fst journal

The Journal of The Foundation for Science and Technology

Volume 23 Number 9
October 2024

Research Integrity

How can the credibility of UK research in all sectors be bolstered?

National Laboratories

Making the best of the breadth of the UK's national laboratories

Edge Technologies

Transformative potential, but also new threats and risks

News

Quantum Technology – from research to reality

PLUS:

News: Future Leaders Conference – building skills for future challenges

THE FOUNDATION FOR SCIENCE AND TECHNOLOGY

COUNCIL AND TRUSTEES

THE FOUNDATION FOR SCIENCE AND TECHNOLOGY

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CONTENTS

fst journal

Volume 23 Number 9 October 2024

THE COUNCIL AND TRUSTEES OF THE FOUNDATION Inside front cover

FOUNDATION NEWS

- In Conversation with Professor Dame Angela McLean • Foundation Future Leaders hit the road 2
- FST podcast returns • Quantum tech – from research to reality • Identifying critical technologies
- Building skills for future challenges

RESEARCH INTEGRITY

How can we safeguard trust in science? **Professors Andrew George and Rachael Gooberman-Hill** 3
Research Integrity as part of rebuilding trust in government **Cathy Alexander** 5
Taking concepts from the humanities and applying then to science **Professor Christopher Smith** 7
The revolution in publishing ethics **Sarah Jenkins** 8

NATIONAL LABORATORIES

A brief tour of the UK's National Laboratories **Sir Patrick Vallance** 12
This much I know about National Laboratories **Steven Cowley** 14
Everything starts with a rock **Dr Karen Hanghøj** 16
The UK National Measurement System (NMS) **Dr Julian Braybrook** 19

EDGE TECHNOLOGIES

The here and now **Joe Butler** 22
How AI can support those living with dementia **Professor Payam Barnaghi** 24
Everyday tech can put victims of abuse further at risk **Professor Leonie Maria Tanczer** 26
What is needed for an ethical future with Edge Technologies? **Dr Peter Novitzky** 28

EVENTS

Foundation events: recent and upcoming 32

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In Conversation with Professor Dame Angela McLean

On Wednesday 9th October we hosted a special "In Conversation" event with Government Chief Scientific Adviser, Dame Angela McLean at The Royal Society.

FST Chair Lord David Willetts joined Professor McLean to discuss the role of science and engineering in society, the challenges of her Government role and what it is like to work with Ministers and civil servants. With a full house, questions from the floor came in thick and fast and the after-dinner discussion provided much food for thought. You can watch the public section of this event on our events page.

Foundation Future Leaders hit the road

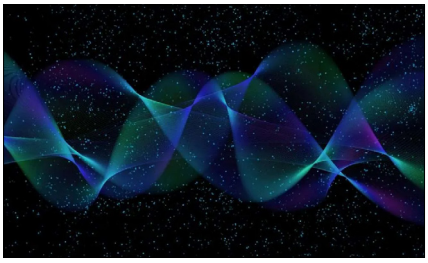
This autumn has been very busy for our Future Leaders, starting off with a two-day trip to Edinburgh. This included a visit to the Scottish Parliament to meet MSP Claire Adamson – with a surprise visit from Richard Loughead, Minister for Business in the Scottish Government). The group also met Julie Fitzpatrick (Chief Scientist for Scotland) and colleagues at the Scottish Parliament, with visits to the Royal Society of Edinburgh and the Dynamic Earth exhibition. The second day of the trip involved visits to several research areas of the University of Edinburgh. In October a group also visited the Harwell Science Campus in Oxfordshire, and they are set to visit the Houses of Parliament in Westminster, London, this December.

FST podcast returns

After a short summer break, our podcast has returned with a selection of new episodes for the autumn season. From what the future might look like for personalised healthcare, to Quantum Technologies, social justice and science and diversity and inclusion in STEM, there is plenty of new content to choose from. Our podcasts are a bitesize length of 25-30 minutes and available on most regular podcast platforms (just search for "Foundation for Science and Technology"). All episodes are also uploaded to our website here.

Quantum Tech – from research to reality

In September, we travelled to the University of Strathclyde in Scotland to host an afternoon discussion on Quantum Technologies. Chaired by President of the Royal Academy of Engineering, Professor Sir Jim McDonald, the event explored where the UK sits in quantum technology, and what is needed to transition from research into real-world applications. Our expert speakers included Chair of the Royal Academy of Engineering's 2024 Quantum Infrastructure Review Dr Dame Frances Saunders, and Professor of Quantum Sensing and Engineering at the University of Nottingham Melissa Mather. You can watch the presentations and following debate on our events page.



Identifying critical technologies

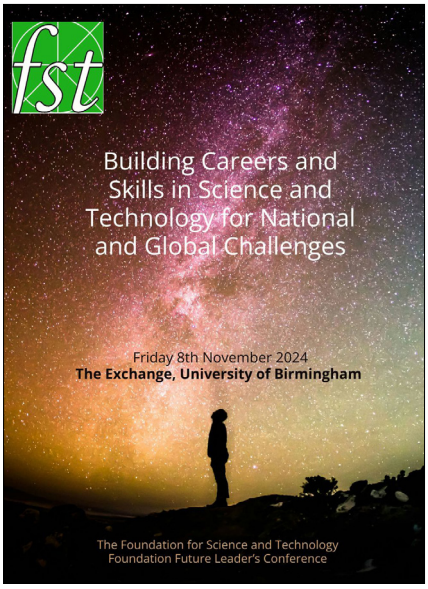
In a joint event with the Royal Academy of Engineering, we set up a roundtable discussion over the summer (July 8th) to explore the critical technologies such as quantum that could be prioritised by a new Government.

Questions such as how these critical technologies will be identified, what the criteria for selection might be, and whether there would be an industrial strategy, were all on the table. A report on the conversation and a paper which reflects on previous discussions, is now available online. We hope they will be a useful contribution to Government thinking in that area.

Building skills for future challenges

Our 2024 Future Leaders will be leading their own one day conference at The Exchange in Birmingham on Friday 8th November. The theme for this event will be 'Building Careers and Skills in Science and Technology for National and Global Challenges'. A panel of expert speakers will include Sharah Sharples, Chief Scientific Adviser at the Department for Transport, and Christopher Smith, International Champion for UKRI.

Details of the Conference, which is open and free to all and targeted at early to mid-career professionals across Government, industry and academia, is available on our website. We are grateful to the University of Birmingham for supporting this event.



CONTEXT

Excellent research is carried out in the UK across higher education, government, private and third sector organisations and national research laboratories. Research Integrity underpins trust in the excellence of our national and global science base. Research that has integrity is carried out in a way that is trustworthy, rigorous, ethical and responsible, which includes rigour and openness. High-profile challenges in Research Integrity include intentional misconduct and concern about credibility of scientific publications, including concerns related to new technologies and organised fraudulent practice. But these global debates do not necessarily reflect the robust health of UK research. What is the situation in UK research? How can the credibility of UK research in all sectors be bolstered?

On Wednesday 9th July, the Foundation held an event to explore Research Integrity and safeguarding trust in science. Speakers included: Professor Rachael Gooberman-Hill, Co-Chair; UK Committee on Research Integrity, Professor Andrew George; Co-Chair, UK Committee on Research Integrity, Cathy Alexander; Deputy Director for Science & Innovation, Systems and Capability at the Government Office for Science, Professor Christopher Smith; Executive Chair of the Arts and Humanities Research Council and Sarah Jenkins; Senior Director, Research Integrity and Publishing Ethics Centre of Expertise at Elsevier.

A video recording, presentation slides and speaker audio from the event are available on the FST website at **www.foundation.org.uk/Events/2024/Safeguarding-trust-in-science---the-role-of-resear**

How can we safeguard trust in science?

Andrew George and Rachael Gooberman-Hill

SUMMARY

- The principles laid out in the Concordat to Support Research Integrity cover all research, but they need to be interpreted in different ways depending on the context and discipline in which someone works
- Integrity requires the whole research system to work together to ensure that the research we do is the very best
- There is a distinction between thinking about the individuals that we place trust in and thinking about the organisations, the institution and the groups that they work in
- Trust in scientists has remained high and stable over a number of years
- There has been interest in characterising who trusts science and scientists most and least.
- Scientists can support trust in science by maintaining Research Integrity in their work so that science remains as good as it possibly can.

In this report we explore different aspects of Research Integrity, of how we safeguard trust in science, and the role of Research Integrity within that. The UK Committee on Research Integrity is responsible for promoting and driving Research Integrity in the UK. This includes ongoing work exploring whether we have the right mechanism in the UK for looking at misconduct, work to understand what indicators might be used to recognise Research Integrity, and examination of the impact of artificial intelligence in Research Integrity.

The Concordat principles of Research Integrity

The principles of Research Integrity are designed to ensure that the research that we do is excellent and high-quality across all disciplines.

- Honesty: For example, honesty requires researchers to describe their work accurately.
- Rigour: How well the research has been done in a technical sense.
- Transparency and open communication: Making sure that we are clear about describing the research we have done, how we have done it, and any conflicts of interest.
- Care and respect: Care and respect not only for the participants in research (humans and/or animals), but also for other members of the research community, and people that we interact with.
- Accountability: Being clear who is responsible for each aspect of the research enterprise.

These principles cover all disciplines, but they have got to be interpreted in different ways. What

Professor Andrew George and Professor Rachael Gooberman-Hill are the co-chairs of the UK Committee on Research Integrity. Professor Andrew George is an immunologist who has spent much of his career at Imperial College London and as Deputy Vice Chancellor at Brunel University London. He is Chair of Oxleas NHS Foundation Trust and on the board of the Health Research Authority. Professor Rachael Gooberman-Hill has a background in social anthropology and leads interdisciplinary research in her recent role as Director of the Elizabeth Blackwell Institute and current position as Professor of Health and Anthropology, both at the University of Bristol.

Slightly higher proportions of women than men trust scientists, while the number of years in education also affects the amount someone trusts science.

rigour means for a medieval linguist will be different from what it means for somebody working in CERN. Different disciplines also have different norms about how to apply different aspects of Research Integrity. For example, philosophers and subatomic particle physicists at CERN would have very different understandings of who should be included as author on a research work. That is something that we have to think through and balance. An understanding of what Research Integrity means in different disciplines is vital for collaboration between those disciplines.

These principles are also useful when talking about collaborative work between sectors, such as translation of work between academia and government, or academia and industry, or indeed industry and government. The principles provide a framework for communication between the different parties in research, so that there is clarity about the research and it is translated into practical application.

Research Integrity is the responsibility of the whole sector. This includes individual researchers, organisations that undertake research, funders, publishers, regulators, and professional or learned societies. One of the dangers is that there can be a tendency for people to blame another party for failings in integrity, whether it be the publishers, funders or universities. Such failures should be better thought of as a system failure, and are often due to issues in the interactions between various components of the system. While all of the components of the system are important, it is actually how the whole system works that determines how the research we do can be the very best that we can ask for.

The importance of trust

Collaboration in research and between science, policy and members of the public depends on trust. Like integrity, the concept and practice of trust has been explored by many scholars and disciplines. In the broadest terms, trust is described as an attitude towards or a belief about individuals, groups, organisations, or institutions. Trust can occur when there is anticipation that expectations will be met. When we think that expectations will be met we tend to think that someone or something is trustworthy. Trust is earned.

Trust is often thought about in terms of interpersonal relationships between individuals. But trust also takes place in relationships between individual and groups, institutions, organisations, areas, and fields such as science. Trust of or between individuals may have a different flavour to trust of, or between, institutions and groups. When we think about trust of science and scientists we may be wise to consider views of those who use science, members of the public, and from the wide variety of people working within the science ecosystem.

Trust in science in the UK

In the UK, evidence clearly indicates that trust in science and scientists is high and stable. A recent Ipsos survey, the *Veracity Index*, highlighted that scientists, professors, and engineers are among the most trusted professions in the UK today. This level of trust in scientists and related professions has remained relatively stable over a number of years.

There has been considerable work to understand who trusts scientists and science most and least. This work has tended to explore the characteristics of the individuals who are expressing views about their trust: i.e. the people doing the trusting. For instance, surveys often suggest that slightly higher proportions of women than men trust scientists. Other studies indicate that how many years' experience they have in education appears to impact on the amount that people trust science. Recently, a growing body of work examines how social media and internet sources relate to views of, and trust in, facts or evidence.

As well as providing research evidence about who trusts scientists and science most, it is important to consider what science itself can do to maintain or support trust in its processes and outputs.

The five principles set out in the Concordat to Support Research Integrity point to ways that scientists can deliver science with integrity. Science that has greater integrity, and that is seen to have integrity, is more likely to be trustworthy and trusted.

The principle of honesty is vital to trust in science. Science that is carried out and described with honesty is the bedrock of good practice. We also know that trustworthiness in science is supported more fully when honesty includes candid discussion about uncertainties and boundaries of knowledge, as well as reflection when evidence or information changes.

Equally, when science is rigorous and when rigour is made clear then this supports trust in science. This clarity is particularly important as a means of making scientific method understandable, reproducible where appropriate or possible, and open to refinement and development over time.

We also know that openness and transparency in the work that we do as scientists helps to support the sense and expectation that science is doing the best job that it can. Transparency in this sense includes provision of information about why some information cannot be shared, whether that be for valid reasons of privacy or security.

Care, respect, accountability

Finally, commitment to the principles of care and respect throughout the research ecosystem and to accountability work with one another to support trust in science. Well-defined and visible approaches to care, respect and accountability demonstrate attention to ethical practices in ways that serve those working in science and wider society.

Research Integrity enables science to be as good as it possibly can. As such, integrity in science supports trust in science. But integrity is not important solely because it is underpins trust in science. Instead, science can only be good if it has integrity. □

DOI: 10.53289/UILJ5828

Research Integrity as part of rebuilding trust in government

Cathy Alexander

SUMMARY

- There is evidence that trust in Ministers and Government has fallen and there are challenges around trust and integrity which we are working to address
- In 2019, the Government Office of Science published the Goverrnment Science Capability Review, which recognised that Research Integrity was important for government
- Government Office for Science has overseen the implementation of Research Integrity principles across all government departments
- Building on the ethical standards observed by the Civil Service, we published guidance to apply the Concordat to Support Research Integrity in a government context
- We have asked government departments to publish annual statements setting out how they have applied the principles of the Concordat.

Last year, an IPSOS survey indicated that there had been a decline in trust of politicians, ministers and civil servants. However, scientists are trusted by 75 per cent of people. We know that trust is really important as it gives governments a mandate to govern. It is therefore necessary to rebuild trust.

Government Office for Science (GOS) works to put excellent science advice at the heart of decision making, across the whole of government. The Government Chief Scientific Adviser, Professor Dame Angela McLean, leads GOS and advises the Prime Minister and the Government on all matters relating to science, engineering and technology. This year we are celebrating the 60th anniversary of the Government Chief Scientific Adviser role. The Adviser's work helps to ensure that we have a strong focus on science and engineering within government.

