When Science Fails

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When science fails, all hell breaks loose. “Science is simply common sense at its best, that is, rigidly accurate in observation, and merciless to fallacy in logic” - Thomas Huxley, and there are many ways for the senses to become uncommon, the observations inaccurate and the logic fallacious. Science is nothing but a tool, a method, and whenever we forget how to properly wield it, shenanigans ensue.

The first step of the scientific method is defining a question based on preliminary data (preexisting observations and knowledge of the inquest subject). Here lies one of the great challenges of the process, formulating a coherent and relevant question can be a very tricky thing to achieve. For example, in quantum mechanics the formalism of the measurement explicitly destroys information and collapses the state of the system in only one of a multitude allowed in a superposition. Physicists were, and to some degree still are, perturbed by this fact, even as the initial shock has passed.

Usually closed physical systems also conserve on top of the usual physical quantities the amount of information. However, the collapse of the wave-function seems to indicate the opposite is sometimes the case, and this has forced the hand of physicists to try to patch up the theory. The question they asked was, “What if the information is conserved in the multiverse?”. Thus sprang to life Everett’s *many-worlds interpretation* of quantum mechanics.

Sadly, the *many-worlds interpretation* of quantum mechanics is unfalsifiable. The physical theory of quantum mechanics prohibits any interactions between world lines after they split. The metaphysics of Everett’s interpretation makes us ask the question of whether somewhere out there lies a world where an exact copy of us made a different choice at a pivotal moment and where it might’ve led us. Fascinating the imagination, though it might be, this question has the same bearing on our life as asking whether our bank account might indicate a number with more digits. Yes, it could but it would require work **in our** physical reality.

Next on our list is the difficult task of obtaining “rigidly accurate observation”. In science in general, and in physics especially, the aim of any given experiment is to control as much as possible the parameters of the system and let as few degrees of freedom evolve freely according to the natural dynamics in order to isolate the laws governing the system with as much clarity as possible. However, in spite of scientists’ best efforts, it is often the case that the complex experiments devised to uncover increasingly fine and granular details about the universe become extremely sensitive to even slight external perturbation and as such easily produce misleading data. One particularly egregious example of bad observation is the very (in)famous detection of superluminal neutrinos by OPERA (a CERN - LNGS collaboration).

The laws of physics, as we understand them at the time of writing, explicitly forbid information (and implicitly particles) from traveling faster than the speed of

light. The reader may therefore understand the absolute mayhem that ensued from OPERA's *detection* of neutrinos traveling at speeds faster than light. For close to a year the discussion kept going at a dizzying pace, scientists competing to justify, explain and expand the existing models in order to account for the new discovery. It was all for naught, within six months reports of a loose optical fiber induced mismeasurement started making their way through the news, within a year the whole revolution had been discarded following thorough remeasurements.

Scientists are human beings too, often the mistakes they make aren't intentional, it's either systematic error as we've seen previously or merely their mind playing tricks on them. All humans have biases and when doing science the worst thing that can happen is whenever you trick yourself into believing your wrong hypothesis.

Humans are full of biases and fallacies, as the folks at *schooloftthought.org/* are ready to point out at their two sister websites, *yourbias.is* and *yourfallacy.is*, and escaping a wrong first impression gained from a cursory glance may take oh-so-many-more hours of grueling work where the cognitive dissonance reigns supreme as mounting evidence to the contrary is summarily ignored.

Alas, scientists are human beings too, and unfortunately this means they are subject to incentives and peer pressure as well. I am not the first, and certainly I will not be the last to decry the current state of scientific communication and how it has woven itself into an unholy matrimony with the funding process for public research. For the long version I invite the reader to watch the in-depth expose done by Rohin Francis. For the short version I invite the reader to keep reading.

