

Hoaxing, Forging, Trimming and Cooking: The Cases and Causes of Scientific Fraud

Colin Stoneking

“There are several species of impositions that have been practised in science, which are but little known, except to the initiated, and which it may perhaps be possible to render quite intelligible to ordinary understandings. These may be classed under the heads of hoaxing, forging, trimming, and cooking.”

Charles Babbage, Reflections on the decline of science in England, and on some of its causes (1830)

Woo Suk Hwang, at the height of his career as a stem-cell researcher, was described as the “national treasure” of Korean science - a stamp was even issued to commemorate his research. Jan Hendrik Schön, an experimental physicist, was described as having “magical hands” and had an uncanny knack for getting spectacular results. These scientists had two things in common: one was amazing scientific success, making them stars in their respective fields, the other was that they were both guilty of fraud.

Hwang’s claim to fame was human cloning. In 2004, he reported coaxing donated egg cells to develop into embryos using nuclear transfer (the same process used to clone Dolly the sheep), and then harvesting human embryonic stem cells when the embryos were five to six days old [2]. Previously, human cloning had never been convincingly demonstrated and was thought to be extremely difficult, due to the sensitivity of primate cells. Later, he claimed the creation of 11 genetically distinct human embryonic stem cell lines, which would have been a key step forwards for stem cell therapy. However, no cloned stem cell lines actually existed.

Schön reportedly induced stable superconductivity in a plastic - labelled “Plastic Fantastic” by the media - and went on to claim a string of experimental firsts, including in 2001 the first molecular-scale transistor [3]. This had the potential to revolutionise modern technology, shrinking transistors by several orders of magnitude. However, none of these results were real; Schön had been making up data since his PhD days.

Both scientists became prominent in the media when their misconduct was finally discovered - Schön’s in 2002, Hwang’s in 2006 [3,4]. More recently, the misconduct of Marc Hauser, evolutionary biologist at Harvard, has been brought to light, and scientific fraud is again under the media spotlight. Hauser was found responsible for eight instances of scientific misconduct by an internal university investigation. He had been regarded as one of the stars of the study of human and animal cognition. So far, three of his papers have been identified as faulty, and the reliability of his other results remains undetermined.

How widespread is fraud? What drives scientists to commit it? In order to begin, it is first necessary to clarify what scientific fraud, or misconduct, means. In the UK and USA, the standard “working definition” of scientific misconduct is provided by the policies of the research councils, the National Science Foundation (NSF) and the National

Institutes of Health (NIH): misconduct consists of fabrication, falsification or plagiarism (FFP) [5].

“ **Misconduct consists of fabrication, falsification or plagiarism.** ”

Both fabrication (invention of data) and falsification (altering data or tampering with experimental procedure) have the same effect: misrepresentation of research results. Plagiarism, where the work of another is misappropriated, inflicts damage on a different level, namely the proper attribution of credit. This is severely harmful because credit and authorship motivate a great part of research, and have legal implications within intellectual property law. However, it can be argued that the “F-words” are more serious. The entire enterprise of scientific research fundamentally depends on the integrity of those involved; without the ability to trust in others’ findings, there is no basis for further progress. As with Hwang and Schön, when fraud is used to invent new findings it diverts the attention and the resources of other specialists in the field. The resulting waste of time and money is unbounded. Indeed, several independent labs spent years trying to replicate one of Schön’s setups, attempting to make an organic crystal behave as a transistor [3].

If fraudulent findings make it into established theory, they can delay progress for decades. The Piltdown man forgery (consisting of a human skull with an orangutan jaw) warped the mainstream view of human evolution for 40 years, and the fraudulent work of physiologist Eric Poehlman was still cited even after he was jailed for falsifying federal grant applications [6]. In this way, cases of research misconduct can easily damage public perceptions of science.

As Babbage’s treatise on the state of science in 19th century England shows, misconduct is not a new problem. Although the high-profile cases mentioned above provide useful examples, they cannot indicate the full extent of fraud in the scientific community. Are these cases isolated, or are they just the tip of the iceberg?

