

Research

Horizons

Pioneering research from the University of Cambridge

Issue 31

Spotlight

Digital society

Feature

Singing sand dunes

Feature

Bronze Age exposé



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Welcome

Around 3.5 billion people use the internet – that’s almost half of the world population. Our digital connectivity is rapidly transforming almost every aspect of our working and personal lives. Soon, innovations that were inconceivable a few years ago will be commonplace – autonomous vehicles, devices that diagnose disease, household appliances that talk to each other. Digital technologies being built in Cambridge and beyond are reshaping health, business, education, public services and the economy.

A digital society – the Spotlight focus this issue – also raises challenges. The more connected we are, the more we open ourselves to risk, whether it’s from cybercrime, invasions of privacy, digital infrastructures that are not up to the job or, ultimately, the advent of machines that are more intelligent than we are.

Here in Cambridge, we understand that addressing these challenges needs social sciences and computer sciences to work together, and we think this is an area where we make a difference. Among various initiatives, we have strategic research priorities in Digital Humanities, Big Data and Public Policy, and we are a partner in the UK’s national centre for data science, the Alan Turing Institute. In addition, the recently funded Leverhulme Centre for the Future of Intelligence will help us to look at some of the overarching issues at play.

As well as our focus on digital society, we also cover a fascinating breadth of other areas in this edition of *Research Horizons*: singing sand dunes and flamenco flashmobs, a chance observation that led to a breakthrough cancer drug, how to keep patients safe in hospital, the sights, sounds and ‘feel’ of a data centre, and some of the amazing Bronze Age treasures discovered at what’s been dubbed ‘Britain’s Pompeii’.

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News



Next Vice-Chancellor appointed

International law scholar and university leader Professor Stephen Toope has been appointed to take over from Professor Sir Leszek Borysiewicz on 1 October 2017.

Currently Director of the University of Toronto's Munk School of Global Affairs, Toope formerly served as president and vice-chancellor of the University of British Columbia. He graduated from Harvard with a degree in history and literature in 1979, and is also an alumnus of Trinity College Cambridge, where he completed his PhD in 1987.

"I am thrilled to be returning to this great university," says Toope. "I look forward to working with staff and students in the pursuit of academic excellence and tremendous international engagement – the very mark of Cambridge."

As a scholar, Toope has specialised in human rights, international dispute resolution, international environmental law, the use of force, and international legal theory with degrees in common law (LLB) and civil law (BCL) with honours from McGill



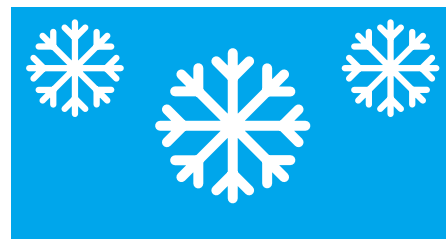
Image
Professor Stephen Toope

University (1983). He has published articles and books on change in international law, and the origins of international obligation in international society.

Toope also represented Western Europe and North America on the UN Working Group on Enforced or Involuntary Disappearances from 2002 until 2007.

Cambridge has carried out an international search for the position of Vice-Chancellor headed up by the Master of Jesus College, Professor Ian White. He explains how the appointment will build on seven years of Borysiewicz's visionary leadership: "Professor Toope has impeccable academic credentials, a longstanding involvement with higher education, strong leadership experience and an excellent research background."

Borysiewicz, who will continue to lead the University until Toope takes up his post on 1 October 2017, says: "We are delighted to be welcoming a distinguished leader with such an outstanding record as a scholar and educator to lead Cambridge."



Hot ticket for air travel

Researchers have developed a paint-on anti-icing technology to make flying safer and more efficient.

Ice on a plane can spell disaster. It can increase drag, reduce lift, hit propellers and build up inside the engine. Every year, vast amounts of de-icers and anti-freeze are sprayed onto planes by ground staff while passengers wait – a solution that is costly, time-consuming and detrimental for the environment.

Now, airlines have an alternative that can be painted onto the plane and turned on in the cockpit. Developed by Dr Dawid Janas and Dr Krzysztof Koziol in the Department of Materials Science and Metallurgy, the ThaWing product comprises an ultralight coating of nanomaterials like carbon nanotubes or graphene, which have excellent thermal and electrical properties.

As little as 80 g of material is needed to cover the wings of a jumbo jet. When a current is passed through it, the material has a near-instantaneous rise in temperature – providing planes with their own thermal 'jacket' to stop ice forming. The paint-on 'heaters' are so cheap to run that they could be left on continuously.

After receiving a Proof of Concept grant from the European Research Council to produce a prototype, the researchers formed start-up company Cnergytec to deploy the system onto any aircraft currently in operation to make flying safer and more efficient.

www.thawing.eu



Film available:
<http://bit.ly/2dboluP>



News in brief

More information at
www.cam.ac.uk/research

10.10.16

Cambridge alumnus Professor Oliver Hart shares the 2016 Nobel Memorial Prize in Economic Sciences for work in the field of contracts.

04.10.16

Three Cambridge alumni awarded the 2016 Nobel Prize in Physics for their work in condensed matter.

Artificial pancreas wins European funding

An artificial pancreas developed in Cambridge will be trialled in young children with type 1 diabetes.

Type 1 diabetes is one of the most common chronic diseases in children. Each year in the UK, around one in 4,000 children under 14 years of age is diagnosed with the disease, in which the pancreas stops producing sufficient insulin to regulate blood sugar levels.

People affected by the condition have to manage their condition through regular insulin injections – in some cases, several times a day. However, a team at the University of Cambridge and Cambridge University Hospitals hopes to replace these treatments with a small portable device that carries out the function of a healthy pancreas in controlling blood glucose levels by automated insulin delivery.

The system is worn externally on the body, and is made up of three functional components: continuous glucose monitoring, a computer algorithm to calculate the insulin dose, and an insulin pump.

Trials have shown that it is effective in adults and school children. Now, KidsAP, a collaboration led by Cambridge and involving institutes in Europe and the USA, has received €4.6 million from the European Commission to carry out a trial of the artificial pancreas among children aged 1–7 years with type 1 diabetes.

“We’ve already seen that the artificial pancreas can have a very positive effect on people’s lives and now, thanks to funding from the European Commission, we can see whether young children will also see these same benefits,” says project leader Dr Roman Hovorka from Cambridge’s Department of Paediatrics and Addenbrooke’s Hospital. “Children have to have frequent insulin injections that are at best inconvenient, but at worst painful. We hope this new technology will eliminate this need.”



Credit: Abraham and Jehuda Cresques/wikimedia

What the Ancients did for us

Cities and writing: two new projects look back 4,000 years at the roots of these universal aspects of contemporary life.

Why did the ABC alphabet develop? How have the ancient cities of the Mediterranean contributed to the history of urbanism? These are some of the questions researchers in the Faculty of Classics are tackling in two new programmes funded by the European Research Council.

Professor Andrew Wallace-Hadrill leads *Impact of the Ancient City* – a project whose strength, he says, “is to dare to look over such chronological and geographical scope” as the Greco-Roman and Islamic worlds of the Mediterranean from 2,000 BC to the present day.

“There is a continuous sense of wonder at the phenomenon of the big city,” he explains. “The Ancients felt it and wrote about it, and there’s now intense interest in urbanisation. We want to look back to these roots and trace their impact to the present day.”

He anticipates a “methodological pincer movement” to assess the physical archaeology of cities such as Rome, Athens and Istanbul, and the history of ideas about urbanism, city planning and citizenship.

Meanwhile, Dr Philippa Steele leads *Contexts of and Relations between Early Writing Systems*, which is exploring the long-lasting relationship between society and writing that persists today.

For example, the ABC alphabetical order first appeared over 3,000 years ago in a wedge-shaped ‘cuneiform’ script in Syria. It also appeared in otherwise unrelated alphabets including Phoenician, Greek, Etruscan and Latin.

How did the idea spread and remain so stable for thousands of years? “We can only understand it by looking at the social settings in which writing was being used,” says Steele. Because of the high level of interconnectedness of the region, people were communicating these ideas as they traded and interacted with different cultures.

“Globalisation is not a purely modern phenomenon,” she adds. “We might have better technology to pursue it now, but essentially we are engaging in the same activities as our ancestors.”

14.09.16

Cambridge to receive £114 million government investment in NHS research to boost medical breakthroughs.

30.07.16

Some of the finest illuminated manuscripts in the world go on display in celebration of the Fitzwilliam Museum’s bicentenary.

22.07.16

Humans and wild birds in Africa collaborate through special calls to find precious resources of honey and wax.

Bronze Age exposé

Some of the stunning finds at Must Farm, a Cambridgeshire settlement of roundhouses believed to be the best-preserved Bronze Age dwellings ever found in Britain.