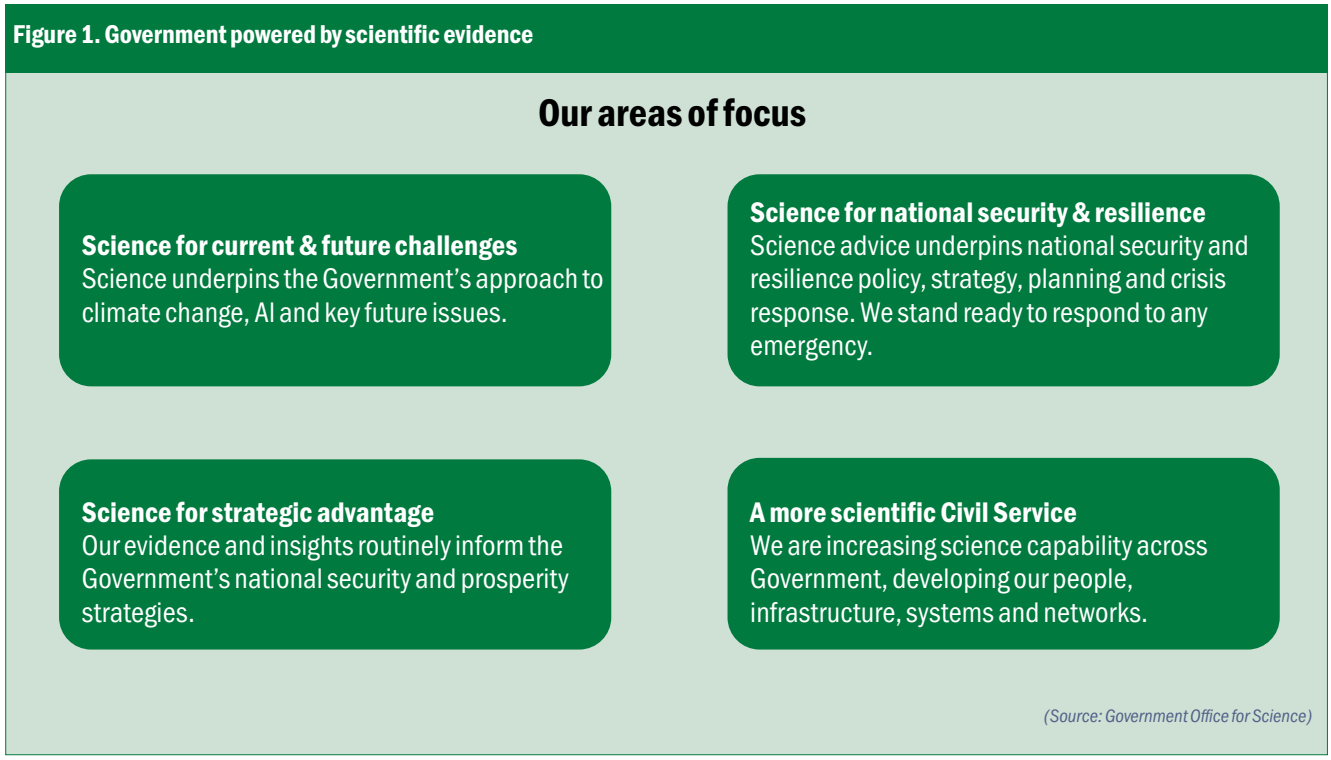
Government Office for Science has made it our priority to develop a more scientific civil service. My team lead this priority and, as part of that, we oversee a network of Chief Scientific Advisers in all government departments. We also lead and support a 10,000-strong Government Science and Engineering Profession, which brings together people across government and public organisations who have a role or a background in science and engineering. We are working to increase the science capability of departments by supporting and advising them to develop science systems. We also help departments to develop Areas of Research Interest (ARIs) and publish these. ARIs, which are now available and searchable on a public database, enable academics and other experts to connect with relevant Government departments so that their research or expertise can inform Government policy. Government departments and bodies also conduct or commission their own research, which is where our work on Research Integrity applies.

Guidance and review

In 2019, GOS published the Government Science Capability Review (with a progress update published in January 2024), which recognised Research Integrity as being important. We also published guidance in February 2022 which applied The Concordat to Support Research

Cathy Alexander is based in the Government Office for Science where she is Deputy Director for Science & Innovation, Systems & Capability. Her responsibilities include leading work to build a more scientific Civil Service. Cathy joined Government Office for Science in March from the Department for Science, Innovation and Technology where she was Deputy Director for Research Talent & European Programmes, leading work to deliver the UK's Association to Horizon Europe. Previously, she worked on a range of international, energy and resilience policy roles across Government.

Figure 1. Government powered by scientific evidence



Integrity to all government research. This built on the ethical standards that all public servants must follow, as set out by The Seven Principles of Public Life, also known as the Noland Principles. The Guidance sets high standards for our research community, including ensuring that research is conducted to legal and professional standards. We believe that this leads to better quality research, knowledge growth, and a stronger evidence base, which in turn supports the Government's decision-making process. Since publishing the guidance, we have worked with departments to embed the requirements within their science systems, and we have discussed and considered some of the practical implications with them, such as having the right resources available and identifying suitable training.

The Department for Energy Security and Net Zero is the first Government department to publish its annual statement for 2023-24.

Implementation

As required by the Concordat to Support Research Integrity, we have asked government departments to publish annual statements to set out their progress with implementation. 11 government departments and bodies published annual statements for 2022-23 and the Department for Energy Security and Net Zero is the first department to publish its annual statement for 2023-24. Other departments are also making good progress with these.

In terms of next steps, we need to consider the implications of AI for Research Integrity. We also need to identify measures and indicators for success and to look at how we embed them into our processes. We know that there is more work to do and we intend to continue our Research Integrity journey – improving and supporting research culture within government, and engaging with the academic community to continue to identify good practice. That will be a really important part of rebuilding trust and confidence in Government, the evidence it uses and the decisions it makes. □

DOI: 10.53289/UZBH2474

Applying concepts from the humanities to science

Christopher Smith

Professor Christopher Smith is Executive Chair of the Arts and Humanities Research Council and UKRI International Champion. He was previously Professor of Ancient History at the University of St Andrews. His research explores constitutionalism and state formation with particular emphasis on the development of Rome as a political and social community, and how this was represented in ancient historical writing and subsequent political thought. He is the author or editor of over 20 books and in 2017 he was awarded the prestigious Premio "Cultori di Roma". He is a Fellow of the Society of Antiquaries Scotland, the Royal Historical Society, the Society of Antiquaries of London, the Royal Society of Arts, the Royal Society of Edinburgh and a Member of the Academia Europaea.

SUMMARY

- We are moving from a notion of Research Integrity to a notion of the integrity of the researcher
- We need to hang on to the broad notion of science because one of the problems with a narrow version of science and thinking is that it emphasises a particular kind of integrity that misses the social context of the scientific endeavour
- We need knowledge professionals to help us and we must look after our librarians because they are our 'datanauts' – navigators of data
- We need more 'meta-humanists' in metascience to land the message that science is something very complex, something that is constructed by us to talk about ourselves.

When I started as a classicist, we got our notions of Research Integrity rather by osmosis. I think much of what we learnt about Research Integrity was from reviews, particularly book reviews, which at that stage was one of the most important aspects of the knowledge economy. We knew you had to be careful about the way that you cited things from stories, like the (no doubt) apocryphal tutorial, where the student stumbles through reading an essay, stops halfway through and says, "I'm so sorry, sir. I ca not read this person's handwriting".

Now when we look at the framework from the UKRI, we have our own policy on governance of good research practice, and that guidance forms part of our grant funding terms. We are a signatory to the UK Concordat which supports the Research Integrity that we have been hearing about. We are also a part of a call from that working group which is asking the research sector to participate in a consultation to shape revisions to the Concordat. We are also training people in a way that is rather more systematic than the one I have described for myself above. For instance, the Future Leadership Fellows have an enormous amount of training and resources available to them, including an annual conference which addresses issues of Research Integrity and open access.

Philosophy and Research Integrity

We often hear some classic comparative statements ,such as what you do as a philosopher is not the same as what you will do as particle physicist, and I just want to think about whether that is entirely true. One of the changes that has happened, I think, is that we have moved from a notion of Research Integrity to a notion of the integrity of a researcher. It seems to me to be quite similar, whatever you are doing. In fact, one of the things one might say about the arts and humanities in particular is this as it has become more of a team game rather than an individual game. We talk a lot about Research Integrity in science and sometimes it is the case that when we say science, we mean that very British, Anglophone, narrow version of science. We have lost the notion of science in the broader sense of the word.

I think that this is significant because almost everything we have heard about how you do Research Integrity, draws from the humanities. We talk about trust, honesty, openness and integrity, and these are ethical concepts. They are about the way that you approach knowledge and information. They are not necessarily owned by arts and humanities, but there may be a misalignment when you take 'humanities' concepts like these and address them to science, or narrowly defined science. I am interested in this, because there is a question about what happens in the future when you take notions such as individuality, personhood and trust (which are very human-centric and work brilliantly for me when I am writing my book), and you apply them to a world where it is entirely likely that we are citing our chatGPT pilot on our articles.

So what happens when we take those notions and put them together? I think that what we need to do is to hang on to that very broad notion of science because one of the problems with a narrow version of science and thinking is that it has a particular kind of integrity that misses its social context. It misses all the problems that those of us who look at knowledge and think epistemologically know. A broader notion of science reminds us of how complicated this is and helps us to tease out what is not so straightforward.

Here are a couple of final thoughts. First, we might need knowledge professionals to help us. One of the most trusted professions across the UK is that of librarian. We must look after our librarians and archivists because they are our navigators of knowledge, our 'datanauts.' They help us not only understand the data on the Excel spreadsheet, but also begin to unpack all of that information about how it got there, how it arrived to us and what the mechanism is of arriving at knowledge. My last point is on meta science. One of the things I find most striking about meta science is that it ought to be a social science-informed enterprise but frequently is not. We need more 'meta-humanists' in meta science to land the message that science is something very complex, that is constructed by us, to talk about ourselves. That might then help us understand Research Integrity in all its fullness. □

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The revolution in publishing ethics

Sarah Jenkins

Sarah Jenkins is the Senior Director for Research Integrity & Publishing Ethics for Elsevier. She and her team promote Research Integrity and publishing ethics through policies, best practices, and education, support Elsevier's publishing teams and editors to investigate and resolve concerns about the integrity of published papers, and work with specialists across Elsevier to build tools and develop processes that detect unethical practices during the manuscript submission and peer-review process.

SUMMARY

- Publishing ethics has undergone a revolution in the last five to ten years and article retractions are increasing sharply
- The number of retractions of UK authored papers has remained pretty steady throughout this particular period and absolute numbers are low
- Problems with data, which included both fabrication and falsification as well as honest errors, was the most common reason for articles of UK-authored papers to be retracted
- The UK is in a unique position in that we have been able to keep breaches of Research Integrity and publishing ethics to a minimum.

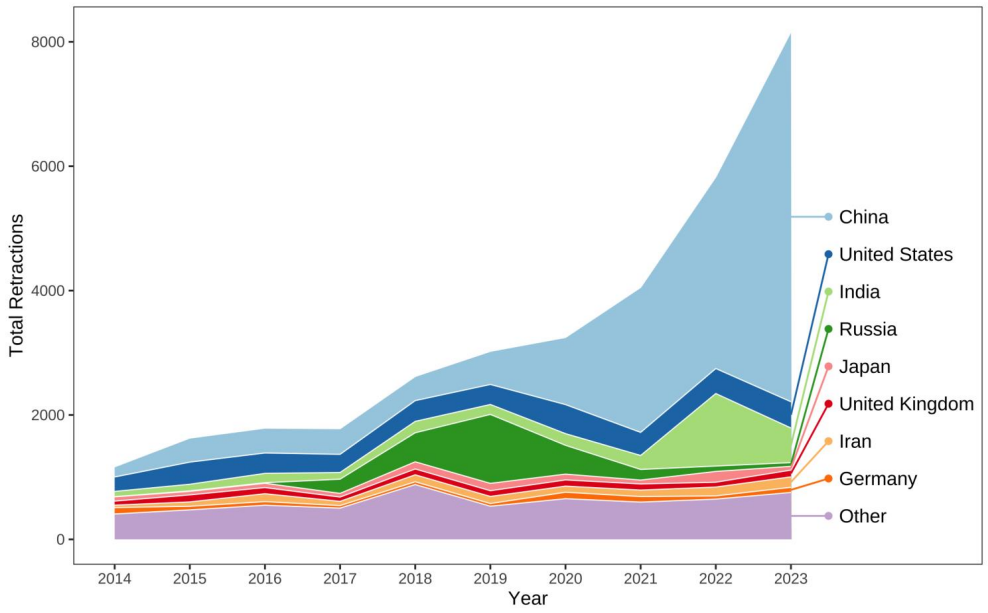
I am going to explore Research Integrity from a publisher's perspective and share some observations from my role as a publisher and Director for Research Integrity and Publishing Ethics.

Firstly, publishing ethics has undergone a revolution in the past five to ten years and article retractions are increasing sharply. In 2023, for example, Elsevier (my publishing house) retracted over 850 articles. That is more than double the number of articles that we have ever retracted in a single year, up until that point. This year that number is going to increase further. Article retractions are increasing due to systematic manipulation of the scholarly publishing process, both by individuals and organisations, for gain.

Sometimes that gain is financial. For example, when we see authorship positions being sold on papers, sometimes that gain is around increasing impact and output metrics. This leads to professional promotions and invitations to speak at scientific conferences and events. Indeed even invitations from people like myself to sit on the editorial boards of scholarly publishing journals. In turn, that means the publishing ethics cases that come to my door are far more complex than they have ever been. They often encompass multiple papers published in multiple journals, across multiple disciplines. This takes a lot of investigative skill, tooling, and time to resolve. However, if we think about the UK, is it true to say that there is a revolution here on our shores?

Figure 1 (See page 9) shows data taken from the *Retraction Watch* database, which tracks article retractions across all publishing journals. What I have done here is to map the total number of article retractions between 2014 and 2023. I have then broken that down by country. The UK is represented here by the red line. Fortunately, the number of retractions of UK-authored papers has remained pretty steady throughout this particular period and the absolute numbers are also low. In 2021, the *Retraction Watch* database recorded 99 retractions of articles by UK authors, 78 in 2022 and 109 in 2023. So over the most recent three-year period, 286 articles by UK authors were retracted compared with a total number of 17,214 global retractions over the same period. If my math is correct, the UK contributed to only 1.6% article retractions in the most recent three years. However, absolute numbers only tell a certain part of the story. I want to delve a little bit deeper into the reasons that these

Figure 1. Retractions by year by country



(Source: Retraction Watch Database)

The number of retractions of UK authored papers has remained steady through the period 2014-2023, and the absolute numbers are also low.

UK authored publications were retracted.

