Brown, who goes on to ask what sort of beast, exactly, is a thought experiment? Brown contrasts two theories, his own – according to which thought experiments are a perception of a kind of Platonic reality – and that of John Norton, who thinks that thought experiments are actually a form of argument. I will not take sides, partly because I'm not sure that the two views are actually incompatible with each other; but it is instructive to examine both views in an attempt to wrap our minds around what exactly our minds are doing in these cases.

Let's start with Brown's position, which he claims to derive from two starting points: a Platonic view of mathematics, and a realist view of the laws of nature. Platonism in mathematics is the idea that certain entities – like numbers, and relations among numbers – are 'out there' independently of human minds. Numbers in some sense 'exist' regardless of the presence or ability of a mind to conceive them. Accordingly, mathematicians are akin to scientists: they do not invent things, they discover them. Similarly, following Brown, natural laws like say the law of gravity described by Galileo and later formalized by Newton are 'real' in the sense that they exist, again, independently of human observers. (If all this talk of human-independent phenomena has you wondering about the sound of a tree falling when there is nobody there to hear it, stop right now:the analogy is only superficial.)

What does all of this have to do with thought experiments? According to Brown, thought experiments are genuine examples of how the human mind can 'perceive' laws of nature by simply thinking about reality. This was the goal of rationalist (as opposed to empiricist) philosophers since Plato: to discover things about the world by sheer intellectual power, independently of empirical evidence, which was seen as unreliable.

In contrast, Norton has a very different take on the whole matter. For him, thought experiments are a form of argument, starting from empirically derived premises and reaching conclusions by deductive logic. In essence, Norton thinks of experiments such as Galileo's as 'if-then' forms of reasoning, which yield valid results when the premises are empirically justified and the reasoning is logically correct.

There is something very appealing about both Brown's and Norton's notions. On the one hand, with Brown there is a sense in which thought experiments are formalizations of an intuitive grasp of an objective reality. Yet this reality – if it exists – is surely of the Platonic, abstract type, not of the more mundane "this table is real" kind. On the other hand, it is hard to resist Norton's construction of thought experiments as arguments based on a proper mix of induction (the empirical premises) and deduction.

Whatever thought experiments *really* are, they have been instrumental in the progress of both philosophy and science, and they constitute a powerful tool for understanding the world. True, sometimes they don't work, but the same can be said for physical experiments. In both cases it's all in the soundness of the premises and the rigor with which the conclusions are derived.

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Further reading:

• Brown, J.R. 2004. 'Peeking into Plato's heaven.' Philosophy of Science 71.