Buried in silt for 3,000 years, the treasures provide a remarkable snapshot of everyday life. They were preserved after a community of stilted wooden houses were destroyed by fire and collapsed into the shallow river beneath. Recent excavation of what has been dubbed 'Britain's Pompeii' was carried out by the Cambridge Archaeological Unit and funded by Historic England and Forterra. Work on the finds is now taking place at Cambridge's McDonald Institute for Archaeological Research and other centres.

www.mustfarm.com



Film available:
<http://bit.ly/29V9FW3>







Beyond the castanets



Image

Flamenco illustrates the close relationship between music, identity and politics



Words

Alex Buxton

Political protest and social activism are not what first comes to mind when thinking of flamenco, but for some performers it has always been a powerful tool for voicing political protest. New research asks what happens when a musical genre becomes a powerful symbol of regional identity.

For audiences around the world, flamenco symbolises the colour and romance of southern Spain. An energetic blend of song, guitar and dance, it is most strongly associated with Andalusia, a region richly influenced by its historic connections to Islamic North Africa.

Flamenco has long been supported by the Andalusian government, which sees it as an important element of regional identity and a magnet for tourism. But in 2010 it garnered global recognition when UNESCO designated it an Intangible Cultural Heritage of Humanity (ICH).

The designation was a seminal moment in the history of flamenco, which has progressed from a tradition embedded

in gypsy and working class communities to a genre taught in conservatoires alongside more classical styles. Its listing as an ICH raises important questions about culture and identity: how best to keep regional art forms alive and flourishing in an increasingly globalised world and, more specifically, how musical forms intersect with politics.

Dr Matthew Machin-Autenrieth is an ethnomusicologist in the Faculty of Music. He is interested in how and why music has come to be as it is. As an expert on flamenco, he has a fascination for the shifting politics of what he sees as a 'grassroots' art form that has been packaged as a global commodity, a symbol of regional identity and a tool for social activism.

"Flamenco is perhaps Spain's most alluring cultural phenomenon, characterised by the stereotypes of sun, passion and tumbling black hair," he writes, in an article published recently by *The Conversation*. "Political protest and social activism are less likely to come to

mind when thinking of flamenco, but for some performers it has always been a powerful tool for voicing political protest.”

Spain, and especially Andalusia, suffered immensely in the global economic crisis, and has one of the highest levels of unemployment in Europe. In 2011, the infamous 15M protest movement mobilised millions of citizens across the country to challenge policies of austerity following the banking crisis. On the back of this movement, the anti-capitalist flashmob group Flo6x8 “rebranded flamenco as a powerful political weapon”, he explains, when they staged flamenco performances in banks all over Andalusia and even in the Andalusian parliament.

“By claiming public, capitalist spaces, the performers give a powerful political message that challenges the status quo. But these performances also break with typical gendered stereotypes in flamenco. The exotic, seductive and ‘oriental’ image of the female dancer is turned on its head. Instead the female dancers in these performances become powerful, political figures.”

Although a new law introduced by the Spanish government in 2015 restricted

the activities of Flo6x8, members remain committed to flamenco as a political weapon against continued social and economic inequalities in Spain.

Building upon this research, Machin-Autenrieth has probed flamenco’s cultural complexity and contested politics. He asks how an iconic performative tradition contributes to the formation of identity at local, regional, national and international levels in his new book, *Flamenco, Regionalism and Musical Heritage in Southern Spain*.

Much has been written, and contested, about the origins of flamenco, which emerged as a genre only in the mid-19th century when it was ‘discovered’ by middle class audiences searching for the exoticism and romanticism of folk traditions. Its deeper roots are entwined with the music of gypsies and other marginalised groups. Its themes play on the highs and lows of human experience – love and loss, death and sorrow – reflecting the suffering of a population living in a region scarred by centuries of feudalism.

Flamenco is not universally popular in its country of origin. “Many Spaniards I have met (from outside Andalusia) disregard and even detest the conflation of flamenco with Spanish-ness, viewing it as nothing more than an Andalusian-Gypsy tradition,” says Machin-Autenrieth. “However, arguably, a process of appropriation is occurring within Andalusia, the tradition being developed by institutions and in the popular media as a definitive symbol of regional identity.”

In setting the context for his discussion, Machin-Autenrieth traces the recent history of flamenco, which was repressed and then appropriated by the Franco regime. When the regime ended in the mid-1970s, Spain underwent a process of democratisation and decentralisation during which flamenco was used as a political tool, becoming a potent marker of the culture of Andalusia. Its popularity may not be universal across the region but, by virtue of educational initiatives and festivals, all Andalusians are familiar with its distinctive style.

Music has a powerful cohesive effect on communities, and orally-based traditions in particular offer a voice to groups who might remain unheard. But when music is appropriated by institutions, its authenticity and relevance for local communities may be under threat, he explains.

Concerns about the alleged commercialisation of flamenco are nothing new. Early in the 20th century, the poet Federico García Lorca and the composer Manuel de Falla, both

Andalusians themselves, emerged as champions for an art form that had gained negative stereotypes, and was under attack by antiflamenquistas intent on depicting flamenco as an outdated cultural phenomenon that was out of step with Spain’s European ambitions.

In recent years, however, flamenco has seen an increase in institutional support in a country where regional identity is high on the agenda. But institutional involvement in the arts can be counter-productive. Making a point that could apply equally to other art forms, Machin-Autenrieth quotes the Spanish sociologist Aix Gracia, who argues that “the affability with which the administrations treat flamenco in Andalusia, through ‘festivalisation’ and its preservation as a representation of identity, is also its biggest threat... I cannot resist the question: could this art die of success? Or more specifically, could it lose its autonomy?”

In exploring the question of artistic freedom, Machin-Autenrieth attended dozens of flamenco performances and interviewed many of those involved as artists and promoters. He describes the tensions that exist between the styles of flamenco approved by the heritage industry and those out of favour with the dominant institutions. Strength of feeling against the institutional development of flamenco led to the emergence of *Flamenco es un derecho* (Flamenco is a right), a protest movement that claims flamenco is a gift to humanity – but one over which Andalusians have a right.

Much research on flamenco has focused on the role of three cities (Seville, Cádiz and Jerez) as the defining ‘golden triangle’ for its performance. As well as exploring the regional politics behind flamenco, Machin-Autenrieth looks beyond the ‘golden triangle’ to examine the relevance of flamenco for local identity in Granada beyond its regional associations.

Spanish identity, by virtue of the country’s history, is strongly local. To be Andalusian is to feel a strong sense of regional belonging. With flamenco, a sense of locality splits even further into the competing styles performed in different cities, clubs and venues. It is this richness of diversity, rather than adherence to proscribed authenticity, he says, that will keep the genre moving forward.

Machin-Autenrieth’s work shows the hidden complexities of flamenco both as a tool for political protest and as a marker of regional identity. “Beyond the castanets and polka-dot dresses, flamenco is a diverse and politically contested tradition that illustrates the close relationship between music, identity and politics in a globalised world.”

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A deliberate lack of common sense



When you're under attack, you fight back. You gather your troops and attack the invading enemy, hoping to wound and defeat them, while supporting and treating your own injured soldiers. It's common sense.

If you're based at the Wellcome Trust/Cancer Research UK Gurdon Institute, however, the common sense approach is not necessarily the road most travelled – and for good reason. The word 'counterintuitive' is one you will hear surprisingly often when you talk to its researchers about their work.

No one illustrates this better than Professor Steve Jackson, who has been at the Institute since it opened 25 years ago and made his name – and a new class of cancer drug – from a seemingly

counterintuitive approach to cancer: to switch off a mechanism that is meant to repair our DNA and prevent it mutating, akin to taking out your army medics.

Jackson, like all of the researchers at the Gurdon, is a basic scientist – in other words, his work looks at the fundamental biology that underpins how our bodies work. Basic science is rarely fashionable, rarely flashy, but without it we would have few of the medicines we take for granted today.

However, this process also takes time: Lynparza, the medicine that resulted from Jackson's work, was granted Marketing Authorisation from the European Commission and the US Food and Drug Administration in 2014, more than two decades after he began researching this area; the drug is now available in over 40 countries worldwide.



“The hardest thing for me was getting people to buy into the idea as it was counterintuitive: why would you want to inhibit DNA repair?”

In fact, as with a surprising amount of science, his breakthrough moment was the result of a chance observation. He co-discovered an enzyme that was activated by DNA, and then observed that it was actually activated by breaks in DNA. Most DNA used in labs is circular, but Jackson was using ‘strings’ of DNA, which have ends.

“If I’d been using circular DNA, I’d have never seen this effect and I never would have developed my career in this direction, but this discovery made me think ‘Wow, maybe because this enzyme is activated by breaks, it must be involved in DNA repair’. When you’re working in basic science and you follow your nose, you can spot things and hopefully recognise what they’re telling you – and in my case, it was saying ‘Maybe you want to work on DNA repair’.”