The graph on page 10 (again, using data from the *Retraction Watch* database), shows the reasons for retraction of UK authored papers between 2014 and 2023. A problem with data was the most common reason. Problems with data can be a very broad reasoning which includes dishonest behaviours such as data manipulation and fabrication. It also includes serious errors, which mean that the findings of the paper no longer hold up, and also includes not being able to reproduce the data itself. The important thing to note here is that it is often the authors of the work who have discovered these problems post-publication, and have done the right thing by coming to the journal editor and requesting retraction so that other authors do not build on invalid results. Retractions are not always negative. They are a necessary correction of the scientific record.

Process and reference

Am I being hasty in my conclusion that the UK does not have the same problems as some of the other countries? There are two other categories that I would like to point out. The first is "process" and the second is "references". Process refers to any issues during the course of the editorial evaluation and review process which have compromised the acceptance of that article. References refers to any form of citation manipulation, or indeed papers that cite a rather large number of other retracted articles, meaning that the editor has perhaps lost confidence in the findings. There is a marked uptick for these in the UK, and both categories grew in 2022 and 2023.

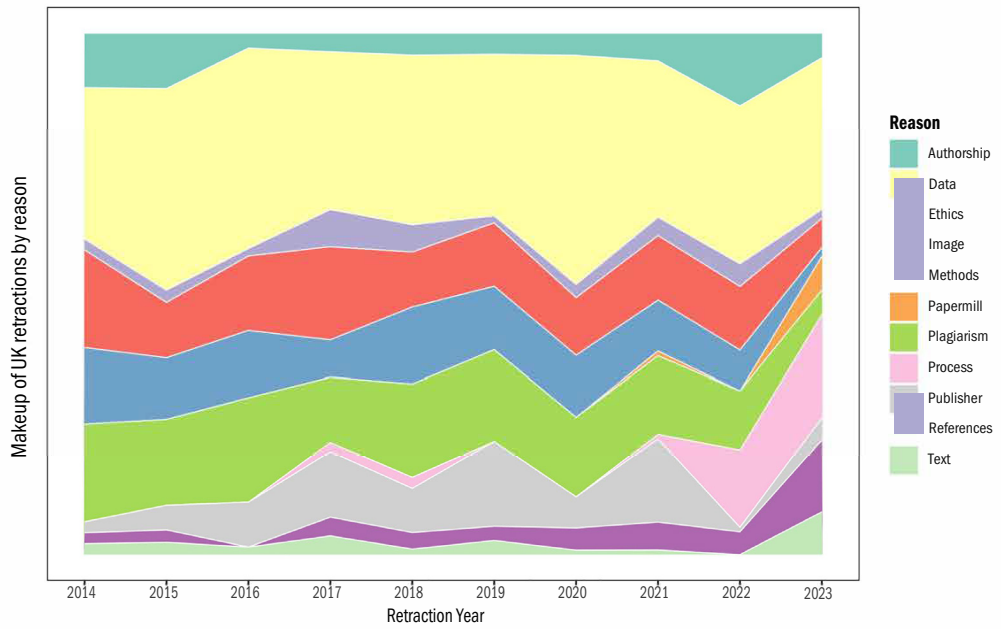
I think that a question we need to ask ourselves is: are those two categories going to have grown further in say, five or ten years? Does the UK have the same kinds of problems as other places or does the sharp uptick in 2022 and 2023 simply represent a cleaning up of the scientific literature by publishers? Are we now more alert to some of the problems in our historic published papers and have better techniques to identify them?

So having spoken a little bit about article retractions, how do we, as publishing houses, uphold both Research Integrity and publishing ethics? Most publishing houses have specialist teams who work together with editors and publishers to do this. We usually have four main areas of responsibility, regardless of which publisher we are talking about.

- We need to detect potential fraud or unethical behaviours in submitted manuscripts prior to publication, to make sure that we protect the scientific record.
- We need to make sure that we resolve concerns in published articles, both efficiently and also transparently, so that the community can understand what went wrong.
- We need to ensure that our policies continue to evolve so that they reflect the realities of today and are in step with the expectations of the community.
- We need to collaborate. We must not only

A problem with data is the most common reason for retraction of UK papers. This can include data manipulation and fabrication, as well as serious errors.

Figure 2. UK retractions by reason



(Source: Retraction Watch Database)

share informal data, but also technology and expertise across different publishing houses.

The central message that I think many of us on the panel have tried to impart is that science does a huge amount of good. The UK is in a unique position in that we have been able to keep breaches of Research Integrity and publishing ethics to a minimum. So perhaps part of the discussion we can have is: what makes the UK so unique, and is there anything that we can impart to some of our colleagues in other countries? □

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The debate

After the presentations, the speakers joined a panel to answer questions from the audience on a variety of topics, including the push to publish, peer review problems and research ethics.

The incentives and rewards for finding positive results and publishing them are now so strong that people will push the limits to get published. Researchers are under ever-increasing pressure to get published and incentives inevitably shape behaviour.

One of the things that is happening in the UK that is helping us with this problem is an increasing push to publish negative or null results and a changing census across universities that those results are also valid. Alternative methods for publication of research are also becoming more accepted and enable the broader spectrum of science to have a platform. Research that may not be accepted in traditional avenues can indeed be published.

We need to try to recreate why people enter science and research, i.e.: to push the boundaries of knowledge rather than just to publish papers. It is the duty of those further on in their careers to educate the younger generation about this.

Is there an appetite for a version of the hypocritic oath for researchers? One panelist said the time it would take to decide on exactly what researchers should sign up to may discourage the community from setting something like this up. However, a declaration tailored to each particular discipline might be a more customary and useful way to approach the idea.

One panelist said that common challenges for professionals that lead to barriers for submitting rigorous research was time and resource. This challenge is one catalyst for issues around Research Integrity, particularly in other countries. However, the UK is in a good position when it comes to rates of retraction of scientific articles. It was later noted that there is a named owner of Research Integrity in each UK Government department who is responsible for

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how evidence is used by scientific advisors.

There is enormous strain on the peer review pool that we have. Trying to get a peer reviewer with the right skills, experience and time to do the work, can take a long time and many applications. Publishers can help make the process of peer review more efficient and easier for those taking part with the aim of increasing participation. What publishers are focusing on now is what the experience of the peer reviewer should be.

Science by nature matures and changes and we need to take this into account. Reproducibility and replicability are really important concepts, but they are not sacred cows and we should not treat them as such. We need to take a step back in our interpretation of reproducibility and replicability of research, and be a little more nuanced and subtle in how we talk about it. We could take some perspective from the humanities in how we do so.

Ethics and integrity

What is the connection between research ethics and integrity? One panelist said that research ethics is a subset of integrity. Research ethics should be thought of as a way of thinking about how to do things in the right way, rather than a process that we are getting through.

When it comes to issues around 'group think' within the scientific community and the effect of this on research and results, we have got to learn as scientists is that actually what we are doing is constructed within a social framework and therefore we do adopt the group think of our community and it can take time for this paradigm to change. It was noted that a contributing factor to group think in science is that often communities are self-selecting and monolithic, and not sufficiently diverse. A diverse community often produces better research.

Is Research Integrity ready for Artificial Intelligence (AI)? One panelist said that there is a lot of activity going on, including the publication of guidelines but that, honestly, the joining up of thinking is not yet there. They said that the honest answer would be that the Research Integrity community is not yet ready for AI. Another panelist gave a final word from a publishing perspective. She said that two years ago, publishers were not 'match fit' for the fast developments in AI and digital misconduct. They had trouble identifying fraudulent papers and issues associated with new technologies.

However, over the past few years, publishers have had to tread the line carefully between taking advance of the opportunities that some new technologies provide, and also thinking very carefully about the downsides, threats and the way that some of these technologies are applied. What this has allowed is proper thought on policies around generative AI, i.e.: authors can use certain generative AI tools, but generally, editors and reviewers cannot. This has also lead to careful thinking around the tools for both submitted manuscripts and published papers within the historic arena. Her final thought was that publishers were some way to being ready for the new 'industrial revolution' of AI. □

Challenges facing research include finding suitable peer reviewers for articles and dealing with the emergence of AI.

LINKS

The online version of this section is available by scanning this QR code and includes links to featured research and reports.

CONTEXT

The UK has a range of National Laboratories, which have a number of different roles within the national science and technology ecosystem. These include the provision of large-scale research facilities and related scientific expertise, supporting regulation and standards, curation of key scientific assets, protection of national infrastructure and the natural environment, and the provision of advice to government and regulators. These different national research laboratories have different governance models, often driven by history rather than design, and are funded from a mixture of public and private funding, with public funding from both within and outside of the science budget. Recent reviews by both Sir Paul Nurse and Sir Patrick Vallance have considered the role of these facilities, and whether the UK is making the best use of them.

On Wednesday 12th June, the Foundation held an event to explore the breadth of National Laboratories within the UK, and how the new incoming government could make the best uses of them in the years ahead. Speakers included: Sir Patrick Vallance; former Government Chief Scientific Adviser, Professor Steven Cowley; Director, Princeton Plasma Physics Laboratory, Dr Karen Hanghøj; Director, British Geological Survey and Dr Julian Braybrook Director; National Laboratories at LGC, and the UK Government Chemist.

A video recording, presentation slides and speaker audio from the event are available on the FST website at: **www.foundation.org.uk/Events/2024/The-Role-of-UK-National-Laboratories**

A brief tour of the UK's National Laboratories

Patrick Vallance

Lord Vallance is a doctor and a scientist. He was Professor of Medicine at UCL and ran a large research group. Subsequently he was Global head of R&D for GSK for a decade and a main board member. In 2018 he became the UK Government's Chief Scientific Adviser. He was also appointed as the chief scientific adviser for COP26 and started the 100 Days Mission for pandemic preparedness under the G7. He is a Fellow of the Royal Society, Academy of Medical Science and Royal Academy of Engineering and has been knighted twice for services to science.

SUMMARY

- There are around 50 public sector research establishments all over the UK which are as diverse as they are geographically dispersed
- Due to the diversity of the UK's National Laboratories, it is quite difficult for people to move between them. However, they create an infrastructure and a capacity which is important for science overall
- Progress has been made towards better utilisation of government-owned public laboratories and expanding eligibility for funding streams. However, this is often difficult for public laboratories to exploit because it is not a full economic cost for them
- Every department should have a senior, accountable individual who actually cares about each PSRE
- We need to define what each PSRE is for and what we want them to do, as well as a system for quality assessment.

I do not think anyone can really define what a public sector research establishment is and there is no accurate definition or whether they are the same as National Laboratories, but when I look around, there are something like 50 public sector research establishments all over the UK. They report not into a single department in Government, but into eight different departments. The public sector research establishments are less well known than they should be. I must admit that before I joined Government, I did not know much about them. There is a report by Paul Nurse which illustrates how many people are not aware of them. They are geographically dispersed and highly diverse. They do research, monitoring, policy, and they have links to business. They also have vastly different funding models. Some are private public partnerships, some are privately run, but on behalf of the state, some of them are totally public. I'll begin by giving some examples.

First, the National Physical Laboratory (NPL) is based in Teddington and it has a site in the North East, another in the South and a site in Scotland. It was set up to look at the science of metrology in 1900 and did a lot of important work in the early days of computing. It was the place that made the first atomic clock in 1955. When I was at GlaxoSmithKline, we had a collaboration with the NPL on imaging mass spectrometry, which is a very difficult technology to quantify but it was crucial for industry to try and get some images of where drugs were going into cells.

In York, we have the Food and Environment Research Agency which was transferred to become a public and private joint venture in 2015.

It used to house the Plant Health Inspectorate and the National Bee Unit which are now at the Animal Plant Health laboratories and, despite the fact that it is now an independent private organisation, it remains a natural, national reference laboratory. It is also part of the National Laboratory Alliance. Just after the Novichok poisonings, there was a question about cleanup of the environment and it turned out that the ability to access mass spectrometry to understand what was needed to make measurements in the environment, was difficult. This lab became a really important resource during that national emergency.

Another example is the Met Office in Exeter. Of course, the Met Office deals with weather but actually during Margaret Thatcher's Government, the Hadley Centre was set up which meant that the Met Office is also conducting world-class climate science activity, which has been hugely influential in UK and global climate science. It also has a joint unit with the Environment Agency on flooding, Another significant thing is that that it has a supercomputer. One of the things that the UK does not have is a very strong and effective computing infrastructure. But this supercomputer and the following one that it will be obtaining are an important part of this. The Met Office is also an important source of information on potential impacts in space weather and is working with the Alan Turing Institute to look at what Artificial Intelligence might do to improve the ability to get greater granularity on weather forecasting. This will become really important as we think about adaptation to climate change.

Marine surveillance

The UK also has the Centre for Environment, Fisheries and Aquaculture, in Weymouth, among other sites. This laboratory does surveillance of fish stocks and marine quality around the coast of the UK. It also does research and policy work. The Natural History Museum (of which I am now chair of trustees) has 350 scientists, and those scientists work on a range of areas, including things directly relevant to government policy, such as climate and biodiversity research. Using collections going back over a very long period, the museum has put together a biodiversity intactness index, which allow you to look around the world and say how much of the biodiversity that was present pre-Industrial Revolution, even pre-appearance of mankind, is still present today. In the UK, we are down about 50% of the biodiversity that we had. This biodiversity intactness index is now on Bloomberg terminals, so investors can start to look at it and ask: "what are companies doing?". So there are unexpected links through to companies and finance.

> Just after the Novichok poisonings, this lab became a really important resource in terms of mass spectrometry for environmental clean-up.

Due to the diversity of the UK's National Laboratories, it is quite difficult for people to move between them. However, they create an infrastructure and a capacity which is important for science over all. In 2019, together with Treasury, government officers of science wrote a report for the science capability review asking the question, what was the capability of science across government and what needed to happen. One of the areas that we touched on was public sector research establishments (PSREs). There are many good things going on, but it is all a bit ad hoc and uncoordinated. We also touched on an important area, which is how they might be involved in business and link through into the economy. Through this report, we shared a number of things that should happen to ensure that important R&D infrastructure departments have adequate long-term funding. Due to a bizarre situation where certain PSREs could apply for a UKRI grant and others could not, we suggested that research funders needed to open up funding schemes. As part of what was then the aim to get to 2.4% of GDP R&D, we also said that this should be part of looking at what the public laboratories could do to stay afloat.

But what has happened since then? Well, there was an update this year of the science capability review and one of the four things it looked at was the public laboratories. It still said that we should ensure sufficient capacity, capability and quality within the public laboratories. The Government response to the review said that the wide range of PSREs in the UK present a significant resource for Government and will have a higher priority in Government thinking. However it is important to try to pin down what that means in practice. Progress has been made towards better utilisation of government-owned public laboratories and expanding eligibility for funding streams. Happily, they are now able to apply for UKRI funding but the funding is often provided in a way that is very difficult for public laboratories to take because it is not a full economic cost for them. So there are still challenges and in many cases, the science missions of the public laboratories need to be better defined.