The current funding model for research is based primarily in the scientometric approach whereby to every scientist a plethora of coefficients are assigned, each and every one attempting to characterize the ability of said individual to produce high quality science which is of use to the community. In order to increase their indexes, every scientist is in a constant race with their peers to try and produce increasingly novel and bombastic research and disseminate it via articles in peer-reviewed journals. This is because in spite of hosting the world's knowledge, funded primarily out of tax-payer money, the journals are, in fact, very much for-profit business, requiring both fees for publication and access.

Additionally, the journals set high bars for what constitutes scientific communications worth publishing. The accent has been increasingly placed on *mold-breaking* and *innovative* research. This has had the effect of guiding scientists to ever more exotic hypotheses that are hard to test and have limited sample sizes, all in an attempt to curry favor with the reviewers and gain access to a journal that is bound to improve their statistics. To top it all off, many of the same journals refuse to publish **reproducibility** studies, drawing a safety corridor for the first to publish and implicitly defending bad-faith authors from consequences of fraud.

Dubbed the "publish or perish" model of science, it has taken the careful, rigidly accurate and mercilessly fallacy free science and has perverted it into a

machine that spouts article after article of sensationalized science, plenty of it lacking the necessary details required for exact reproduction - ambiguity which is not a mistake, but a feature meant to obfuscate any attempt at qualifying the work as bad science. After all, *nobody remembers the second person to achieve something*, and in the world of science funding your fame carries half of your grant request. This has had the additional side effect of creating a toxic and back-stabbing atmosphere in the community, where once upon a time the ideal was collaboration, nowadays careful collaborations ends before either party gets the chance to absorb too much of the other party's expertise.

This phenomenon, while present in all modern branches of science, is of orders of magnitude more pronounced in the social sciences along with some areas of medicine. A frequent hack which allows research groups to publish constantly is that of foregoing a hypothesis and instead running measurements of many quasi-independent parameters in a given population. If the number of parameters considered is large enough and the population small enough, it is not very difficult to find spurious correlations which can be hacked to be statistically meaningful and eligible for publication.

The final pitfall of science that I'd like to touch on is scientism. Yet another bias, however this one is for the people who wield the science of others and refuse to engage it critically, elevating it at the rank of absolute truth and reflexively attacking anyone who might oppose the consensus. Science was born out of doubt, if you cannot doubt it, you cannot know it. It is always changing, evolving and becoming increasingly accurate through the constant honing action of scientists across the world. It will, however, never be complete, nor will it be the absolute truth. The act of doubting the established science and aiming to reproduce each and every result is at the heart of science and should be encouraged. However, those who choose to do this must take great precaution not to befall the same cognitive traps as those who've adopted scientism. Instead of just opposing the established conclusions, they have to simply and in good-faith look for the truth.

The reader, upon reaching this far, might be left with the impression that science is a thoroughly unreliable endeavor with each and every result, nothing but a sea of doubts. This is in fact not the case. Science is a tool like any other and when wielded properly it produces outcomes which benefit everyone and which should be trusted. However, as we've incentivized the baby to run with the scissors we shouldn't be surprised by the outcomes. Eventually, after enough time has passed, all incorrect hypotheses will be found and dealt with, the unfortunate aspect is that some of these will affect living people, such as was the case with fraudulent treatments for all kinds of illnesses. If we desire for things to change, we've got no alternative, **the incentives structure must change!**

Science wasn't always like this. The old masters were polymaths who used empirical methods very similar to modern science to develop their crafts through trials and error. The difference lies in the different motivations people had back then and now. Even nowadays, when people seek to find the truth they will unwittingly employ the scientific method by trial and error. This particularly

applies to artists who will generate a vision within their own mind, visualize an outcome if you will, and then proceed to meticulously experiment, changing one parameter of the process at a time in an attempt to realize said vision.

In analogue photography, especially, the outcome is never known until much later. Hence bracketing became the norm, taking many exposures while changing the aperture, exposure time, until exhausting the parameters. Adding and changing filters. Revisiting a location. Using different focal lengths. All in order to obtain a very deliberate look. When the apprentice becomes a master he will have gained enough experience to no longer require constant experimentation, the laws governing his exposure become well established, albeit unwritten.