It was a second DNA repair enzyme – known as PARP – that was to lead to the development of olaparib (marketed as Lynparza) and to Jackson setting up his own company, KuDOS, as he saw its potential as a drug target. KuDOS was eventually bought out by AstraZeneca, the pharmaceutical giant that will soon move its headquarters to Cambridge.

DNA repair is so important to our survival that we have evolved a backup mechanism in case PARP fails, known as homologous recombination, in which DNA is exchanged between identical pieces of DNA to repair it. In some cancer cells – most notably those associated with mutations in the *BRCA1* or *BRCA2* genes – this mechanism fails. Tumour cells in individuals with these genes carry two ‘bad’ copies of the gene, which inactivates homologous recombination, but the individual’s healthy cells carry one good copy, meaning that they can still carry out this process.

“This was a ‘Eureka’ moment,” says Jackson. “We realised that if you block the PARP repair mechanism in these individuals, the healthy cells revert to their backup and survive, but the tumour cells have no backup and so will die.”

Just under one in three cases of ovarian cancer is caused by the *BRCA* genes, and it is for these individuals that Lynparza has been licensed. Recent studies suggest that around the same

proportion of prostate cancer cases may be linked to *BRCA* gene mutations, and to one in ten cases of breast cancer; if Lynparza is approved for all of these patients, it could make a huge difference to survival rates. The drug isn’t perfect – it doesn’t work in all *BRCA* patients and some patients develop resistance to the drug – but it is clearly extending and enhancing many lives.

“We all hope to cure cancer, and PARP inhibitors are curing a small proportion of patients,” says Jackson, “but what we’re doing is moving cancer towards becoming a long-term disease that is kept in check through different phases. That’s a good business model for pharmaceutical companies, ensuring that they invest in this area, but most of all, it’s good for the patients.”

Jackson jokes that he had much more hair when he started out – running his own company alongside his work, and trying to get others to support his approach “nearly did me in,” he laughs. “The hardest thing for me was getting people to buy into the idea as it was counterintuitive: why would you want to inhibit DNA repair? DNA repair’s good – that’s what the pharma companies said, that’s what the venture capitalists initially said.”

Just as Jackson’s work eschews the common sense approach, so too does the work of his colleague Dr Eugenia Piddini. If switching off cells’ repair mechanisms sounds counterintuitive, then so does the idea of stopping the mechanism that is intended to cause diseased cells to fall on their swords – programmed cell death, or ‘apoptosis’.

Like many of the scientists at the Gurdon, Piddini mostly works on much simpler organisms than humans. In addition to studying human cells, Jackson also works on yeast, while Piddini complements her mammalian studies with work on the fruit fly. We may not have shared a common ancestor for hundreds of millions of years – a billion, even – but we still share many of the fundamental processes that take place in our bodies.

Piddini looks at the competition that takes place between cells, and in particular how cells talk to each other and how this enables the tissue to select

the strongest cells. “It’s a kind of quality control,” she explains. “But it’s been suggested for some time that cancer cells somehow disguise themselves, making them look stronger so they can kill off their neighbours and colonise their space.”

She believes this may help explain why, as cancers spread throughout the body – or ‘metastasise’ – they cause organ failure. “There will come a point where there are no longer enough healthy cells for the organ to continue to function.”

Many existing chemotherapy drugs encourage apoptosis. Not only does this cause collateral damage to healthy cells – which is why chemotherapy patients get so sick – but, says Piddini, apoptosis is exactly the process that cancer cells are using against healthy cells. So once again, this leads to a seemingly counterintuitive solution: stop cell death.

“If you can somehow inhibit apoptosis, then you can keep the healthy cells alive. And if you keep the healthy cells alive, you stop the cancer cells spreading and the tumour should die away.”

This is still very early stage research: to some extent, Piddini is where Jackson was not long after he first joined the Gurdon, but as for PARP inhibitors, she believes her approach shows a great deal of promise. “I hope that one day we’ll talk about this in the same way we talk about Steve’s work now,” she says enthusiastically.

Piddini – talked of as one of the rising stars in her field – will be leaving Cambridge next summer for the University of Bristol. Jackson believes her move further emphasises the strengths of the Gurdon Institute.

“You can tell a successful research environment by its alumni,” he says, “by looking at who has trained there and has moved on to lead a group elsewhere.” At the last count, since its launch in 1991, the Gurdon has created 200 group leaders around the world. That’s quite an army of scientists fighting counterintuitive battles.

www.gurdon.cam.ac.uk

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F **Film available:**
<http://bit.ly/2aGkEyU>



When solids flow like liquids they can make sand dunes sing, and they can also result in a potentially deadly avalanche. Cambridge researchers are studying the physics behind both of these phenomena, which could have applications in industries such as pharmaceuticals, oil and gas.

For Marco Polo, the desert could be a spooky place, filled with evil spirits. Writing in the 13th century, he described the famous singing sands, which “at times fill the air with the sounds of all kinds of musical instruments, and also of drums and the clash of arms.” But the low, loud rumbles coming from the dunes were not the work of spirits. They were the work of physics.

As grains of sand slide down the side of certain dunes, they create vibrations that can be heard for miles around. The sand avalanches trigger the dune’s natural resonance, but only when conditions are just right. It can’t be too humid, and the

behaviour starts with observation, which I then incorporate into a model – it’s nature where I get my inspiration from. That, and curiosity – I see something and I want to try to explain it.

“Since there are particles which collide and interact in a granular flow, there is a certain degree of randomness to the process, so how do you incorporate that into a model? You try to translate what you’re seeing into a physical description, and then you perform numerical or theoretical simulations to see if the behaviour you get from the models is the same as you observe in nature.”

Despite their somewhat chaotic nature, avalanches and other types of granular flows share some distinct patterns. Owing to a phenomenon known as segregation, larger particles tend to rise to the top in an avalanche, whereas smaller particles sink to the bottom, falling into the gaps between the larger particles. A similar phenomenon can be

grains of sand need to be just the right size and contain silica. Only then will an avalanche cause the dunes to start singing.

An avalanche, whether it’s made of sand or snow, is an example of a granular flow, when solid particles flow like liquids, colliding, bouncing around, interacting, separating and coming back together again. Granular flow processes can be found everywhere from the world’s highest mountains to your morning bowl of cereal.

Dr Nathalie Vriend, a Royal Society Dorothy Hodgkin Research Fellow in the Department of Applied Mathematics and Theoretical Physics, is a specialist in granular flows. Her PhD research at the California Institute of Technology unravelled some of the physics at work in the same singing sands that mystified Marco Polo. At Cambridge, her research focuses both on sand dunes and on avalanches, and how to quantify their behaviour, which can have practical applications in industries including pharmaceuticals, oil and gas. Vriend’s work relies as much upon laboratory experiments and fieldwork as it does on mathematical models.

“An avalanche can behave as a solid, liquid or gas, depending on various factors, which is what makes them so difficult to model mathematically,” says Vriend. “For me, modelling their

seen in your breakfast cereal: the smaller, tastier bits always seem to end up at the bottom of the bowl. Larger grains are also pushed to the side and the front, forcing the flow of the avalanche into channels.