Some of the key features which would make a difference and relate to the current and any future system is that, first, every department should have a senior, accountable individual who actually cares about the PSRE. Every department does currently

have somebody, but it is often part of somebody's wider job. It is also not necessarily a very senior person who has got that accountability. So the PSRE needs somebody senior in the department who really cares about it, and there also needs to be a minister who really cares about the PSRE as part of their job.

Second, the department needs to define what the PSRE is for and what it is that they want them to do. What is it that is important for the department that these PSREs can deliver?

Third, they need to have a system for quality assessment. How do they know that what is going on at the PSRE is high-quality science and relevant to the mission? I also think that this is an area where a Chief Scientific Advisor can play a role.

They also need to worry about career structures. If individuals can only think of their career development in terms of the PSRE where they are based, then that is a mistake. The National Laboratory Alliance got together for a review recently and said that we can work better together, do things of common interest, share equipment, and look at staff promotion and development activities.

Finally, there is a Department of Science, Innovation and Technology and this department could take a cross-government accountability to ensure that we have the appropriate quality and we look across all National Laboratories for opportunities. □

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This much I know about National Laboratories

Steven Cowley

Steven Cowley FRS, FREng has been the Director of Princeton Plasma Physics Laboratory since 2018. The seventh director of the Lab, he is a theoretical physicist and international authority on fusion energy, as well as a Princeton professor of astrophysical sciences. Previously he was Chief Executive of the UK Atomic Energy Authority. In May 2024 he was named Chair elect of the Faraday Institution.

SUMMARY

- The Princeton Plasma Physics Lab at which Steven Cowley works is legendary within the field of plasma physics and fusion research
- There are problems in science that require scale. You need a national labortory to deliver science and technology at scale. Thus, they are an essential part of the scientific landscape
- We have a small but really impressive set of National Laboratories in the UK which need nurturing – not just money, but also organisation and a place to report into Government
- Large facilities at laboratories pose significant engineering challenges because they necessarily involve cutting-edge technologies, such as superconducting magnets and fast electronics
- National laboratories are a strategic asset. In times of trouble government turns to laboratories for specific expertise.

My experience with National Laboratories is predominantly shaped by the model developed in the United States during the Second World War, which Britain subsequently adopted. While National Laboratories have existed in various forms since the time of Napoleon, the model that most prominently captured public imagination was and is the Manhattan Project at Los Alamos. Los Alamos today is a vast operation, employing about 16,000 people and forming part of the US Department of Energy (DOE) system of National Laboratories, which includes 17 institutions.

My laboratory, the Princeton Plasma Physics Laboratory (PPPL), is one of the smaller DOE national labs, with approximately 850 employees. Despite its size, PPPL is legendary within the field of plasma physics and fusion research.

Our response in the UK to the Manhattan Project, both for military and for civilian reasons was of course Harwell and subsequently the whole of UKAEA. I have often felt that we have never quite celebrated enough the immense achievement of the 1940s, 1950s and 1960s, putting ourselves on the map as a nuclear power. This was done through National Laboratories and it could not have been done without combined resources from many different laboratories.

My experience comes from what I call "my beloved Culham" or Culham Centre for Fusion Energy – an amazing laboratory where incredible things are achieved every day. Culham hosted one of the world's premier large facilities, JET, for 40 years, and ran it beautifully during that time. It is an incredible resource for the country. I now run the Princeton Plasma Physics Laboratory; a 91-acre site with 290 engineers and 130 PhDs – another gem.

PPPL began in 1951 as a dedicated center for fusion research. While fusion research remains a core focus, our mission has expanded to support the microelectronics industry by developing

next-generation plasma tools for chip manufacturing. As the feature scale on chips reaches down to about 4 nm, the challenges of manufacturing with plasma tools increase. Given our expertise as the US's premier plasma physics laboratory, this extension of our mission was a natural progression. This new research program is well-coordinated with industry and academia.

PPPL is managed by Princeton University on behalf of the US government, creating a unique managerial structure that links a leading academic institution with the primary funder. This arrangement allows the government to set the research agenda while leveraging Princeton's academic strengths.

Being a science super power

If you look at the rankings of universities around the world, British and American Universities stand out. The model of an individual investigator leading a university group, supported by postdocs and graduate students, and characterised by an almost entrepreneurial spirit, has proven to be spectacularly successful. Furthermore, research in many UK universities (e.g. Cambridge) is well connected to the tech, pharmaceutical, biomedical and computer industries. The US excels at this model. It is a very efficient structure, but it is not something that National Laboratories are funded or suited to do.

Certain scientific problems require significant scale, such as the Manhattan Project, which was comparable in size and scale to the United States' automobile industry at the time. With 130,000 employees, the project necessitated teamwork and an incredible mixture of skills, including engineers, materials scientists, chemists, and physicists. Effective project management was also essential. Some scientific challenges cannot be tackled in a garage in Palo Alto or on a lab bench at Imperial College London; they require the resources of a National Laboratory.

As lab directors in the DOE system, we often convene to discuss the management of National Laboratories and interactions with the government. These laboratories have been remarkably successful. For example, the Lawrence Berkeley National Laboratory (LBNL) is a shining example of success, having employed 16 Nobel laureates. LBNL, situated just up the hill from the University of California, Berkeley, maintains a strong connection with the university. This relationship mutually benefits both the laboratory and the university.

When you look around the world, it is not just the American laboratories that are successful. We have a small but really impressive set of National Laboratories in the United Kingdom. These need nurturing and that nurturing is not just money, but also organisation and a place to report into Government. There are also very strong laboratories in Europe. CERN is the classic example and every National Laboratory director is envious of the stability of the funding and the European commitment to CERN.

To become a science superpower, it is crucial to invest in both universities and National Laboratories – neglecting either would be detrimental. Additionally, many scientific fields require large facilities, such as the Large Hadron Collider at CERN, and Diamond and ISIS, which are at the forefront of scientific advancement and vital for both laboratories and universities.

Historically, large scientific facilities were owned and operated by a single nation and, even earlier, by universities. Nowadays, these facilities are increasingly shared among countries and often involve global teams. Designing, building, and operating such facilities necessitates teams of skilled engineers, as these projects push the boundaries of technology with components such as superconducting magnets and advanced electronics.

Building large facilities is not only about construction but also about collaboration with multiple industrial partners and stakeholders. The engineering challenges are immense, requiring the invention of new technologies and innovative solutions. Throughout my career, I have found this work extraordinarily rewarding. For success, the laboratory's engineering team and industry partners must collaborate closely, enhancing each other's capabilities in the process.

National laboratories are a strategic asset – essential in times of trouble. Whether it is developing new weapons systems or addressing national emergencies, we rely on them for their vital expertise, which has been intentionally nurtured and grown over many years. I witnessed this first-hand at Culham, where we had—and still have—an extraordinary workforce that seamlessly transitioned between us, STFC, Oxford Instruments, Atkins, Jacobs, and various other parts of the high-tech engineering industry. Culham remains a crucial component of a portfolio of national assets, and it would be a great loss for the UK to lose this portfolio.

What should we be doing to nurture our laboratories? There are some pressing questions: What is the UK's next great science facility? Are we going to be a global competitor? Who are going to be our partners? Who would share the cost? I do not think we should be out of the business of having globally competitive large scale science facilities and it needs long-term planning. □

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We have a small but really impressive set of National Laboratories in the United Kingdom. These need nurturing and that nurturing is not just money, but also organisation and a place to report into government.

Everything starts with a rock

Karen Hanghøj

Dr Karen Hanghøj is the Director of the British Geological Survey (BGS). She is a geologist with extensive experience in research and innovation management and the minerals and metals industry. Karen is passionate about understanding the complexity of resource management, about environmental and social sustainability, and about the role of geoscience in finding solutions to societal challenges.

We are going to do a deep dive into what the British Geological Survey (BGS) does. Generally, people do not know the British Geological Survey and they struggle with understanding the name and what it means in the context of a research centre. The BGS is a world leading Geological Survey organisation and it is focused on public good science and national capability. It has a national capability in the field of geology and earth sciences, and understanding of the planet. It is a provider of objective and authoritative advice, scientific data, information and knowledge for society. The BGS enables these things to be done at scale.

We invented the concept of a geological survey organisation, something that almost all countries have today. We are part of the UKRI and the Natural Environment Research Council (NERC) and are one of six centres, two of which are fully owned by NERC. We map into the network of public sector research and government in a convoluted way and the complexity of this landscape, can make it challenging to get the right kind of advice to the right people in, for example, Government departments. So I think we need to explore how to best champion this work, and get recognition, and not just in the "great job" sense of the word but how we jointly get the most out of what we know, because it is actually a lot.

Our vision is to be a leading and trusted provider of geological data and knowledge to meet societal need for a sustainable future, but what does that mean?

We want to use our knowledge of geology and of earth science to address societal challenges. To do that we generate data information and expertise through observation, analysis and characterisation of Earth and its geological processes. Lots of people do this in the earth sciences and what sets us apart is the scale on which we work. We have the ability to work at local, regional, national and global scales, and to monitor on multiple timescales ranging from real time to decadal. For example, if you need to know the resources in the UK, you need a national-scale project and a national-scale organisation to do it. We are also independent and impartial, so we can provide trusted and authoritative information to people. If different stakeholders ask us the same question, they will be getting the same answer, and it will be based on what we know about the Earth, and geology.

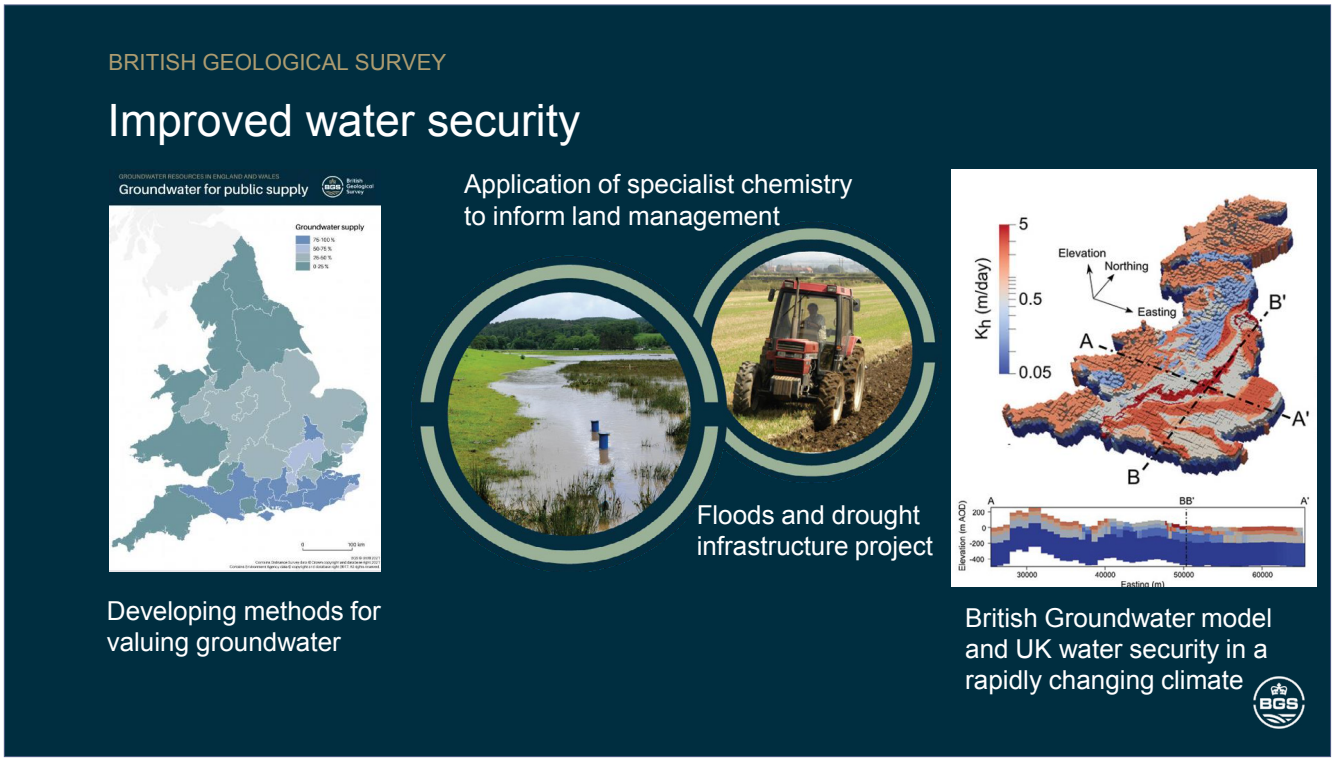
SUMMARY

- The BGS is a world leading Geological Survey organisation and it is focused on public good science and national capability
- UKRI is a complex landscape to navigate when you are a National Laboratory and it can be challenging to get the right kind of advice to the right people, e.g. Government and policymakers
- What sets the BGS apart as a geological survey organisation compared to other earth science research entities, is the scale of the science delivery. BGS addresses societal challenges at a local, national and global scale, and also works on decadal time scales in monitoring and supplying geological data.
- All of the challenges that we are facing as a society in terms of decarbonisation and mitigation of climate change hazards and environmental impact starts with understanding the subsurface. BSG can provide maps, models and data for this
- BGS geological mapping and observations feed into widely used products – anyone who uses a satnav (i.e. just about anyone with a mobile) uses BGS data. BGS products and services are commonly developed with partners, e.g., for natural hazard risk assessment it works with the Met Office.

School of rock

We have been a geological survey for almost 200 years and, right now, all of the challenges that we are facing as a society in terms of decarbonisation, mitigation of climate change hazards, and environmental mitigation – all of that starts with understanding the subsurface. I like to say that everything starts with a rock. If you want to understand, for example, improved water security, decarbonisation and net zero, or living with geological hazards, such as coastal erosion, over the next 20 years, you need to start with understanding the subsurface.

An important priority area for us for the next decade is to produce maps and models for the 21st century. Building on 200 years of legacy knowledge, we want to look at translating that knowledge into products and services that you can use to solve societal problems. We are updating the CO_2 storage database for the UK at



Left: groundwater supply as a percentage of deployable output. Centre: flooding at Eddleston in the Scottish Borders; use of specialist chemistry in soil management. Right: groundwater levels across Britain

a national scale. We are providing data on minerals and supply chains. We are working on geothermal research that can inform policy and regulation. These are just examples. A common factor for these and everything else we do, is that we work closely with different partners across the UK and also in Government to deliver them.

We have had geological maps of the UK for a really long time and these are good maps based on good observations. But with new data, we need new maps. We also think about geology in a quite different way now – including understanding plate tectonics, which we did not when many of the maps were produced. Lots of things have changed and maps and models of geology are how the data and the knowledge that BGS is responsible for are being used by society.

A grasp of groundwater

In the image *(above left)* you can see a map for developing methods for valuing groundwater and what is deployable. The BGS map produced in 2019 shows groundwater supply as a percentage of deployable output. In the middle there you have flooding at Eddleston and the importance of measuring emergent contaminants in groundwater. This addresses important questions about how we monitor what is going into our drinking water and how we work with agriculture and the interface between agriculture and geology, and soil science. How do we assess how groundwater flooding is influencing these issues? On the right hand side is a map that shows groundwater levels across Britain simulated by the Environmental Modelling Topic's British Groundwater Model (BGWM) – in this case based on the August 1976 drought addressing the question of climate change mitigation and how the UK groundwater responds to periods of drought, which is something we will probably be seeing more of.

