Open Science and Reproducibility

Science is a valuable tool to improve our knowledge and improve the world we live in. It can be defined as the process of making hypotheses from observations and maintaining the most accurate theories. To achieve this, science must be objective, and any result obtained must be reproducible and replicable. This means that other researchers can replicate the results using the original data and methodology from a study and secondly, can arrive at the same conclusion using their own data ("Reproducibility and Replicability in Science," 2019). Unfortunately, the modern state of science might not recognise this fact anymore with a survey claiming that at least 90% of scientists think there is a reproducibility crisis, with more than 70% of researchers failing to reproduce an experiment from another scientist (Baker, 2016). This can be due to research being performed with poor methodology, too small sample size, or failure to consider external factors. More troubling is the possible impact of unethical behaviour on this issue, which can range from data dredging (p-hacking), manipulating data to match favoured hypotheses, or outright creating data without conducting the study. The major effect that pushes this behaviour is the pressure to publish in an increasingly commercial and competitive environment (Harvey, 2020). This need to publish for financial needs or visibility can reduce the quality of scientific knowledge (Munafò et al., 2017). Moreover, the importance of impact, increases pressure on researchers to write an increasingly large paper with a broader assertion but compromising depth (Kaelin, 2017).

To alleviate these issues with science, there has been a push toward 'open science'. The concept does not have a precise definition or unified view but is a new vision for conducting science with more transparency. There have been attempts to provide guidelines to perform more open science encompassing: open access; open material, data, and code; reproducible analyses; preregistration; replication research; and teaching open science (Crüwell et al., 2022). Other research tried to implement AI-based statistical analysis to detect errors or even fraud (Stephen Buranyi, 2017). This effort might help science move in the right direction, but it could also have negative consequences. More regulation could make running experiments too costly and complex for some researchers (Amaral & Neves, 2021). We could see a reduction in freedom of research essential to create discoveries, as well as paranoia and distrust in the science community. Humans are creative and will always find a way to circumvent the system in place. It might be necessary to reflect on science as a whole to root out the fundamental issue. Although the number of retracted articles seems low with 4 of every 10,000 articles retracted, it is hard to predict the actual number of articles with a potential issue. In any case, it would be a good opportunity to renew the way we perform science for a better future. The system still used today does find its origin in the 17th century. Maybe the concept of scientific journals and issues needs to evolve to something new, where the increasing complexity of science can be better divided and cooperation promoted. Transdisciplinary examples in the past have shown to produce highly valuable results (Ramirez & Cayón-Peña, 2017). It would be good to learn from the past to utilise the concept that works and adapt them to the current context where we must consider a

constant increase in scientific output while utilising the modern tools we have at our disposal. The current publishing system is a huge financial burden on researchers and society, where the funds could be allocated to better use. In a time with easier than ever communication and transfer of information, one could have expected that science could have evolved to a system outside of these boundaries where work can be shared more easily. The need for peer review is still necessary but as mentioned before, the current method is not effective to catch fraud, with the vast majority of fraud being detected through whistle-blowers (Stephen Buranyi, 2017). One argument could be made to defend a certain standard of science publishing, but with the huge amount of paper having subpar writing with confusing, incomplete and poorly written content in all journals, leaves me highly doubtful and the proper functioning of such a method. I do not pretend to know how science should be conducted, due to my lack of experience but I have a strong feeling that cooperation and modern tools could certainly arrive to a better result, reduce pressure on scientist, help with cooperation and standardisation. Technology can help researchers across the world cooperate easier. We can already see the premise of this with preprints for example, allowing for quick presentation of your work and discussion with other researchers (Sanjana, 2021). The objective of science is to further our collective knowledge, for this to be possible it needs to be shared and approved. Their used to be a time where publishing in journals was the only way of having your work known, but the world has changed and science should change with it or better lead the way.

For a new researcher starting a science career can be surprising and complicated. It is hard to make new contact, know how people operate in your field and understand what already exist. The apparent lack of proper standards and communication, renders the search for information confusing. One would expect science to be on the forefront of knowledge, rigour and new technologies. However, the reality is far from this ideal scenario. Scientists are often faced with improper material, lack of structure and improper methodology corrected after the fact. In those conditions open science might not be enough to help bring back science to the level it should be. It is important for new researcher to use the technology we know to their full extend and try to connect as much as possible with other research in different fields. As a young researcher I am full of hope and energy to make the world a better place, but the delusions and hard work in this career path for underwhelming outcome, scares me for the future.

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