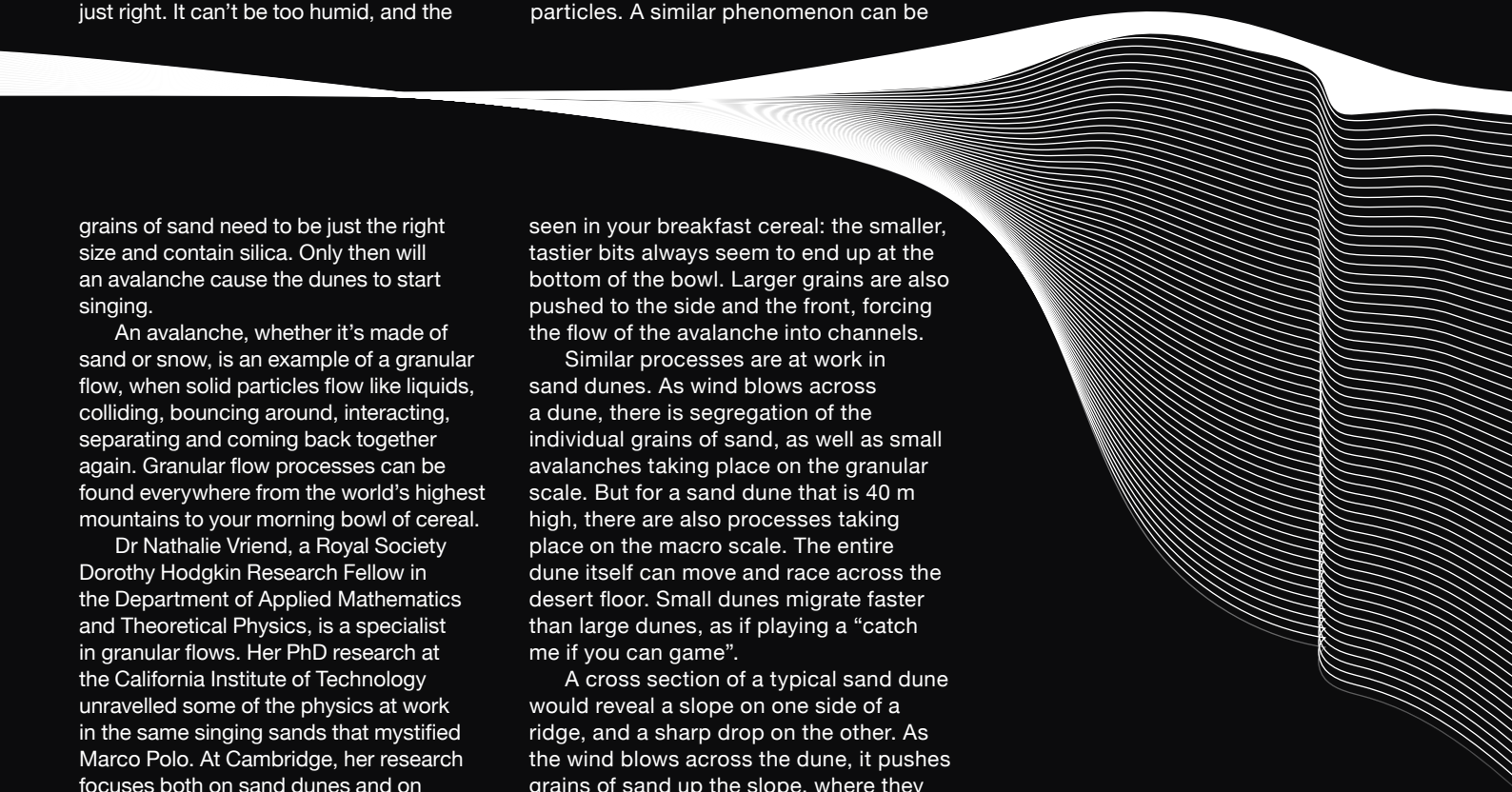
Similar processes are at work in sand dunes. As wind blows across a dune, there is segregation of the individual grains of sand, as well as small avalanches taking place on the granular scale. But for a sand dune that is 40 m high, there are also processes taking place on the macro scale. The entire dune itself can move and race across the desert floor. Small dunes migrate faster than large dunes, as if playing a “catch me if you can game”.

A cross section of a typical sand dune would reveal a slope on one side of a ridge, and a sharp drop on the other. As the wind blows across the dune, it pushes grains of sand up the slope, where they gather in a heap. When the heap gets too big, it becomes unstable and tumbles over the other side, causing an avalanche, eventually coming to a stop. This process happens again and again, causing layers to form within the dune. “A sand dune may look like a monolithic mass of sand, but there are multiple layers and structures within it,” says Vriend.

How does this understanding of the anatomy and movement of a sand dune translate into practical applications?



Words
Sarah Collins



WHAT MAKES A SAND DUNE SING?

Understanding granular flows can be useful in the pharmaceutical industry, where two different active ingredients may need to be mixed properly before a pill is made. Granular flows are also highly relevant to the oil and gas exploration process, and with this in mind Vriend is working with Schlumberger, the oilfield services company.

Sand dunes are major sources of noise in seismic surveys for oil and gas in deserts, which are conducted to probe the location and size of underground oil and gas reserves. The surveys use an acoustic pulse from a source and carefully placed receivers at

different points to listen to the signal that is received, which can then be used to calculate what is hidden underground. The problem encountered by surveyors is that the sand dunes are composed of loose sand and therefore have a much lower wave velocity than the rocky desert floor, and as a result they act as traps of wave energy: the energy keeps reverberating and creates a source of noise in the post-processing of the seismic surveys. As part of a secondment at Schlumberger, one of Vriend's PhD students is performing numerical simulations to understand the origin and features of this noise.

Another industrial problem that Vriend's group is currently working on is the phenomenon of 'honking' grain silos. As grains are let out of the bottom of a silo, the friction of the pellets on the walls of the silo makes a distinctive 'honking' sound. Annoying for the neighbours perhaps, but hardly dangerous. However, when the vibrations get loud enough, it can cause a resonance within the silo, leading to structural failure or collapse. Vriend's students are attempting to understand what affects the way that silos honk, which could someday be used to minimise noise, or even to prevent collapse.

The phenomenon behind honking silos on a busy farm is similar to that which causes massive desert sand dunes to sing, although one could be perceived as an annoyance while the other is considered captivating. For Vriend, however, it's the real-world observations and the opportunity to spend time in nature that motivate her.

She explains: "What I love about my research, whether it's looking at silos or avalanches, is that you can observe it, see it, feel it, touch it."



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Healthcare is a complex beast and too often problems arise that can put patients' health – and in some cases, lives – at risk. A collaboration between the Cambridge Centre for Health Services Research and the Department of Engineering hopes to get to the bottom of what's going wrong – and to offer new ways of solving the problems.

Safety

PLASMA

In November 2004, Mary McClinton was admitted to Virginia Mason Medical Center in Seattle, USA, to receive treatment for a brain aneurysm, a potentially serious swelling in a blood vessel. What followed was a tragedy, made worse by the fact that it was entirely preventable.

McClinton was mistakenly injected with the antiseptic chlorhexidine. It happened, the hospital says, because of “confusion over the three identical stainless steel bowls in the procedure room containing clear liquids – chlorhexidine, contrast dye and saline solution”. Doctors tried amputating one of her legs to save her life, but the damage to her organs was too great: McClinton died 19 days later.

Nine years on, an almost identical accident occurred at Doncaster Royal Infirmary in the UK. Here, the patient, ‘Gina’, survived, but only after having her leg amputated.

Professor Mary Dixon-Woods is one of Cambridge's newest recruits, and she is on a mission: to improve patient safety in the National Health Service and in healthcare worldwide. She has recently taken up the role as RAND Professor of Health Services Research, having moved here from the University of Leicester.

It is, she admits, going to be a challenge. Many different policies and approaches have been tried to date, but

few with widespread success, and often with unintended consequences.

Financial incentives are widely used in the NHS and in the USA, but recent evidence suggests that they have little effect. “There’s a danger that they tend to encourage effort substitution – what people often refer to as ‘teaching to the test’,” explains Dixon-Woods. In other words, people focus on the areas that are being incentivised, but neglect other areas. “It’s not even necessarily conscious neglect. People have only a limited amount of time, so it’s inevitable they focus on areas that are measured and rewarded: it’s an economy of attention as much as anything else.”

In 2013, Dixon-Woods and colleagues published a study, funded by the Wellcome Trust, evaluating the use of surgical checklists introduced in hospitals to reduce complications and deaths during surgery. The checklists have become the most widely used patient safety intervention in the world and are recommended by the World Health Organization. Yet, the evidence shows that checklists may have little impact, and her research found that in some situations – particularly in low-income countries – they might even make things worse.

“The checklists sometimes introduced new risks. Nurses would use the lists as a box-ticking exercise rather than as a true reflection of events – they would tick the box to say the patient had had

their antibiotics when there were no antibiotics in the hospital, for example.” They also reinforced the hierarchies – nurses had to try to get surgeons to do certain tasks, but the surgeons used it as an opportunity to display their power and refuse.


Problems are compounded by a lack of standardisation. Dixon-Woods and her team spend time in hospitals to try to understand which systems are in place and how they are used. Not only does she find differences in approaches between hospitals, but also between units and even between shifts. “Standardisation and harmonisation are two of the most urgent issues we have to tackle. Imagine if you have to learn each new system wherever you go or even whenever a new senior doctor is on the ward. This introduces massive risk.”

Even when an institution manages to make genuine improvements in patient safety, too often these interventions cannot be replicated elsewhere or scaled up, leading to the curse of “worked once”, as she describes it.

One place that has managed to break this pattern is Northern Ireland, which has overcome the problem of poor labelling of lines such as intravenous lines and urinary catheters. A sick patient may have several different lines attached to them; these were not labelled in any consistent way – if at all – so a nurse might use the wrong line or leave a line in place too

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 **Words**
Craig Brierley

SALINE

in

numbers

DEXTROSE

long, risking infection. Over 18 months, the health service in Northern Ireland came up with a solution. Soon, whether you are in a hospital, a nursing home or a hospice, every line will be labelled the same way.

“I’m interested in how they managed to achieve that and what we can learn that can be used in the next place that wants to standardise their lines.”

Dixon-Woods compares the issue of patient safety to that of climate change, in the sense that it is a “problem of many hands”, with many actors, each making a contribution towards the outcome, and where it is difficult to identify who has responsibility for solving the problem. “Many patient safety issues arise at the level of the system as a whole, but policies treat patient safety as an issue for each individual organisation.”