Everyday usage

Our mapping feeds into everyday uses too. Every time you look at your satnav, it has data from the BGS in there, because we contribute alongside the Ordnance Survey, Met Office and others to national datasets. We are also working on developing a hazards platform where you can get a one-stop shop for understanding hazards such as landslides, flooding and coastal erosion.

In summary – if you need to build infrastructure or you are looking at extracting resources (including groundwater), the first thing that you need is a geological map. Mistakes can be made if you do not know where you are starting from or what you are working with. The urban landscape is a great example. We are used to thinking about

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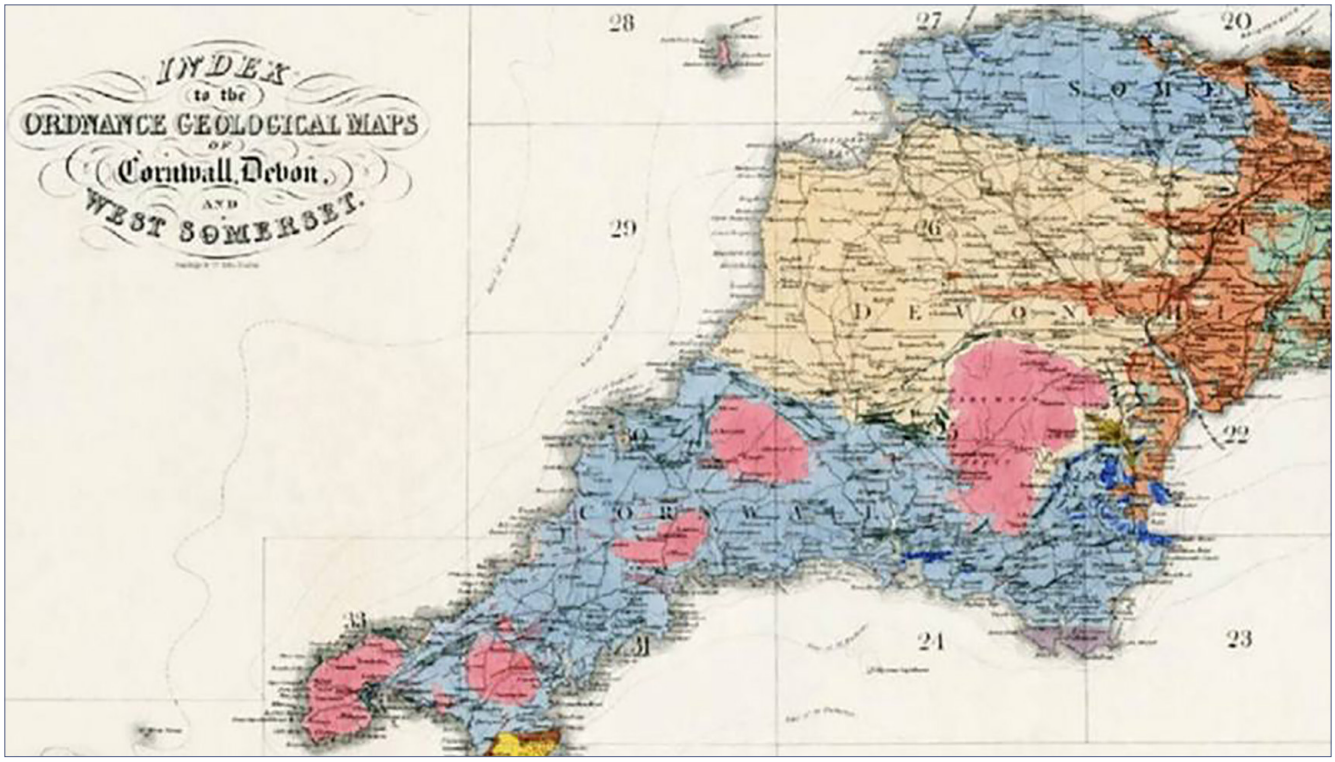

The origins of the BGS: Index map from the Geological Survey's first publication Report on the geology of Cornwall, Devon, and West Somerset, issued in February 1839

the urban environment as a skyline, but think about all the stuff that is happening underground, all of the waste disposal, all of the transportation, the groundwater – this all affects cities. For example, in some large cities pumping up groundwater without appropriate knowledge is causing subsidence.

What is next for the BGS?

We are currently looking at upgrading and revising our onshore maps, as well as our marine maps. Coastal maps can help provide a lot of solutions to the challenges that we are facing right now regarding raw materials, energy security and decarbonisation. About 20% or 30% of the gravel and sand that we are using for building roads and houses in the UK is being extracted from the marine environment. Not many people know that, but it is true and resource management is going to become increasingly important because there are going to be competitive uses of that space.

We also need new habitat mapping which is significant for both resource management and living resources. Spatial planning of the subsurface, both onshore and offshore, is going to be very important for infrastructure – but also for national security. Maps and knowledge about the subsurface will help address questions of how we create security for our infrastructure in the offshore and in the onshore environment. This scale of work would need to be done with partner organisations over two or three decades. Another big challenge that this country is facing is what are we going to do with our radioactive waste. It is potentially very controversial, and it is very difficult but it is a real and important environmental challenge and the BGS will need to be involved in helping to solve it.

Whatever you put into the ground, you need to understand how the rock is going to behave. We have experiments at BGS that have been running for more than 15 years on the properties of rocks that may be suitable for storing radioactive waste. We can run experiments for decades, which shows the kind of timescales that we are able to operate at.

The BGS is fairly small in comparison to other National Laboratory organisations – we currently have 641 staff. We produce numerous reports and publications. The Natural Environment Research Council (NERC) Open Research Archive (NORA) had 369,600 downloads of BGS publications last year. That is more than 1000 downloads per day and shows that the expertise that BGS has is in high demand. Our staff are thinking about solving real-world problems. They are thinking about geoscience in the context of societal challenges and they are thinking ahead for solutions for tomorrow's society. □

We have experiments at BGS that have been running for more than 15 years on the properties of rocks that may be suitable for storing radioactive waste.

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How the UK measures up

Julian Braybrook

SUMMARY

- The UK National Measurement System develops and maintains internationally recognised measurement capability, standards and practices
- The National Measurement Laboratory uses advanced chemical, molecular and cell biology measurement to support innovation and economic growth in the UK life sciences, green industries, and food sectors
- We need an environment that encourages continued long-term commitment from the National Laboratories
- Such commitment would allow the National Laboratories to foster innovation, secure human resources and ensure provision of the infrastructure needed to deliver our capabilities
- We need a champion that values National Laboratories across the system; broadly across government and into the public
- We need to allow greater accessibility and permeability across and between the National Laboratories to make best use of these capabilities for the benefit of the UK.

There are more than £620bn worth of goods and services traded annually in the UK that rely on some measured quantity or specification, and that is probably an underestimate. Without the confidence behind purchased goods or services meeting their specification or conforming to regulatory or statutory requirements, UK businesses are undermined. This is where the UK National Measurement System (NMS) really comes into play. It is an essential part of the UK research infrastructure and effectively develops and maintains internationally recognised measurement capability standards and practices. There are a number of laboratories that are part of the NMS, but I will focus on the National Measurement Laboratory at LGC.

Our role is about the science of measurement. We are designated for areas involving chemical and biological measurement, with some exclusions where other laboratories cover part of the space. We are internationally leading in our measurement science, as indicated by a recent international science review. We have what we would term as sovereign measurement traceability in chemical quantitation and areas such as nucleic acid quantitation and nanoparticle number concentration. We are recognised as a Public Sector Research Establishment (PSRE) and a strategic national asset.

Food for thought

As a UK Government Chemist, I have a statutory referee analysis and advisory function to government, particularly around food and feed. We are a national reference laboratory for certain areas of food and feed additives, and in genetically modified organisms (GMO) in food and feed. We also offer GMO authorisation services, post EU exit. In addition, we manage MHRA laboratories for the chemical testing of medicines on the UK market.

Now, being a relatively small National Laboratory, we achieve agility through use of our core platform analytical technologies into different measurement challenges areas (healthcare, sustainability etc). We supplement these by strategic technology- and sector-based partnerships with universities, providing place-based measurement solutions.

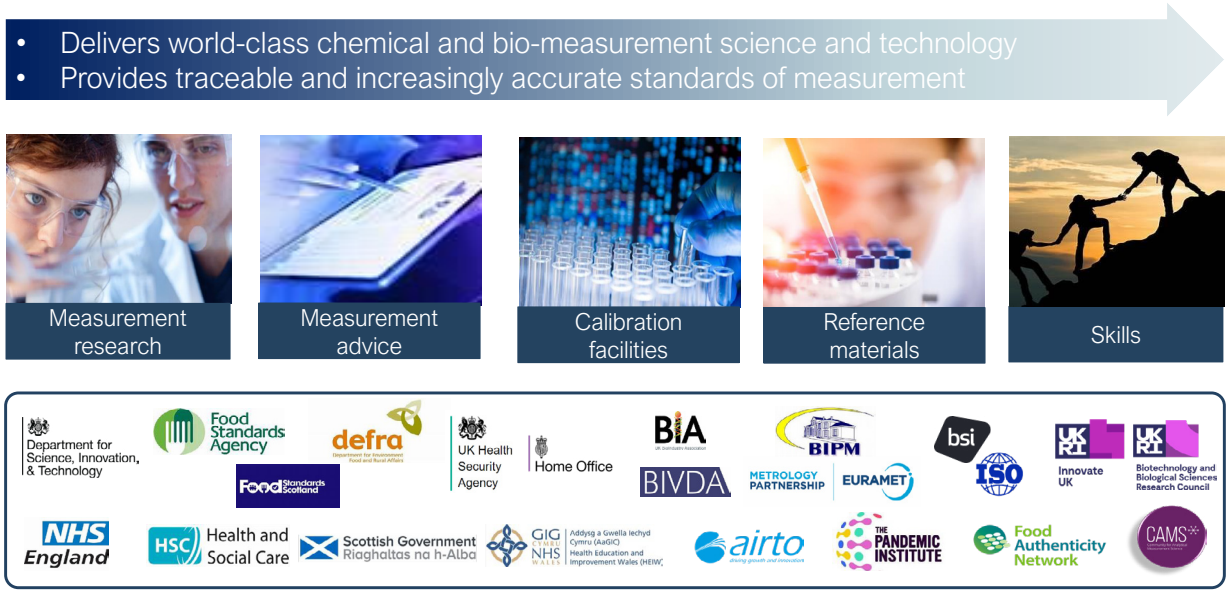
We maintain and grow measurement capabilities so that the UK is recognised around the world as a major contributor to a global harmonised measurement system. This provides confidence in UK businesses, but also confidence for inward investment from other countries. I am going to provide just one example of the development and application of these measurement capabilities.

We use our advanced nucleic acid measurement capabilities to support the UK diagnostics industry, beyond infectious diseases and pandemic preparedness. You can also think about antimicrobial resistance and precision medicine – some of the things of the future that we are going to have to start to think about for patient benefit. We lead the development and delivery of the international roadmap to metrology readiness for infectious disease pandemic response. We did respond nationally and internationally in the last pandemic within a several month timescale, but we need to respond as a measurement community even faster next time. We need to do this in a way that can be called upon by ministers and the like, in a matter of a few days.

For this reason, we established an international pandemic task group and we are running measurement comparison studies (so-called fire-drill exercises) that are demonstrating molecular diag-

Dr Julian Braybrook became the UK Government Chemist in June 2018. He is currently Director of the National Measurement Laboratory at LGC, a leading life-science tools company providing components and solutions across human healthcare and applied market segments, where he is responsible for the science strategy and partnership development for regulatory analysis and metrology (measurement science) programmes that support the UK National Measurement System.

Figure 1. Activities of the NML



(Source: National Measurement Laboratory

The NML is an essential part of the UK research infrastructure and effectively develops and maintains internationally recognised measurement capability standards and practices.

nostic standardisation globally at this timescale. We have also developed test criteria that allow decisions to be made for novel diagnostics, particularly around COVID-19 variants of concern and variants of interest. We value assign nucleic acid control materials for the Health Security Agency (HSA) and NHS laboratories that are really important in the clinical adoption of these infectious disease tests.

It has not just been COVID-19. Since the pandemic, we have addressed monkey pox, avian flu, and swine flu issues that are still around today. We are providing the core reference methods and materials that allow people to measure accurately and we are taking a complementary technology approach with UK HSA to develop nucleic acid synthesis capability. This will help remove some of the current reliance on international providers during pandemics, and help improve biosecurity at the same time.

We have provided access for NHS healthcare scientists to the breadth of UK PSRE measurement capabilities to help them create, expand and test new approaches that will improve the quality of patient care. Some of our outcomes to date include improving the national newborn screening testing programme, establishing best practices for minimal residual disease testing and working with the national genomic laboratory hubs to standardise their approaches to the rapid adoption of novel genomic sequencing technologies into the NHS. Other PSREs have provided implementation and new audits that assess and improve the accuracy of patient treatment for delivery of solutions for detecting cancers of various sorts.

We are working with colleagues, not only to think about what the national vision for engineering biology might be to revolutionise medicine, food and environment, but more specifically about how that can be done. So we are working with the UKRI/BBSRC-funded engineering biology mission hubs and awards and our first task was to embed metrology and standards practice into their thinking. With others in the NMS and government more broadly, we have also been helping shape what the regulation might need to look like for these products in the future. We have already delivered pilot training modules for both students and early-career scientists across the engineering biology centres and we are now rolling these out to the wider community. This provides the concept for upskilling the next generation of workers in the field, and helps reduce the threat of skills shortages down the line.

Gene regulation

We have initiated the first of several draft standards within the International Standards Organisation (ISO), debating gene expression analysis of engineered cell systems. This is us leading the way for the UK in new and emerging standards and regulation for the field. We are now starting to work collaboratively with the UK engineering biology community to adopt best measurement practice, helping establish measurement methods and materials that will be used to develop robust data that best addresses the complex challenges that the community is facing at the moment. That may be in microbial food and its regulatory hurdles, plastic pollution, recovery of metals through

environmental processing, or even genetic control systems for advanced medical therapies. These are the areas where we are operating at the moment.

In conclusion, first, I think we need an environment that further encourages continued and long-term commitment and investment in the National Laboratories.

Second, we need to look at how that long-term commitment will allow us to foster innovation, secure the necessary human resources and ensure provision of a suitable infrastructure needed to deliver nationally and internationally acknowledged capabilities that will allow us to stay at the forefront of scientific research and innovation and meet broader research infrastructure system needs.

Third, we do need recognition in the form of a champion that values National Laboratories across the system and broadly across government and into the public.