A direct way to answer this question is to consider the proportion of submitted papers which are found to be fraudulent. In one example, 8 out of 800 papers submitted to The Journal of Cell Biology turned out to contain images

that had been improperly digitally manipulated [6]. The findings from surveys distributed to scientists have also been striking. A meta-analysis performed in 2009 found that, averaging over 7 different surveys, 1.97% of participants admitted that they “fabricated or falsified research data, or altered or modified results to improve the outcome” [7].

Overall, the findings from surveys and case reports demonstrate that misconduct is more widespread than one would expect, particularly when the inherent underestimation in such reports is considered. How alarmed should we be? To understand this prevalence of misconduct, let us examine the motives behind it.

One of the few comprehensive accounts of the factors behind scientific fraud was given by Dr. David Goodstein, who, as vice provost of Caltech, laid out a set of institutional guidelines for handling cases of scientific fraud and since then became an expert on the subject. He argues that three motivating factors underlie all cases of fraud, based on his assessment of particular cases [8].

“ **Data are massaged, modified or made up entirely until they conform.** ”

First of all, career pressure plays a role, and seems to be a much stronger factor than any potential monetary gain. The second motivating factor is widespread, but not ubiquitous: it is the prior expectation of an experimental outcome. While one might reasonably expect an experiment to confirm a hypothesis, if the expectation becomes a conviction it can lead researchers to take short-cuts when interpreting results - no longer relying impartially on experiments, but rather on their preconceived version of scientific fact. This leads to fabrication and falsification: data are massaged, modified or made up entirely until they conform.

Alternatively, fraud may be committed simply to mask poor experimentation, or to bring a study into line with previous results. This typically proceeds by subtle falsification - the data are tidied up, “trimmed” or “cooked”, in Babbage’s terms [1]. Even scientific luminaries are not immune to this sort of behaviour. Newton himself is thought to have misreported the result of an experiment which would have disproved his assertion that it was impossible to construct an achromatic (multi-wavelength) lens [3]. A key point is that fraudsters never seem to force through, by misrepresentation, a conclusion they believe to be false – they are not anarchists lobbing bombs against the foundations of their fields. As Goodstein puts it, “scientific fraud is always a transgression against the methods of science, never purposely against the body of knowledge” [8].

The final motivating factor, according to Goodstein, is

triggered when experimental results are not expected to be fully reproducible - lowered standards of reproducibility automatically result in reduced accountability. Goodstein argues that this is a particular feature of the biological sciences, grounded in biological variability - the inherent differences between organisms or biological preparations that cause them to behave differently under identical experimental conditions. However, it can be argued that in every field, issues with reproducibility can be found if one looks hard enough. There is always the potential to label errors as systematic when they are in fact random, subsequently biasing the reported results.

In summary, Goodstein’s three motivations for fraud are very unspecific. That is, there is no “smoking gun” to be found by examining the situation of a scientist suspected of fraud. Rather, they have the same habits and are under the same pressures as all other members of the scientific community.

Goodstein’s three fraud factors:

1. Career pressure;
2. Prior conviction of what the outcome of an experiment “should be”;
3. Low expectations of reproducibility.

The findings so far are good grounds for concern. A wide range of studies have shown fraud to be present at a low level in science, and a lack of detection means that the true extent is almost certainly higher. Examining the motives for misconduct has shown that there is no distinct factor in the research environment which separates fraudsters from more ethical scientists.

Ultimately, the only certain knowledge of fraudulent behaviour rests with the individual concerned. However, fraud can at least be impeded, if not rendered entirely impossible. The cases of Schön and Hwang provide one clear example: the life of a fraudster can be made much more difficult if his or her community demands access to full data, such that consistency and reproducibility can be evaluated. More attempts to replicate work and more vocal questioning when such attempts fail would hasten the detection of fraud, costly though these measures may be in terms of lost time and resources. In the cases presented here, the self-regulating process of replication worked eventually. But the damage remains, both from these instances and from those yet to be discovered.

Colin Stoneking is a second year student studying natural sciences at Emmanuel College. He is also the incoming Events Director of The Triple Helix Cambridge Chapter.

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