Nowhere is this more apparent than the issue of ‘alarm fatigue’. Each bed in an intensive care unit typically generates 160 alarms per day, caused by machinery that is not integrated. “You have to assemble all the kit around an intensive care bed manually,” she explains. “It

doesn’t come built as one like an aircraft cockpit. This is not a problem a hospital can solve alone. It needs to be solved at the sector level.”

Dixon-Woods has turned to Professor John Clarkson in Cambridge’s Engineering Design Centre to help. Clarkson has been interested in patient safety for over a decade; in 2004, his team published a report for the Chief Medical Officer entitled ‘Design for patient safety – a system-wide design-led approach to tackling patient safety in the NHS’.

“Fundamentally, my work is about asking how can we make it better and what could possibly go wrong,” explains Clarkson. It is not, he says, just about technology, but about the system and the people within the system. When he trains healthcare professionals, he avoids using words like ‘risk’, which mean different things in medicine and engineering, and instead asks questions to get them thinking about the system.

“We need to look through the eyes of the healthcare providers to see the challenges and to understand where tools and techniques we use in engineering

may be of value. I have no doubt that if you were to put a hundred engineers into Addenbrooke’s [Hospital], you could help transform its care.”

There is a difficulty, he concedes: “There’s no formal language of design in healthcare. Do we understand what the need is? Do we understand what the requirements are? Can we think of a range of concepts we might use and then design a solution and test it before we put it in place? We seldom see this in healthcare, and that’s partly driven by culture and lack of training, but partly by lack of time.”

Dixon-Woods agrees that healthcare can learn much from how engineers approach problems. “Medical science tends to prioritise trials and particular types of evidence, whereas engineering does rapid tests. Randomised controlled trials do have a vital role, but on their own they’re not the whole solution. There has to be a way of getting our two sides talking.”

Only then, she says, will we be able to prevent further tragedies such as the death of Mary McClinton.

Things
Rescuing
Sebastiano's
*Adoration of the
Shepherds*



Painted in the 16th century, severely damaged and badly repaired in the 18th century, Sebastiano's masterpiece has been brought back to life after a decade of research and restoration by Cambridge's Hamilton Kerr Institute.

Whoever was charged by the Duc de Orléans with detaching the *Adoration of the Shepherds* from its wooden support and transferring it onto canvas must have had a moment of deep shock.

As a result of the treatment in the 18th century, half the Virgin's face disappeared, only a hint of the beauty of her ultramarine cloak remained, and large sections of the foreground were missing. The attempt to patch it up by repainting made its appearance even worse.

"It was a ghost of the painting it had once been," says Rupert Featherstone, Director of the Fitzwilliam Museum's Hamilton Kerr Institute (HKI). "We knew from comparison with another version in the Louvre in Paris that the repaint



Credit: The Fitzwilliam Museum



Image

Composite showing the stages of conservation (left to right): before treatment, after cleaning to reveal the 18th-century paint loss, after treatment

no longer reflected Sebastiano's quality or vision. It was too disfigured even to display."

Now, 300 years later, the masterpiece has been restored almost to how it would have looked when it was painted 500 years ago by Sebastiano del Piombo, a friend of Michelangelo.

It's one of the largest projects conservators at the HKI have undertaken in the Institute's 40-year history – it took ten years of painstaking research, scientific analysis and layer-by-layer

reconstruction. As part of the project, a microscopic particle of the Virgin's blue robe was analysed to understand Sebastiano's technique, revealing how he built up his glowing colours using complex layers.

The masterpiece is now on show at the Fitzwilliam for the first time in 60 years. "When you get close, you can see what's damaged and what's not – that's always going to be part of its history – you can't go back," adds Featherstone. "But it certainly does live again now."

HKI is a department of the Fitzwilliam Museum and undertakes conservation, educates painting conservators and contributes to scientific, technical and art historical research.

www.hki.fitzmuseum.cam.ac.uk



Film available:

<http://bit.ly/29Pj3HA>




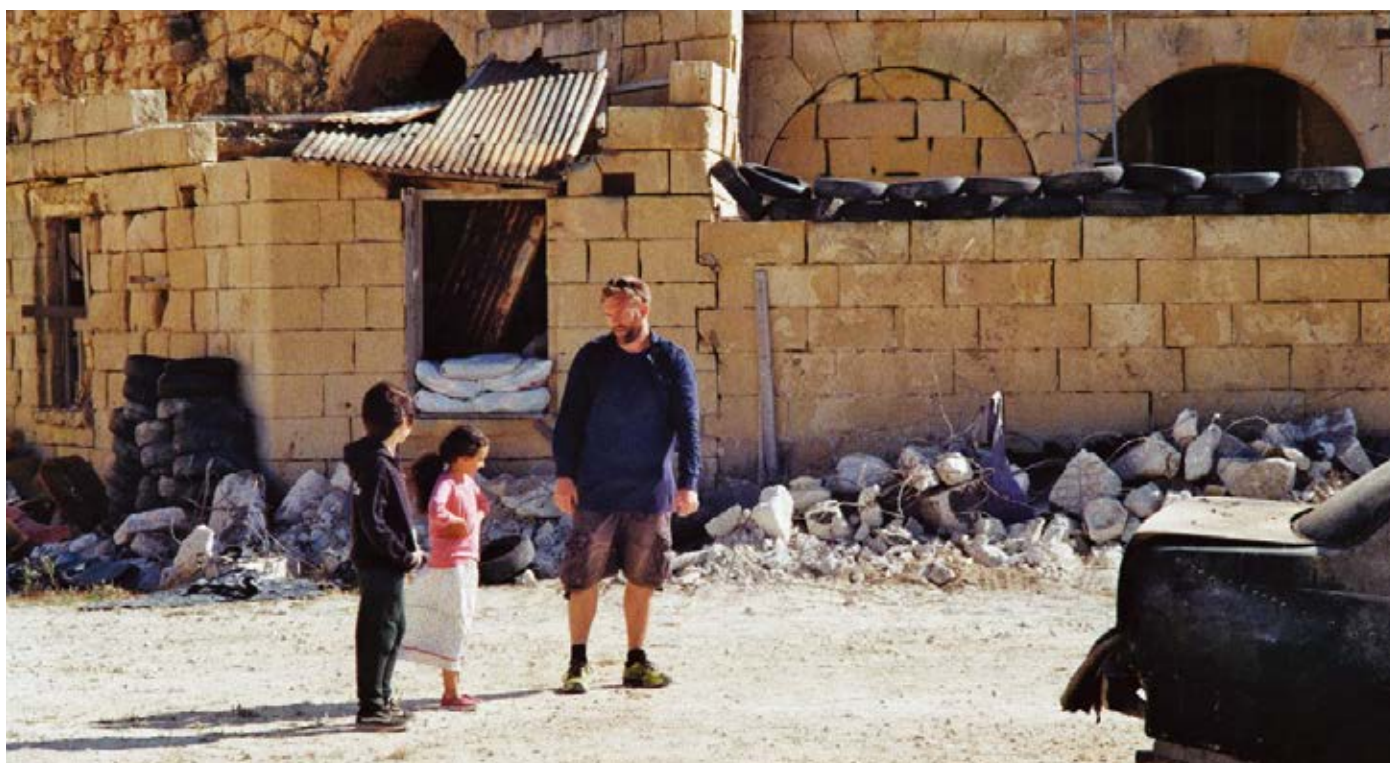
Words

Louise Walsh



THE ACCIDENTAL WITNESS

 Words
Louise Walsh



Credit: All images, Lars Klevberg

Smartphones and social media have made it easy for accidental witnesses “in the wrong place at the wrong time” to capture and share violations and crimes. But how can we tell what’s real and what’s fake?

The footage is shaky but the sounds of gunfire and “Allahu Akbar!” are unmistakable as the boy darts along the dusty road towards the burnt-out car. Puffs of smoke erupt around him. He falls to his knees. Has he been shot? It’s hard to tell, but a moment later he is up again, running for the shelter of the abandoned car. Yet it’s not over. He emerges holding the hand of an even younger girl dressed in pink. They run, hesitantly at first, then

desperately. The fear on their faces is palpable.

This is the ‘Syrian Hero Boy’. The footage appeared on 10 November 2014 on YouTube and it quickly went viral as millions of viewers watched, astonished at the boy’s bravery and shocked at a world that could place children in such danger.

But further shock was to come. The film was fake. It was filmed in Malta on the set of *Gladiator* by Norwegian film-maker Lars Klevberg.

Klevberg’s intention was to spur debate about children and war. By pretending the film was real, he believed that “people would share it and react with hope.”

It also drew attention to an increasingly common scenario: fake footage appearing on social media. “By publishing a clip that could appear to be authentic, we hoped to take advantage of a tool that’s often used in war; make a video that claims to be real,” he said.