Finally, we need to remove the barriers to cross-government engagement that will allow greater accessibility and permeability, ensuring better coordination and flow across and between the National Laboratories to make best use of these capabilities for the benefit of the UK. □

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The debate

Do not start a new National Laboratory unless you can fund it properly. There is a danger of picking on things without the proper funding resource and this has been a sequential problem with many institutes being set up without adequate funding or structure. However, in terms of what comes next, there is the question of what we are going to do around quantum, engineering biology and artificial intelligence. It will be important to evaluate our current laboratories and consider what might be worth changing to make room for something new.

So, what is the next great global facility? This is a difficult question to answer but we do need a process to start thinking about it. Take a potential quantum facility. Could this work be undertaken by a current institution or should a new one be built? Either way, it will be a political process with many partners likely to be involved. In any case, it is always enjoyable to speculate on what shiny new things we would like but the real question is why do we need them? Do we want to put someone on Mars? Do we want to make quantum discoveries? Do we want to build infrastructure around the energy transition? What is the problem that we are trying to solve and what do we need to solve it? We can also do a lot with what we already have by scaling those things up.

Responding to audience questions including one on balancing the tension between the role of science and exploitation through the different institutions we have, one panelist said that a lot of public laboratories are government-funded in some way, but it is clear that the lack of funding that has gone into the public analyst laboratories is causing a problem because it is having a knock-on effect on capability, skills and flow of skills. There is always a tension between public roles and private sector expectations. However, if you have clearly defined roles and missions, then the two do not come into conflict.

This point was countered by another panelist who felt that the PSRE term had been used too loosely in discussions. They said that the really important thing is knowing what we want from these different research organisations. There are such a variety of laboratory institutions across a complex landscape that is hard to logically categorise them. However, there should be a coordinated effort to understand what the centres can deliver, and how they can play together.

What is the picture in the US? Vannevar Bush was the architect of the National Science Foundation but the National Science Foundation is a small part of the funding for public-sector science in the US. The budget of NASA and the National Institution of Health are much bigger, for example. It is done in different ways and there is a strength in having this variety. Having a portfolio of university laboratories and National Laboratories is useful and important.

The National Laboratory landscape is complex and we must try not to simplify this too much. Having a mix of academic, national and industrial science bases is important and this was key during the pandemic, for example. We do however, need a view of what we have got and where the industrial, academic and national strengths are. The UK could do better in this area. Did the COVID-19 crisis show how important National Laboratories were? Yes. Science comes to the fore in a crisis. However we need an understanding and appreciation of the laboratory skillset on a day-to-day basis too. We should not wait for a crisis to work out what we need. □

After the presentations, the speakers engaged in a Q&A with the audience on issues including what the next great global facility might be and which global problems should be prioritised when building new infrastructure.

LINKS

The online version of this section is available by scanning this QR code and includes links to featured research and reports.

CONTEXT

The shift towards citizen-centric Edge Technologies like Artificial Intelligence enhances lives like never before. From personalised adviser apps on smartphones to applications in personalised medicine, these Edge Technologies promise transformative potential, but with those benefits come new threats and risks. Organised in collaboration with The PETRAS National Centre of Excellence, FST held an evening discussion which explored how technologies at the edge can revolutionise citizens' experiences, while ensuring ethical and security considerations remain at the forefront.

Speakers included: Joe Butler, Chief Technology Officer, Digital Catapult, Professor Payam Barnaghi, Chair in Machine Intelligence Applied to Medicine, Imperial College London, Dr Leonie Tanczer, Associate Professor in International Security and Emerging Technologies, University College London, Dr Peter Novitzky, Senior Research fellow at UCL/PETRAS, UK; Associate Professor – Ethics of Emerging Technologies at Avans University of Applied Sciences, the Netherlands.

A video recording, presentation slides and speaker audio from the event are available on the FST website at: **www.foundation.org.uk/Events/2024/Empowerment-and-Ethics-at-the-Edge-the-Benefits-an**

The here and now

Joe Butler

Joe Butler is Chief Technical Officer (CTO) at UK technology innovation organisation Digital Catapult, which covers advanced technologies including future communication networks, AI, IoT and immersive technology. He has a specialism in technology regulation and policy, having had roles as Director of Telecoms and Chief Scientific Adviser at the Department for Digital, Culture, Media and Sport and as Head of Digital Infrastructure at the National Infrastructure Commission. He spent a decade at the UK communications regulator Ofcom, where he held roles as CTO for the radio spectrum and latterly as Director of AI as Ofcom's scope increased to include online safety.

The Digital Catapult is part of the catapult network, which is part of around nine partnership Technology and Innovation Centres across the UK. Digital Catapult works across advanced technology areas such as 6G future networks, IoT (Internet of Things), AI, immersive technologies and quantum. We want to support the adoption, acceleration, and exploitation of new technologies for the benefit of industries, citizens and society. We run accelerated programmes, we undertake research and development, and support take-up and adoption of early-stage technologies. I have been quite privileged to work in a number of Government settings as the director of AI and Ofcom, and in the national infrastructure Commission, as well as at the Catapult. Perspectives given here today are my own from across those organisations rather than perspectives of any one organisation.

To the Edge of the cloud

Technology is moving to the Edge, but what do we mean by the Edge? We are now very used to being cloud-connected and having cloud-connected devices. Our phones are essentially connected to the cloud and into data centres at all times. If you are doing a search on Google Maps, using Alexa, or any of those smart assistants, the query that you make is very often relayed back to a data centre over a network, whether it is 4G or Wi-Fi, or broadband. The processing that then happens in a data centre comes back out of the network to your device. However, increasingly that interaction is too slow and does not really work in a given situation. It might even be that your data is secure and you do not want to share it back to a data centre or you may need much quicker real-time responses or the data may be too big to pass around. The edge refers to a push of computing resources to be close to the user in a network and for sophisticated devices and sensors available in homes, factories, shops, even vehicles, which can do a host of things without going back to the core network and data centres. It is often many sensors and many devices working together.

Both networks and devices are evolving very quickly, with ever more sophistication such AI processing on the device and evolving networks. 5G and 6G networks are an important part of this, enabling very high data rates with little delay. For example, you may well have local processing in a factory, a stadium, or a station which enables you to have the processing close to the devices. We

SUMMARY

- The 'Edge' refers to sophisticated devices and sensors available in domestic and work settings which can do a host of things without going back to the core network and data centres
- We have barely got 5G, and 6G is already being explored in a range of industrial settings with fo-cus on being able to communicate to the edge
- Digital Catapult worked with several organisations on the design of Bridge AI which Innovate UK launched aiming to support AI supply in sectors of the UK economy that are currently underserved.

have barely got 5G, and 6G is already being explored in a range of industrial settings with focus on being able to communicate to the Edge. Examples include deeply immersive technologies such as immersive reality and virtual headsets. In the age of AI where you are passing visual data backwards and forwards to train models, data can be very heavy. Smart factories using robots on private networks within the one factory or connected networks between different factories is a good example. You also have cases like drones and vehicles which need to be connected, and have strong visual processing needs.

The Nvidia Omniverse platform is an example of a digital twin platform focused on use cases such as simulating smart factories, and this is an example where Edge Technologies enable cyber-physical systems simulation and interaction. AI data preprocessing enables robots, machine lines and cyber-physical-type simulations of factories to be close to what is happening in reality, and drive efficiency and communication. There is also a company called Niantic Lightship platform which looks towards the real world, the metaverse, and outdoor immersive experiences. It was the company that bought us Pokemon Go a few years ago. The production of *Star Wars: The Mandalorian* pioneered advanced virtual production film techniques, and Ocado's warehouse uses smart robots with communications built in to pick up groceries from the floor. All of these are real and are here and now, underpinned by the same building blocks of advanced digital Edge Technologies, digital infrastructure and human machine interfaces such as Virtual Reality and Augmented Reality.

Cutting edge media production

At Digital Catapult, we have built two advanced media production studios, one in Gateshead in the north of the UK and one in the east of London which are connected. They both have 5G networks, and are connected by very low latency networks which enables cutting edge media production for things like generative AI to be adopted. We put them together in the pandemic when you could not fly actors over from the US, so it enables you to do things such as explore new approaches when you may have actors in different geographic locations but working on the same digital set. We also hosted a 5G festival which involved a pop band with a singer at the O_2 Arena in London, a guitarist in Metropolis Music Studio and drums and other instruments down at the Brighton Dome; all of them connected by very low latency networks. They were able to perform as a live band, seeing each other with immersive headsets.

***Star Wars: The Mandalorian* production pioneered advanced virtual production film techniques.**

There is a programme that we are working on in partnership with several companies here including Innovate UK, the Standards Institute and the Hartree centre called Bridge AI. It is a programme that will enable AI to be adopted and to flourish in some quite different areas to the UK's usual avenues. Only 5% of AI startups in the UK focus on traditional sectors such as transport, manufacturing, agriculture and construction. The large majority of them are focused on data science consultancies.

To address this situation, Digital Catapult worked closely with Innovate UK and the relevant UK funding agency to design and launch Bridge AI. It aims to support AI supply in sectors of the UK economy that are currently underserved. It is quite a rich and dynamic programme with a lot of organisations around the UK involved. To pick a couple out of a hat, we have VeuNex Global – an oil and gas company specialising in tackling health and safety in that very dangerous environment using AI and computer vision to make things safer for people to work. We also have Neural Echo Labs, which is a UK-based computer games startup looking at immersive virtual experiences through brainwave communications, blending brain computer interfaces, VR and AI together. Through the Bridge AI programme, a colleague from the Information Commission became a mentor of that start-up, and provides ongoing engagement and support.

The rate of progress of AI is exemplified by a recent example shown on X (formally Twitter) attempting to reconstruct what humans imagine from MRI data. It was an example of functional MRI imagery produced when people are shown an image of, for example, a giraffe. AI is then able to take the data from the functional MRI, and construct what the person is looking at. It just shows some of the sorts of examples that we may expect to run into here. □

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How AI can support those living with dementia

Payam Barnaghi

Professor Payam Barnaghi is Chair in Machine Intelligence Applied to Medicine and Deputy Head of Division of Neurology in the Department of Brain Sciences at Imperial College London. He is Great Ormond Street Hospital and Royal Academy of Engineering Research Chair in Machine Intelligence for Medicine and a Principal Investigator and Group Lead for Translational Machine Intelligence in the Care Research and Technology Centre at the UK Dementia Research Institute. His main research goal is to develop AI and machine learning solutions for healthcare and create affordable and scalable digital systems that can be applied across a range of health conditions.

SUMMARY

- There are close to a million people affected by dementia in the UK. One in four hospital beds are occupied by somebody living with dementia and around 23% of these hospital admissions are due to preventable causes
- A lot of our work focuses on using Edge and cloud technologies to develop new care and support solutions for people living with dementia
- We train machines to look at patterns and learn how these patterns associate with different conditions
- It is important to evaluate technology and data – if you do not, your algorithm can start biasing towards a subgroup in your study.

I am a computer scientist. Over the past seven years most of my work has focused on using off-the-shelf technologies to monitor and support people living with dementia in the UK.

There are close to a million people affected by dementia in the UK. One in four hospital beds are occupied by somebody living with dementia and around 23% of these hospital admissions are due to preventable causes. Some of the main causes of hospital admissions are falls, hip fractures, respiratory problems and urinary tract infections (UTIs) *(source: Alzheimer's Society)*. UTIs can be treated with antibiotics, but when you factor in the complex nature of the neurodegenerative process of dementia as a disease, there is often a lot of difficulty communicating symptoms, and this makes dementia care difficult and challenging. People living with dementia are more prone to go to hospital and if they go to hospital are more prone to have adverse outcomes like having a fall. Anecdotally, you may hear that when people living with dementia go into hospital, usually they decline when they come out.

Edge Technologies for dementia

A lot of our work focuses on using Edge and Cloud technologies to develop new care technologies for people living with dementia. Some of the technology we use are sensors to create something which we can continuously monitors people's sleep, physiology and movement around the house. This helps us to build a picture of their day-to-day activities and then look for anomalies, or try to look at for patterns if a person has a specific condition. With generous funding from the Department of Health and NHS, I and my colleagues Ramin Nilfrooshan and Helen Rostill, and their colleagues in the Surrey and Borders NHS Trust, worked on the first generation of our in-home monitoring technologies for dementia.

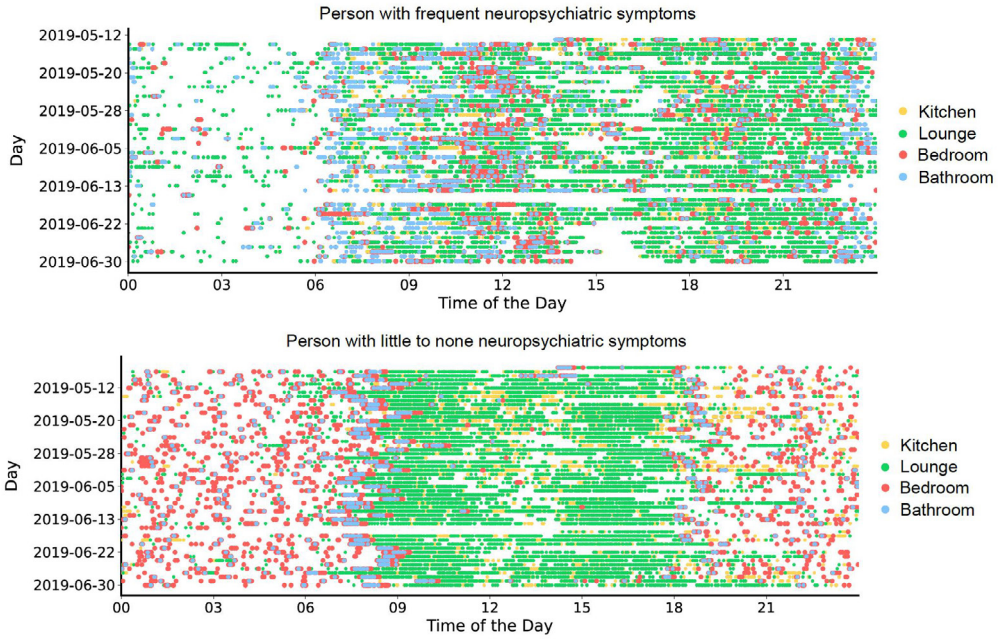
In principle, these sensors are passive infrared sensors, like back-door burglar alarms. When you walk in front of one, it starts sending an alert to a Cloud environment. There are also sensors for when someone is sleeping in a bed, which monitor heart rate and breathing rate, and this information is continuously collected and transferred via a secure network to the Cloud-based platform. There is some human involvement: within the platform, we run some analytical algorithms which do the analysis, and create alerts. We have a monitoring team who look at this information and are able to apply it to their clinical protocols, while at the same time recording everything.

As soon as we start collecting data and labelling incidents, we can reverse-engineer this and create more enhanced algorithms. The study, which has been running for the past four years, has now moved to an initiative supported by the UK Dementia Research Institute called Minder, which is led by my colleague Professor David Sharp.

Just to take a sub-set of this data – in the graph in Figure 1 (see page 25), the x-axis is time of the day and the y-axis represents different days. These are the anonymous data of two real patients. Each colour shows movement in one area of the house. Here, one of the participants has a lot of activity at night and relatively stable patterns during the day. The other also has nighttime patterns but most of these are bathroom visits and in the daytime, there are lots of inconsistencies in the data.

The second participant is someone with a UTI, and one of the symptoms is that people get up and go to the bathroom more often. In any case, just by looking at data you can see nighttime disturbances and someone who wanders around the house at night is at high risk of a fall. I have

Figure 1. In-home monitoring data



(Source: Imerial College London

picked two obvious examples here, but not all of the data is so clear and it is not scalable. The work we have been doing over the past few years is to train machines to look at these patterns and very quickly learn how these patterns associate with different conditions.

Screening versus diagnostics

Some of the symptoms of a UTI are going to the bathroom, temperature and heart rate increase, and changes in breathing rate at nighttime. These are things we can pick up with our sensors. However, technology here is the easy part. Getting the right data and the right clinical insight is the most important thing. We have created an algorithm that looks at how accurate a model is by generating an alert to flag the risk of somebody having a UTI. This is not a clinical diagnostic tool, but it can be used as a screening tool, and our clinical team can take a urine sample and send it to a lab. At the same time, in parallel, a group of my colleagues are working on creating a home test.

In a post-analysis, we were interested in accuracy and demographics. We found that those who slipped through the net were generally female women aged over 65. This demographic is at higher risk than men of having a UTI. It is important to evaluate – if you do not, your algorithm can start biasing towards a subgroup in your study. We must be careful not to create a set of technologies that can discriminate. □

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Above: collecting data on night-time bathroom use can reveal evidence of urinary tract infection. Below: Minder is a home monitoring platform that harnesses recent advances in AI and digital technology to provide in-home support for people living with dementia and their carers.

UK DEMENTIA RESEARCH INSTITUTE

Everyday technology can put victims of abuse further at risk

Leonie Maria Tanczer

Leonie Maria Tanczer is an Associate Professor in International Security and Emerging Technologies at University College London's (UCL) Department of Computer Science (CS) and grant holder of the prestigious UKRI Future Leaders Fellowship (FLF). She is part of UCL's Information Security Research Group (ISec) and initiated and heads the Gender and Tech research efforts at UCL. Tanczer is also a member of the Advisory Council of the Open Rights Group (ORG), a Steering Committee member for the Offensive Cyber Working Group, and a voting member of the IEEE Working Group P2987 "Recommended Practice for Principles for Design and Operation Addressing Technology-Facilitated Inter-personal Control". She was formerly an Association of British Science Writers (ABSW) Media Fellow at The Economist and a Fellow at the Alexander von Humboldt Institute for Internet and Society (HIIG) in Berlin.

It is vital that we look at the adverse side effects of the technologies we let loose into society, and I am specifically focused on issues around intimate partner violence.

At University College London (UCL), I am leading a research group called Gender and Tech. We are interested in how gender or societal assumptions shape the way we design technologies and how technologies that we put on the market affect the way we define gender, race, and other social categories. I will start with three premises that drive my presentation.

Technology is gendered

Number one is that technology is gendered. I can give you dozens of historical examples, and we see them replicated today. These range from the way our mobile phones are extremely big and do not fit into dresses and women's jeans pockets, the way that the bicycle was initially designed for men, and the way we are creating MRI scans and medical technologies that have dedicated "male" and "female" settings. We can also think of the past problems we had around crash test dummies, to more modern phenomena such as making things 'prettier' by putting rose gold and other allegedly 'feminine' colours on them. I think it is essential to emphasise the significance of how we see gendered representations in the design, usage, control and effects of the systems we are putting in place.

Technology is abused

Secondly, the notion that technologies can be abused is no surprise to anyone working on devices and systems. The dual-use discussion has haunted us forever. I recommend the movie *Demon Seed* from 1977 if you have a spare evening. It is old, but it reflects what we are studying at UCL as it relates to a body of work called "tech abuse". This shortens the very lengthy definition of "technology facilitated gender-based violence or intimate partner violence/domestic abuse". That definition ranges from online harassment to cyberstalking to the use of spyware systems installed on smartphones. It also involves the topical issue of image-based abuse, which affects people sharing images (often intimate)of individuals without their consent.

SUMMARY

- Technology is gendered, and it is important to examine how gender manifests in the design, usage, control and the effects of the systems we are putting in place
- That technologies can be abused must come as no surprise to anyone who is creating but also using digital devices and systems
- Technology is changing. A perpetrator does not need to be physically present to make someone's life miserable
- The same household devices that we are installing for the likes of dementia patients could lead to intimate partners being abused
- We are at a critical moment where both the underestimation of the capabilities of technology are just as dangerous as the overestimation.

Now, measuring this particular aspect of domestic abuse and intimate partner violence is challenging. If we think about how we, as a society, use tech, we must acknowledge that everyone owns a smartphone nowadays. So, counting the misuse (like excessive text messaging) is tricky, as we would have 100% of victims and survivors reporting it. However, if we put more nuance to the understanding of tech abuse – such as technical sophistication – we come up with a more specific number. Our research group is currently conversing with UN Women and the United Nations Population Fund on how to measure this phenomenon globally and how it could be standardised. I want to stress that this is not a minor issue, and it relates to the fact that we have tech in every aspect of our lives, from young to old.

I often find that when I call industry partners to attend an event on this topic, they are uncomfortable coming along. Indeed, they do not see it as their role because, as I have indeed been told by one's company's representative, "they have not designed their products and services to be abused". Indeed, of course, nobody sets out to produce something that harms people. Nonetheless, the tech sector must acknowledge that

abuse via digital systems is occurring and that each of them has a role to play in tackling it.

Most of the tech abuse that happens right now is facilitated via what I would call conventional tech. So basically, the devices we have are in our pockets and in our houses – the stuff that is affordable, cheap, and widespread. There is also a heavier effect on Black and Asian minority ethnic groups. So, the same discriminatory aspects that affect societal and minority groups in general are also playing out in the context of tech abuse, unfortunately.

Many people also have predefined ideas of what abuse looks like or should look like. For instance, the perpetrator is never the university professor; it is never our neighbour, and it is never someone we know. It is always a surprise to everyone that someone in their surroundings can be abusive. But we must understand that there are perpetrators amongst us, and intimate partner violence sadly occurs in any demographic group. Abuse is also not always solely physical or sexual abuse. Intimate partner violence takes on many shapes and forms, and I am determined that we, as a society, change our perception of technological abuse.

Technology is changing

My final point is that technology is changing. I was fortunate to have been a postdoc as part of the PETRAS National Centre of Excellence for IoT Systems Cybersecurity. The exposure I received in this role led me to consider and eventually scrutinise the ways smart, Internet-connected devices may be impacting gender-based violence and abuse and what social and technological mitigations could be put in place to counteract this. My research idea started in 2018 and has since led to me setting up a dedicated Gender and Tech research lab, where we study this phenomenon of "smart abuse" – a topic that is now more important than ever.

The same household devices that we are installing for dementia patients could lead to people being abused by their partners, nurses, doctors, and family members. I think an essential recognition is that many of these devices are small and that they contain tiny sensors that are not visible. Besides, many IoT systems look like 'ordinary' things we have seen and been exposed to before, such as a television or toaster. However, these previously analogue products have now become smart, giving them enhanced functionality. IoT's aspect of disguise makes it hard for people to assess their risk. For most consumers, it is difficult enough to conceptualise what a sensor is and what and how much data it collates, processes and measures. However, smart systems capabilities such as remote control exacerbate the reach of a perpetrator. One does not need to be physically present to make someone's life very, very miserable.

Our research group tries to communicate this emerging risk to policy officials and is keen to make this a topic not just for domestic abuse organisations but also for industry and the regulatory domain. In doing so, we aspire to test and study systems to then convey some of the design shortcomings that, for example, developers must have on the radar. The crux of the issue is, however, that the same functionalities many consumers deliberately seek out and buy – such as voice control, location tracking or video recording – are exactly the same tools that can ultimately be misused by domestic abusers.

From a machine-learning perspective – which is a capability embedded and probably soon far more prevalent in these devices – I am interested in understanding what it will mean to have been in an abusive relationship for, say, 20 years and to come out of this relationship with a skewed data model and profile. The latter may mean former abuse victims or survivors may not be eligible for loans or insurance products. There is already research showcasing that insurance providers have acted discriminatory towards domestic abuse victims, as their risk – for instance, in the context of life or health insurance – is so much higher. I, therefore, wonder what the consequences of our increasingly connected and datafied society may be for vulnerable groups such as intimate partner violence victims/survivors.

Unfortunately, domestic abuse is still a very gendered phenomenon and I cannot tell you how often I have worked with support sector organisations (which are generally very female-dominated) and heard representatives express that they were "not tech-savvy". This viewpoint is pervasive. Indeed, looking at most heterosexual relationships, it is frequently the male partner who is in charge of purchasing devices, setting them up, maintaining them, and deciding when and how to replace them. Additionally, they are often the legal owner of the device, the account holder with the knowledge of authentication details such as passwords, and the payer of subscriptions. This creates a gender imbalance that is aggravated in intimate partner violence situations, where power dynamics take hold.

If there is one thing I wish people to take away from our research, then please let it be this: We are currently in a very critical moment in time where both the underestimation of the capabilities of technology are just as dangerous as their overestimation. We see this with victims and survivors, who are being told horrendous things about what smart devices allegedly can do, and this hyped fear is not only fed by advertising and

One does not need to be physically present to make someone's life very, very miserable.

the media but is worsened. Most often, claims about what a perpetrator is technically able to do, do not match the actual capabilities of most of these systems. That said, not accounting for the enhanced functionalities of these products would be just as dangerous. So, the possibility that it could be true and the lack of certainty about what smart devices can actually make possible feeds into victims' and survivors' angst. I consequently support a realistic debate about IoT as well as emerging technologies such as AI, so we can focus on addressing real threats and risks and ultimately help and support victims and survivors without gaslighting them any further. □

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What is needed for an ethical future with Edge Technologies?

Peter Novitzky

Dr Peter Novitzky is a senior research fellow at PETRAS National Centre of Excellence for IoT Systems Cybersecurity. He is also a research fellow at the Faculty of Engineering, Department of Science, Technology, Engineering and Public Policy (STEaPP) at University College London and an Associate Professor of Ethics of Emerging Technologies at Avans University of Applied Sciences in the Netherlands. Peter specialises in the ethical challenges of emerging technologies, AI, safety and security.

SUMMARY

- The ethics of AI technologies for assisted living is a convoluted and complex area due to the sheer number of topics and complexity of different points of view
- The art of an ethicist is to pick the most relevant aspects and highlight them, justifying the course of action
- The small number of visionaries deciding what big tech comes next means that there's a high probability of something going wrong either in terms of financing or agenda setting
- Ethical work on the distant horizon is intellectually appealing, but arguably a diversion from the harder problems of the present
- We need more specialists in the socio-technical fields who can engage and work across the spectrum.

Recently, with the help of other experts, I worked on a definitive list of all the ethical issues related to 'ambient assisted living' technologies. These are AI technologies supporting people with mild cognitive impairment such as dementia, to age and stay longer in their home environment. It was a review of more than 300 papers (see Figure 1 on page 29).

The other paper that I was fortunate to co-author was on the role and impact of emergent technologies on intimate partner violence. What both investigations highlighted is how convoluted and complex these areas are. From a general, ethical perspective, this is due to the sheer number of topics, and complexity of various stakeholders' point of views. What both of these papers emphasise is that modern technologies have a tremendous number of ethical challenges.

Complex entanglements

Moreover, there are some very complex entanglements between, e.g. the public, private or communal individual approaches, and the relationships between stakeholders who are associated with these technologies affected directly or indirectly. An example of the latter is people living with dementia, their informal and formal carers, and healthcare professionals. We are also dealing as a species with wider, societal challenges (or so-called wicked problems) that by definition cannot be easily solved, even with the help of the newest technology. However, we still try and the role of an ethicist in this is to pick the most relevant challenges that need attention, so we ensure respect, rights, and universal and societal values.

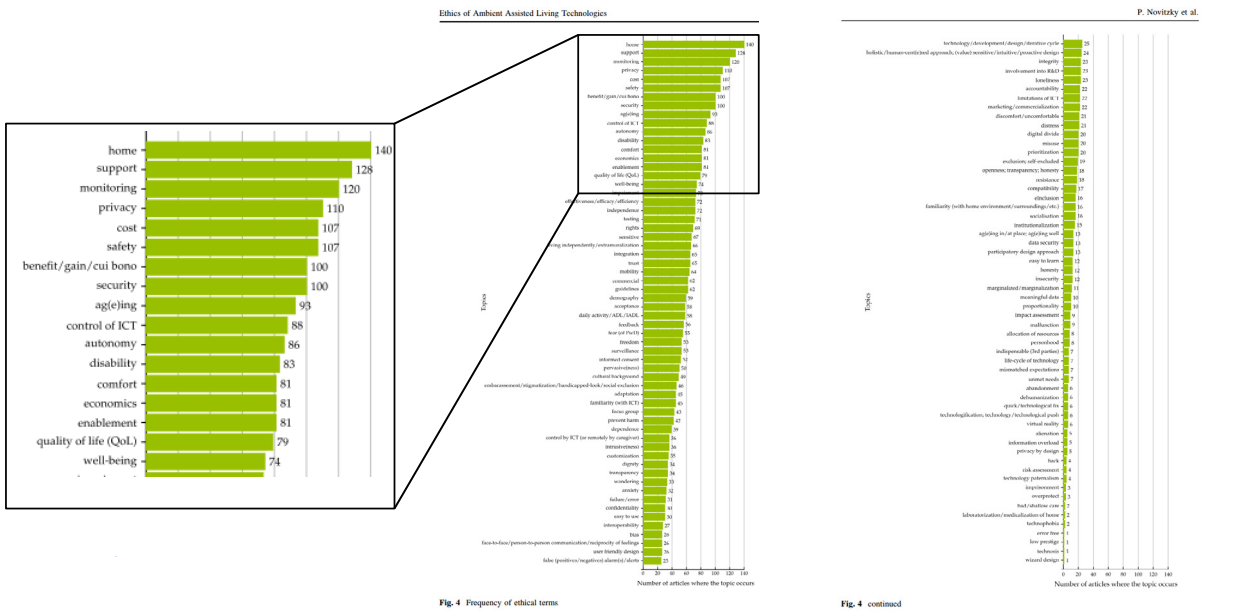
The art of an ethicist is to pick the most relevant aspects and highlight them.

The standard definition of ethics is a systematic reflection on questions of morality (rules, guidelines, principles), values, judgements, normative decisions, and the justification of these. It is an intellectual inquiry about the concepts and principles that help to assess behaviours that help or harm sentient creatures, by providing arguments for choosing one or another course of action.