In our digitally enabled world, a legion of ‘civilian witnesses’ has sprung up: individuals “in the wrong place at the wrong time” who capture an event and then publish the scrap of footage or the incriminating photograph on social media. But amid the fog of propaganda, hoaxes and digital manipulation, how can we tell what’s real and what’s fake?

Cambridge researchers are developing an automated tool, ‘the

Whistle', to help verify the authenticity of digital evidence.

Behind the Whistle is sociologist Dr Ella McPherson: "There is much excitement about the speed with which news can be captured by bystanders and disseminated on social media. In the field of human rights, it allows fact-finders for NGOs to get digital reports of violations from hard-to-reach places.

"In a country such as Syria, which is largely closed to outside observers, YouTube videos are a crucial source of information for people within and without its borders and contribute to an information environment incomparable to the past."

She mentions footage that appeared on social media in 2013 which Syrian opposition activists claimed as being evidence of a chemical weapons attack. An expert told the BBC that the footage was consistent with such an attack, although he cautioned that it was difficult to verify the film owing to the absence of metadata. Meanwhile the state-run news agency SANA said the claims were "baseless" and an attempt to distract United Nations weapons inspectors.

"This example shows the nature of the terrain we are now in: news is disseminated fast but verification is slow and often contested," says McPherson. "For human rights NGOs, credibility can be lost in a moment if the evidence they are using for advocacy or in courts is later found to be false. No matter how devastating the documented violations, they cannot act on them unless they can verify them first."

Many guidelines, handbooks and tools now exist to help the verification process. The 'witness' can be checked through their digital footprint – their organisational affiliations or a social media profile, for instance. The image itself can be corroborated through comparison with landmarks and weather data, or checked using tools that 'reverse image search' for previous publication.

However, all of this takes precious time, which may introduce bias – those who are easier to verify may be more likely to be heard than those who have few resources and a minimal digital footprint.

Through her research interests in how social media can be used by human rights NGOs for generating governmental accountability, McPherson became increasingly aware that fact-finders were struggling with the torrent of information. Time spent verifying was in danger of crippling this most powerful means of communication. For Syria, fact-finders have described the number of videos and photos as becoming a 'Big Data' problem.



The Whistle is a digital platform that speeds up the whole process. Being developed for mobile and web, the app eases the process of reporting for the witness, and prompts them to furnish the information needed by the fact-finder for verification – the "who, what, why, where, when" metadata. A 'dashboard' then aggregates the information and automates the cross-checking process of comparing the civilian witness report to the many databases that are used to corroborate reliability.

"We knew from fact-finders that civilian witnesses do not necessarily know what metadata is or that they should include it with their information – even something as simple as panning the horizon for landmarks or turning on geolocation features. The Whistle prompts them for the information at the time of upload, so the fact-finders don't have to piece it together later. It also provides individuals with information literacy – helps them understand what characteristics their information should ideally have in order to do things for them."

Initially funded by Cambridge's Economic and Social Research Council Impact Acceleration Account, the Whistle is now funded by the European Union as part of 'ChainReact', a multi-partner programme to support whistle-blowing in business. The team has grown to six members and plans to start using the demo of the Whistle to gain feedback from NGOs and civilian witnesses.

McPherson sees the Whistle as a tool for NGOs to use in the field, rather than as a global repository of information, since the latter would create security risks for the whistle-blowers: "Security challenges vary a lot according to context, and we don't see ourselves as ever being able to anticipate all the security challenges of a local context – it depends on the threat model. So we always want to partner with



Image

'Syrian Hero Boy' – or is it?

local organisations." Although civilians may never have heard of the Whistle, they are likely to be aware of the support of a local NGO, who would then direct them towards the tool as a means to submit information. "It would then be up to the NGO to decide what to do with the data," she explains.

McPherson is reflective when she considers the implications of a digital world that requires tools such as the Whistle to verify trustworthiness. "Reporting violations and fact-finding are communicative acts of 'bearing witness' – inherently human activities that involve solidarity, support and rapport. Technological innovations mean that we may increasingly have to replace this with reporting to a machine – how do you balance that opportunity with safeguards around traumatisation? This is something we don't yet have answers for."

Nevertheless, she and her team are aware that an increase in digital information on human rights violations only translates into evidence once it is validated. "Tools like the Whistle are desperately needed by fact-finders to reduce the labour time in sifting the wheat from the chaff, and to make it easier for them to evaluate more digital information for evidence.

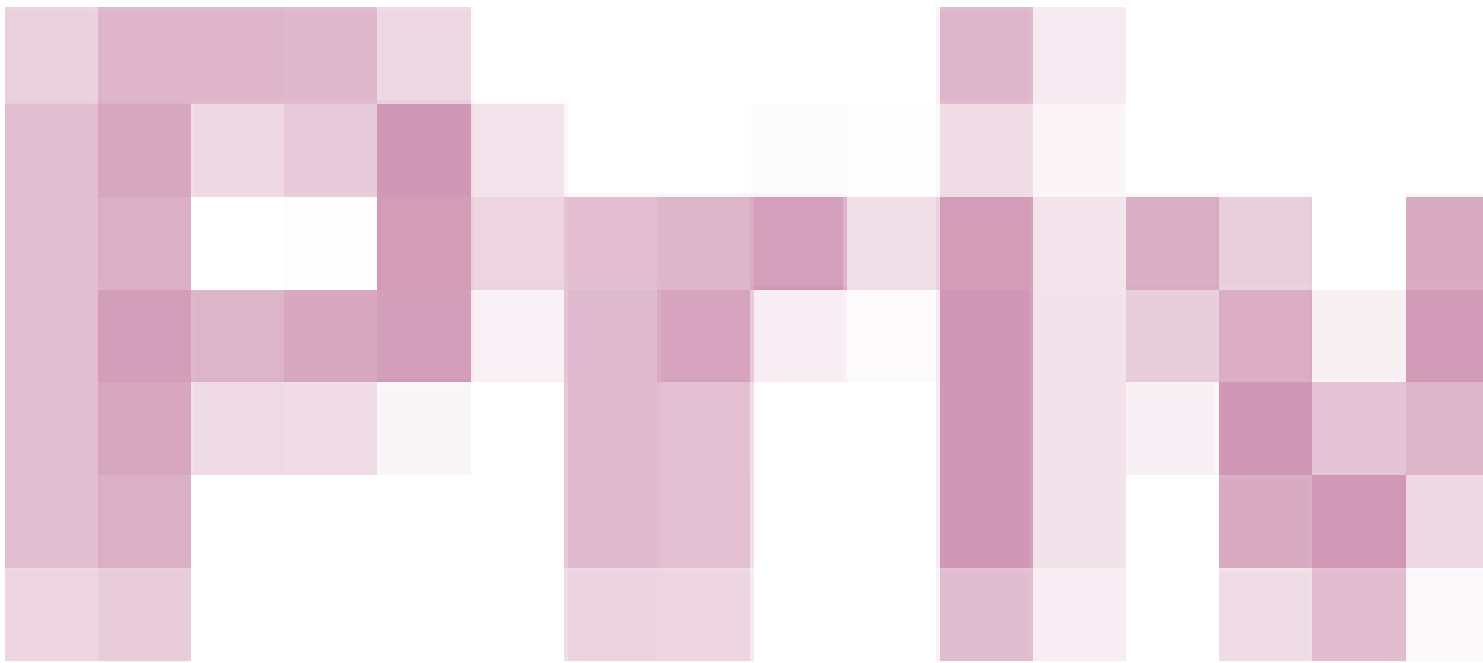
"We hope that our platform will increase the possibility that those who report violations receive attention, and particularly that those who most need access to human rights mechanisms are heard."

www.thewhistle.org



Dr Ella McPherson

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The digital identity crisis

Many of us see our privacy as a basic right. But in the digital world of app-addiction, geolocation tracking and social oversharing, some may have cause to wonder if that right is steadily and sometimes willingly being eroded away.

The freedom of expression and the need for privacy may be strange bedfellows today – but could full-blown estrangement beckon in a digital future that makes the leap from user-controlled content to unfiltered, online sharing of, well, everything?

A future where streaming your life online becomes the norm is not unthinkable, according to Dr David Erdos, whose research in the Faculty of Law explores the nature of data protection. “Take something like Snapchat Spectacles or Google Glass,” he says. “Such technology could very quickly take off, and all of a sudden it becomes ‘normal’ that everyone is recording everything, both audibly and visually, and the data is going everywhere and being used for all sorts of purposes – some individual, some organisational.”

This makes questions about what control we have over our digital footprint rather urgent.

“You can see that we need to get some grip on how the right to privacy can be enforced as technologies continue to develop that can pose serious threats to individuals’ sense of dignity, reputation, privacy and safety,” he adds.

One enforcement Erdos refers to is *Google Spain*, a ruling made in 2014 by the Court of Justice of the European Union (CJEU) that examined search engines’ responsibilities when sharing content about us on the world wide web.

The CJEU ruled that people across all of the 28 EU Member States have a ‘right to be forgotten’ online, giving them an ability to prohibit search engines indexing inadequate, irrelevant or other illegal information about them against

“For consumers to feel safe with emerging technology law makers may have to legislate for potential breaches now”

their name. This right to be forgotten is based on Europe’s data protection laws and applies to all online information about a living person.

Google responded by publishing a form you can submit to have such links to content (not the actual content) removed. I put it to the test – Google refuses on the basis that web links to my long-closed business are “justified” as they “may be of interest to potential or current consumers”.

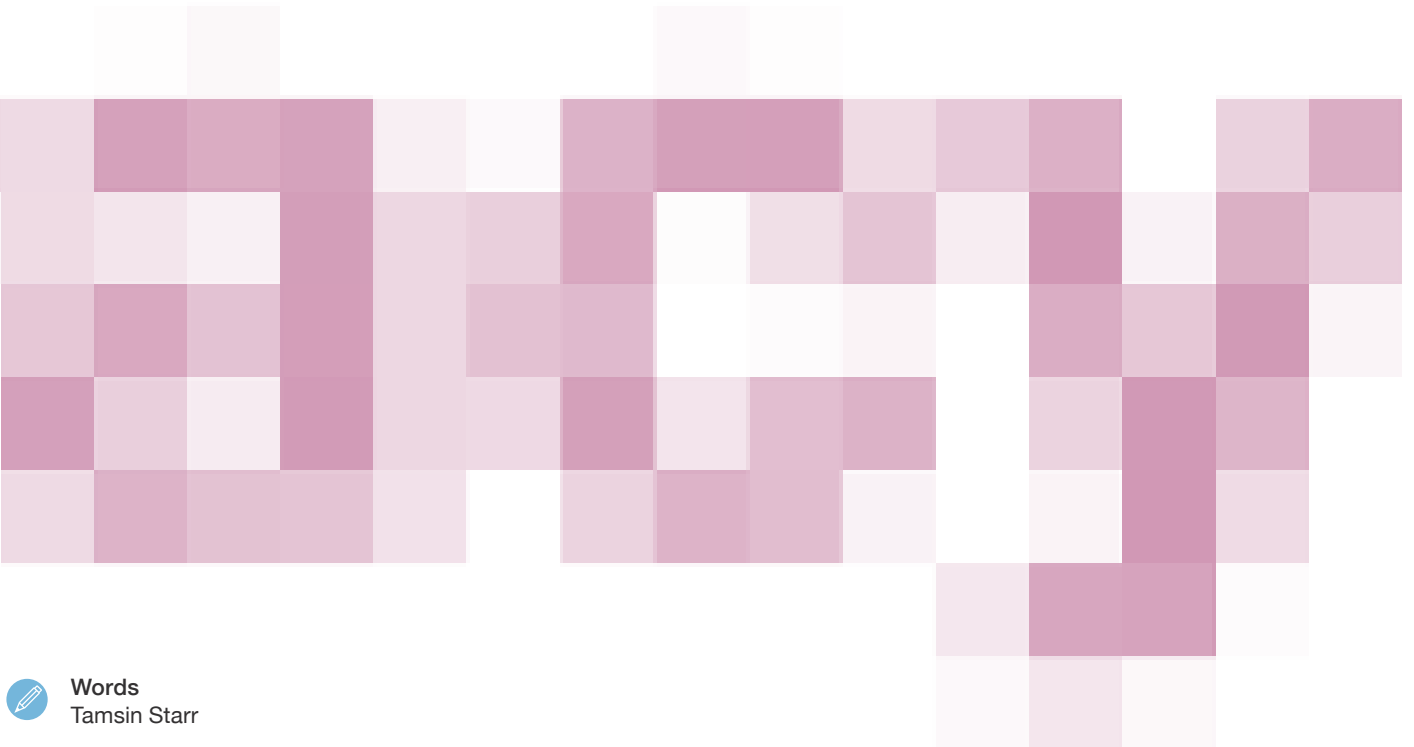
Erdos explains that data protection doesn’t always work as it was originally intended to. “On paper, the law is in favour of privacy and the protection of individuals – there are stringent rules around data export, data transparency and sensitive data, for example.

“But that law was in essence developed in the 1970s, when there were few computers. Now we have billions of computers, and the ease of connectivity of smartphones and the internet. Also, sharing online is not practically constrained by EU boundaries.

“That means the framework is profoundly challenged. There needs to be a more contextual legal approach, where the duties and possibly also the scope take into account risk as well as the other rights and interests that are engaged. That law must then be effectively enforced.”

In fact, the EU data protection law currently extends surprisingly far. “By default, the law regulates anyone who alone, or jointly with others, does anything with computerised information that mentions a living person,” Erdos explains. “That could include many individuals on social networking sites. If you’re disseminating information about a third party to an indeterminate number of people, you’re (in theory at least) responsible for adherence to this law.”

Tweeters, for instance, may have to respond to requests for data (Tweets) to be rectified for inaccuracy or even removed entirely, and field ‘subject



Words
Tamsin Starr

access requests' for full lists of everything they've Tweeted about someone. And under the new General Data Protection Regulation that comes into effect in 2018, the maximum penalty for an infringement is €20 million (or, in the case of companies, up to 4% of annual global turnover).

When it comes to search engines or social media, Erdos admits that a strict application of the law is "not very realistic". He adds: "There's a systemic problem in the gap between the law on the books and the law in reality, and the restrictions are not desperately enforced."

Erdos believes inconsistencies in the law could be exploited online by the ruthless. "The very danger of all-encompassing, stringent laws is that it seems as if responsible organisations and individuals who take them seriously are hamstrung while the irresponsible do whatever they want."

This also applies to 'derogations' – areas where the law instructs a balance must be struck between data protection and the rights to freedom of journalistic, literary and artistic expression.

"Member states have done radically different things in their formal law here – from nothing at all through to providing a blanket exception – neither of which was the intention of the EU scheme."

As the new law in 2018 will empower regulators to hand out fines of up to hundreds of millions of euros to large multinational companies, Erdos is passionate about the urgency of Europe

getting a coordinated and clear approach on how its citizens can exercise their data protection rights.

"We are giving these regulators quite enormous powers to enforce these rules and yet do we have a good understanding of what we want the outcome to be and what we're expecting individuals and organisations to do?" Erdos ponders.

"To me, this means that the enforcement will become more and more important. Data protection is not just a technical phrase – people really do need protection. The substance of the law needs to be hauled into something that's more reasonable. That protection needs to be made real."

Erdos' research also explores the nature of data protection and academic freedom, and he successfully argued for academic expression to be added to the list of free speech derogations in the 2018 legislation. "I have come across the most egregious examples of research guidance stipulating alleged data protection requirements, including claims that published research can't include any identifiable personal data at all," says Erdos.

"In a survey of EU data protection authorities, I asked whether a journalist's undercover investigation into extremist political beliefs and tactics and an academic's undercover research into widespread claims of police racism could be legal under data protection. Not one regulator said the activity of the journalist would in principle be illegal, but almost

half said the academic's activity would be unlawful.

"Academics aim to write something of public importance, and make it rigorous. The old law was seen to prioritise even tittle-tattle in a newspaper over academic research; one hopes this will largely be removed by the new law."

For many, the greatest concern remains the potential threats to their privacy. In order for consumers to feel safe with emerging technology, law makers may have to legislate for potential breaches now, rather than react after the damage is done.

"We don't want to respond in a panic of registering or documenting everything, but the alternative of collapse into an 'anything goes' situation is equally dangerous.

"Apps like Snapchat show many people value being able to upload certain pictures and information that soon disappear. We don't want people forgetting what they're sharing today, and then worrying far too late how third parties are using that information."

Would Erdos himself ever use Snapchat Spectacles or Google Glass (he does own a smartphone)? He laughs. "Let's face it, email, the internet, Google search... people ended up having to use them. So, never say never!"

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COULD CRYPTOCURRENCY...

Many of the world's poorest poor don't have access to a bank account and yet depend on being able to transfer money across borders. Could digital currency help, ask researchers at the Cambridge Centre for Alternative Finance.

'Cryptocurrency' is a form of finance that exists only online. Unlike national currencies like the British pound, it isn't forged as coins or printed as notes and no central authority governs it.

Most often it's associated with an eclectic mix of individuals: gamers, hackers and the tech-savvy; anti-authority libertarians who believe in a global currency; gamblers happy to speculate on 'digital gold'; shady dealers, money launderers, users of adult content services and the dark web; forward-thinking members of the financial sector.

But it has also been looked at as one possible solution to help a very different demographic – the world's poorest poor, the so-called bottom billion. Many in this demographic lack bank accounts, have difficulty in proving they own their own land or business, and frequently depend on sending or receiving money across borders to poorer relatives.