Cybersecurity

As a representative of the PETRAS National Centre of Excellence for IoT Systems Cybersecurity, it is always intriguing for me to focus specifically on the cybersecurity area of emerging technologies. A report of an influential group of researchers written in 2018 entitled *The Malicious Use of Artificial Intelligence: Forecasting, Prevention and Mitigation*, although aged by current standards, collates all the digital, physical and political

Figure 1. Ethical aspects of emergent Assisted Living Technologies (AAL)



(Source: Imerial College London

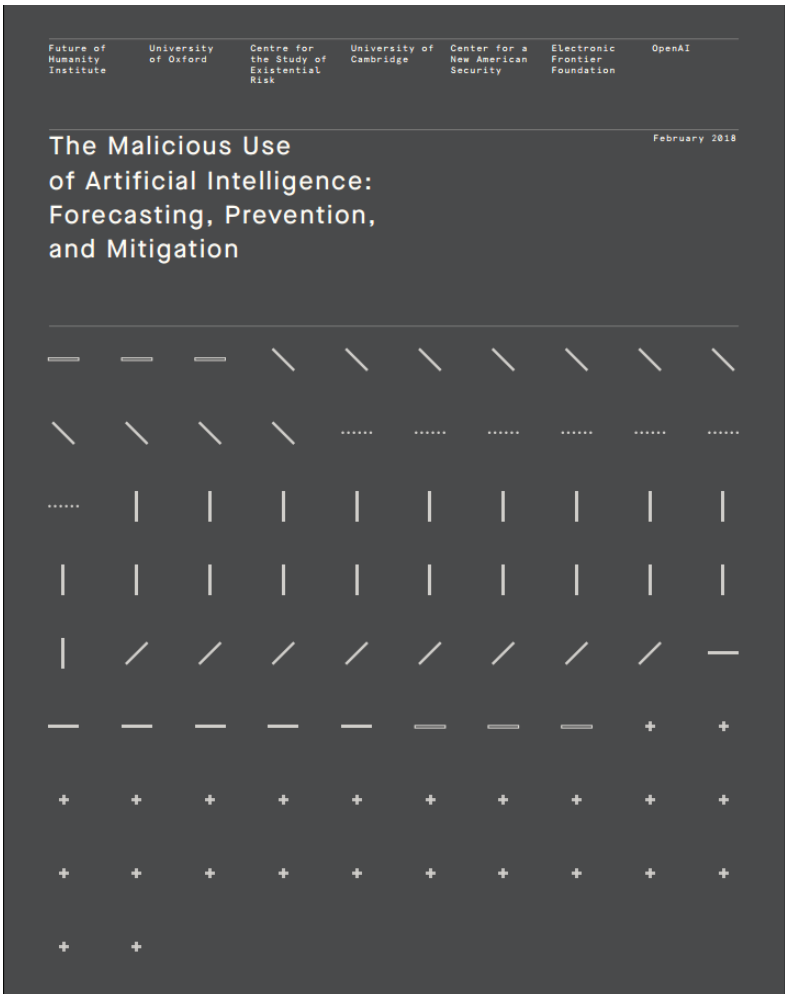
AAL are AI technologies supporting people with cognitive impairment such as dementia, to stay longer in their home.

connotations of AI cybersecurity. The reason why I use this report is to put these cybersecurity AI threats into a chronological context. Most of these malicious AI uses have already taken place since the publication of this report, or—with the exception of one—are currently happening. This list of threats highlight the challenges ahead of us: what AI-related cybersecurity issues we might face, and how ready we are in terms of tackling them. To further qualify this debate, the Booz and Company *Digitization Index*, uses 23 indicators in six key attributes (ubiquity, affordability, reliability, speed, usability and skill), to categorise countries into four areas: constrained, emerging, transitional and advanced. Most of the countries in the Western hemisphere belong to the digitally advanced countries, which also means that our potential cybersecurity vulnerability-exposure is globally the highest.

Figure 2 (see page 30) demonstrates that, for example, Russia is represented on the Digitization Index as an advanced country; China is still a transitional one. Again, I believe this graph demonstrates well how vulnerable our societies are and will become in terms of cybersecurity in the future.

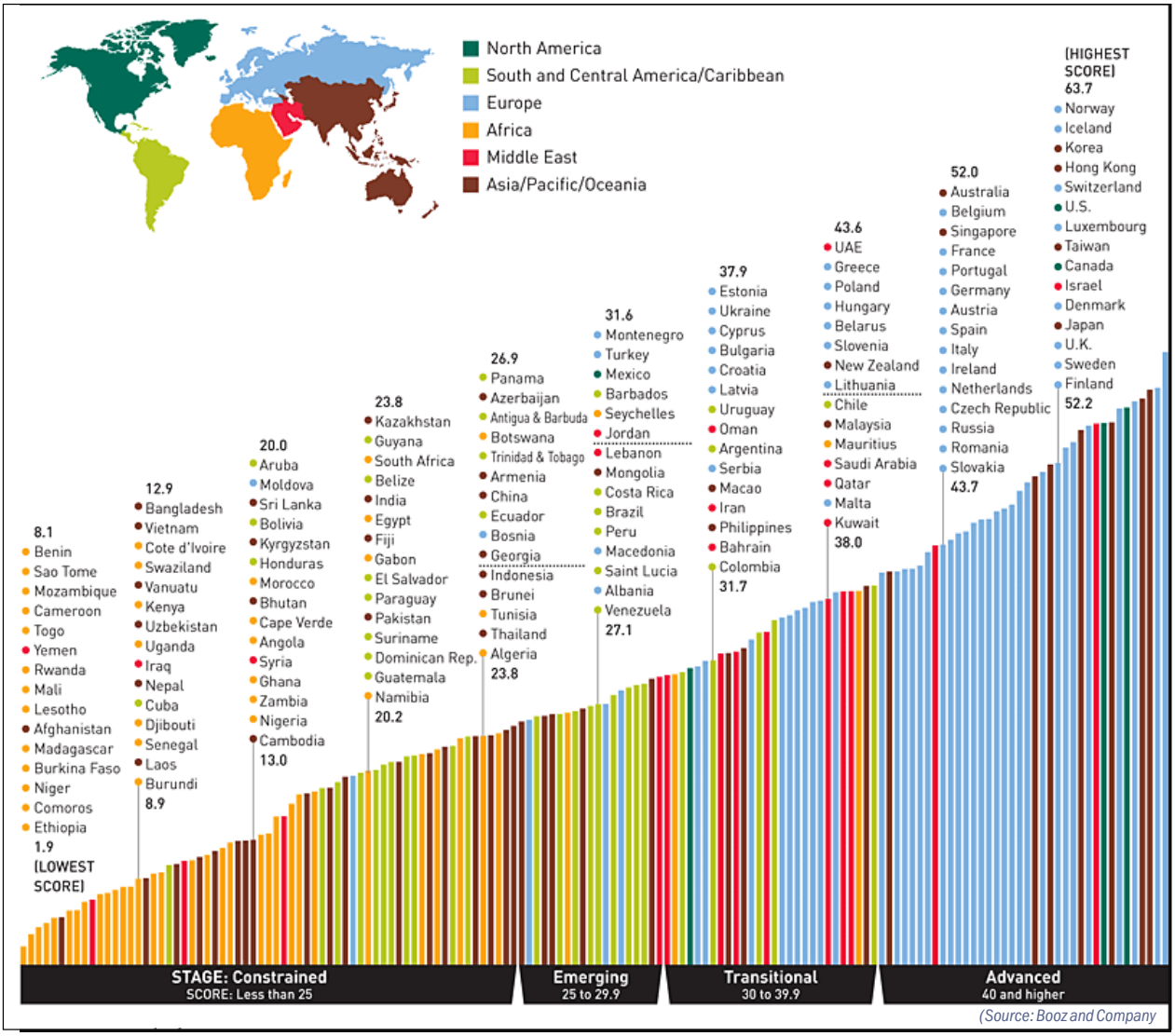
My library

In the second half of my speech I would like to invite you to my library. I recently read Daron Acemoglu's book *Power and Progress* (Basic Books 2023). As an MIT (Massachusetts Institute of



Most of *The Malicious Use of Artificial Intelligence* report's list of 19 AI-security threats have already happened by 2024.

Figure 2. Digitisation Index score for world countries



Booz & Company's Digitization Index is a composite score that calculates the level of a country's digitization using 23 indicators to measure six key attributes, including ubiquity; affordability; reliability; speed; usability, and skill.

Technology) professor of economics, together with Simon Johnson, they looked at the last 1000-year struggle over technology and prosperity, trying to answer how much innovation and regulation we need. They explore a problem that we currently see across the high-tech and AI-debate, which is that a handful of visionaries set the agenda for the next big technology and where the funds will be invested. Such a small number of people sitting at the top means that there is a high probability of something going wrong either in terms of financing or agenda-setting. Acemoglu and Johnson raise the point that we should strengthen our democratic institutions and decision-making processes, involving citizens with these to a greater degree. If there is one argument which summarises their book, it is that throughout history, the 'trickle down' prosperity or economy never worked. This is the challenge that we are facing in terms of technology today, too.

The other book that I would highly recommend is Sir Professor Geoff Mulgan's book *When Science Meets Power* (2023), also published very recently. He very poignantly formulates a critique of fellow philosophers like myself and my colleagues, by writing that many non-philosophers started to consider the work on AI-ethics as a distraction rather than a solution. Many books and conferences investigated high-level moral dilemmas of the trolley problem, others explored the challenges of singularity with hypothetical Artificial General Intelligence. Yet, at the same time AI has been applied in almost every area of our daily lives with very little in-depth and practical analy-

sis on the social and ethical issues. While these analyses of the distant horizon was certainly intellectually important, Mulgan argues that these were "a diversion from the harder problems of the present" (p78).

I fully agree with this statement. I would like to focus on more applied challenges such as dementia and intimate partner violence and how that actually translates in practice. We see a huge influx of ethical frameworks, tools, and methods over the years. Yet, it remains to be seen which of these scale up to a domain-wide level, or which and how frequently they are validated by other researchers. Other questions also remain to be answered: do we have enough staff to test them all? Who applies them? Where on a national or global landscape these frameworks scale up?

This brings me to the conclusion of my speech: we need more specialists in the socio-technical fields, who can engage and work with citizens, users, researchers, industry partners, and the developers of these technologies. ☐

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The debate

After the presentations, the speakers joined a panel to answer questions from the audience on a variety of topics, including user privacy and security, Open-Source software, the ethical responsibilities of developers and designers, and the need to find Edge Technology's David Attenborough figurehead.

Is the Edge enough to say that a system is private? This was a question from the floor which opened the debate. There are many examples of applications and services that are operating in our daily lives where there are huge concerns. Firstly, we must separate privacy and security concerns. Policymakers need to look at where regulation can enhance individuals' privacy and security. To some extent the EU and the UK have better regulations than the other side of the Atlantic. Another panelist noted that it is important to recognise that a lot of data that is collected and held is held by private individuals and wo not be analysed beyond the realms of the company.

The problem of regulation

A lot of people talk broadly about regulation and it is used as a sticking plaster for everything, but nobody really knows how to regulate. She wondered if it would be possible for academics to have radical innovation outside of industry because academics are often bound by the terms of the industry partners that they team up with. Another panelist further expanded on this point to say that from an ethical point of view, the routinisation and tick-box way in which terms and conditions of apps and devices are given and received by its users means there is no valid constant of data gathering. This in turn means that we are feeding a system which is a black box. We need to think about these systems and processes and how this data will be used for or against us in the future.

On the other side of privately owned Edge Technologies and AI software we have Open Source, which is computer software that is released under a licence in which the copyright holder grants users the rights to use its source code for any purpose. One attendee asked if this will be strong enough to keep up with the current development, power players and fast-moving world of AI. Experts discussed how the boundaries of the Open Source principles may have become blurred, with large companies increasingly dominating the space. Historically, Open Source has been a very good thing with a lot of transparency, but there is increasing debate around the powerful growth of large language and visual models and concentration of power.

Ethical responsibility

What would the panel change about the development of Edge Technologies that would make things better? The ethical responsibility should lie with the developers and designers and not be someone else's problem. Engineers should be working alongside social scientists during development of technologies. There should be places where the everyday person can go to get help around abuse, privacy and security issues with technology. Unfortunately, regulation has a chilling effect on innovation and this is often why you find reluctance, but that this does not make it any less important.

Can we find a David Attenborough figure for AI and other Edge Technology who could act as an iconic communications figure for the everyday person? Rather than just hyper-dark, dystopian TV shows, we need a public figure who can break down the benefits but also the great risks of some of this technology. ☐

NETFLIX

Do Edge Technologies and AI need a David Attenborough figure to act as an iconic communications figure?

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In conversation with Dame Angela McLean

Wednesday 9th October 2024

The Royal Society

Professor Dame Angela McLean, Government Chief Scientific Adviser
The Rt Hon Lord David Willetts FRS, Chair, The Foundation for Science and Technology

Should R&D policies and budgets be devolved to English regions?

Wednesday 23rd October 2024

The University of Liverpool

The Rt Hon the Lord Willetts FRS, Chair, The Foundation for Science and Technology
Anne Glover CBE, Chief Executive Officer and Co-Founder, Amadeus Capital Partners
Professor Tim Jones, Vice-Chancellor, University of Liverpool

Foundation Future Leaders Conference

Friday 8th November 2024

The Exchange, the University of Birmingham

Professor Sarah Sharples, Chief Scientific Adviser, Department of Transport
Professor Christopher Smith, UKRI International Champion and Executive Chair of AHRC
Professor Marika Taylor, Pro Vice Chancellor and Head of College of Engineering and Physical Sciences, University of Birmingham
Dr Stephen Hendry, Programme Manager Socioeconomic Inclusion, Royal Society of Chemistry
Daisy Shearer, Outreach and Engagement Officer, National Quantum Computing Centre

Past events

Quantum technologies: from research to reality

Tuesday 24th September 2024

The University of Strathclyde, Glasgow

Professor Sir Jim McDonald, Principal and Vice-Chancellor of the University of Strathclyde, and President of the Royal Academy of Engineering, [Chair]
Dr Dame Frances Saunders, Chair of the Royal Academy of Engineering's Quantum Infrastructure Review 2024
Professor Melissa Mather, Professor of Quantum Sensing and Engineering and Royal Academy of Engineering Chair in Emerging Technologies, University of Nottingham
Simon Andrews, Executive Director, Fraunhofer Research UK Ltd
Rachel Maze, Head of Quantum Technologies Policy, Department of Science, Innovation and Technology

Research Integrity

Tuesday 9th July 2024

Professor Rachael Gooberman-Hill, Co-Chair, UK Committee on Research Integrity
Professor Andrew George, Co-Chair, UK Committee on Research Integrity
Cathy Alexander, Deputy Director for Science & Innovation, Systems& Capability, Government Office for Science
Professor Christopher Smith, Executive Chair, Arts & Humanities Research Council
Sarah Jenkins, Senior Director, Research Integrity & Publishing Ethics Centre of Expertise, Elsevier

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Medical Research Council, UKRI
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