In fact only one in five adults living on less than \$2 per day has a bank account, and nearly 80% of poor adults, or two billion people, are excluded from the formal financial system. Meanwhile, the World Bank estimates that 75% of the

\$581.6 billion global remittances in 2015 were sent to developing countries.

But how can cryptocurrencies help? Since its launch in 2009, bitcoin, the most well known of digital currencies, has had a chequered history. Issues with market volatility, security and regulation, together with its association with online black markets like the now defunct Silk Road, have created suspicion among citizens and policymakers alike.

And yet, a recent headline in *Wired* stated: "Thought bitcoin was dead? 2016 is the year it goes big"; the reason, they explained, is it can "provide a much cheaper and simpler way of moving money from place to place, particularly when you're a consumer or business moving it across international borders or a retailer accepting payments from online buyers."

Dr Garrick Hileman, who researches the impact of cryptocurrency on world finance at the Cambridge Centre for Alternative Finance, adds: "And it's not just transfer fees. Conventional financial systems can suffer from slow transfer times, inconvenient hours for completion of transfers, limited access to transfers,

and the failure of approximately 2% of all international transfers to be successfully completed. These all negatively impact remittances."

He and colleagues have been looking at which markets and countries are the most likely to adopt cryptocurrencies based on 40 different factors, ranging from degree of technology penetration to cross-border transactions fees to history of financial crises and inflation. The results indicate that Sub-Saharan Africa, Latin America and former-Soviet Union countries have the greatest potential for adopting cryptocurrency.

"Cryptocurrency is an immature technology and is not without flaws. However, as with any new technology, it's the applications that have ignited interest – it's raised important questions about how cross-border payments can be improved and, wider still, whether the very special type of ledger system that underpins cryptocurrency can be used for any number of other areas."

At the heart of bitcoin is the 'blockchain', a database that records all transactions chronologically through

"More than \$430 billion was sent in remittances to developing countries in 2015... The costs of these transactions hit the poorest the hardest"

```
return None
if 'error' in resp_obj and resp_obj['error'] != None:
    return resp_obj['error']
if 'result' not in resp_obj:
    print "JSON-RPC: " + resp_obj['error']
return None
return resp_obj['result']
iblockcount(self):
    return self.rpc('getblockcount')
workk(self, data=None):
    return self.rpc('getwork', data)
x):
    x & 0xffffffffL
reverse(x):
    uint32(((x << 24) | ((x >> 8) & 0x000000ff)) | ((x >> 8) & 0x000000ff))
reverse(in_buf):
    ords = []
    range(0, len(in_buf), 4):
        word = struct.unpack('@i', in_buf[i:i+4])[0]
        out_words.append(struct.pack('@i', bytereverse(word)))
    ', '.join(out_words)
reverse(in_buf):
    ords = []
    range(0, len(in_buf), 4):
        out_words.append(in_buf[i:i+4])
    ords.reverse()
    ', '.join(out_words)
r:
    self.__init__(self, id)
    self.id = id
    self.max_nonce = MAX_NONCE
rk(self, datastr, targetstr):
    # decode work data hex string to binary
    static_data = datastr.decode('hex')
    static_data = bufreverse(static_data)
    # the first 76b of 80b do not change
    blk_hdr = static_data[76]
    # decode 256-bit target value
    targetbin = targetstr.decode('hex')
    targetbin = targetbin[:-1] # byte-swap and dword-swap
    targetbin_str = targetbin.encode('hex')
    target = long(targetbin_str, 16)
    # pre-hash first 76b of block header
    static_hash = hashlib.sha256(
        static_hash.update(blk_hdr)
    for nonce in xrange(self.max_nonce):
        # encode 32-bit nonce value
        nonce_bin = struct.pack("<L", nonce)
        # hash final 4b, the nonce value
        hash1_o = static_hash.copy()
        hash1_o.update(nonce_bin)
        hash1 = hash1_o.digest()
```

obit('params') - []

```

else:
    obj['params'] = params
self.conn.request('POST', '/', json.dumps(obj),
    { 'Authorization': self.authhdr,
      'Content-type': 'application/json' })

resp = self.conn.getresponse()
if resp is None:
    print "JSON-RPC: no response"
    return None

body = resp.read()
resp_obj = json.loads(body)
if resp_obj is None:
    print "JSON-RPC: cannot JSON-decode body"
    return None
if 'error' in resp_obj and resp_obj['error'] != None:
    return resp_obj['error']
if 'result' not in resp_obj:
    print "JSON-RPC: no result in object"
    return None

return resp_obj['result']

def getblockcount(self):
    return self.rpc('getblockcount')

def getwork(self, data=None):
    return self.rpc('getwork', data)

def uint32(x):
    return x & 0xffffffffL

def bytereverse(x):
    return uint32(((x) << 24) | (((x) << 8) & 0x00ff0000) |
        (((x) >> 8) & 0x0000ff00) | ((x) >> 24))

def bufreverse(in_buf):
    out_words = []
    for i in range(0, len(in_buf), 4):
        word = struct.unpack('@I', in_buf[i:i+4])[0]
        out_words.append(struct.pack('@I', bytereverse(word)))
    return ''.join(out_words)

def wordreverse(in_buf):
    out_words = []
    for i in range(0, len(in_buf), 4):
        out_words.append(in_buf[i:i+4])
    out_words.reverse()
    return ''.join(out_words)

```



Dr Garrick Hileman
Cambridge Centre
for Alternative Finance
Cambridge Judge Business School
g.hileman@jbs.cam.ac.uk

```

class Miner:
    def __init__(self, id):
        self.id = id
        self.max_nonce = MAX_NONCE

    def work(self, datastr, targetstr):
        # decode work data hex string to binary
        static_data = datastr.decode('hex')
        static_data = bufreverse(static_data)
        # the first 76b of 80b do not change
        blk_hdr = static_data[:76]
        # decode 256-bit target value
        targetbin = targetstr.decode('hex')
        targetbin = targetbin[:-1] # byte 31 is 0 and dword-swap
        targetbin_str = targetbin.encode('hex')
        target = long(targetbin_str, 16)
        # pre-hash first 76b of block header
        static_hash = hashlib.sha256(
            static_hash.update(blk_hdr)
            for nonce in xrange(self.max_nonce):

```

a unique series of numbers arranged in 'blocks', which are then 'chained' to the next block cryptographically, so as to be both secure and accurate. This linking of information makes them like a financial ledger, but unlike centralised banking systems, the blockchain is a database that can be stored and shared worldwide by anyone with a computing device and internet connection – hence its description as a distributed ledger technology (DLT).

Part of the promise of cryptocurrency lies in the absence of a gatekeeper in its set-up, as Hileman explains: "Transactions occur person to person, or machine to machine, without the need for third party institutions – and that means lower or no transaction fees."

"For the seven years bitcoin has been operating, there hasn't been a single minute of downtime, unlike traditional IT networks employed by banks and other institutions. This resiliency has people's attention," says Hileman. "And currency is not the only thing that DLT can be used for. It can be used to exchange anything that has value – stocks, houses, airline miles, notarisations, votes."

This year, the Government Office of Science published a report in which Chief Scientific Advisor Professor Sir Mark Walport described distributed ledgers as "powerful, disruptive innovations that could transform the delivery of public and private services" and "provide new ways of assuring ownership and provenance for goods and intellectual property."

One of the recommendations was for the UK research community to ensure that distributed ledgers are scalable and secure. The report added that the Alan Turing Institute – a joint venture by the universities of Cambridge, Edinburgh, Oxford, University College London, Warwick and the Engineering and Physical Sciences Research Council – would help to support these endeavours.

"We probably have yet to see the full extent of future uses of distributed ledgers," adds Hileman. "However, our research has shown that cross-border transactions are viewed as one of the most promising applications of distributed ledger tech, due to the high transaction fees, technical interoperability issues, complex and conflicting regulatory frameworks, and legacy

equipment and processes associated with existing systems."

To realise this potential, he says, there are problems that need to be solved for customers in developing countries: "people know they are being stung by transaction fees but are still reluctant to switch for a wide range of reasons."

"It could even be that banks themselves adopt the technology, and yet still enable its distributed peer-to-peer set-up, offering it as a separate service to their traditional monetary services. In other words, customers may never know their transactions are happening on a blockchain," he adds.

Bitcoin has had a volatile exchange rate and Hileman concedes that it's too early to know whether regulatory measures will help shield customers from this and other risks, or reduce money laundering and financial crimes committed with bitcoin. In the meantime, the Centre's work on benchmarking cryptocurrency and blockchain activity will provide useful data for policymakers and other stakeholders keeping an eye on the technology.

"More than \$430 billion was sent in remittances to developing countries in 2015, mostly to India, but also China, Mexico and Nigeria," says Hileman. "The costs of these transactions – which can average as high as 12% in Sub-Saharan Africa – hit the poor the hardest. Technological advances like cryptocurrency and distributed ledgers may offer a solution.

"It would be surprising to me if in 30 years from now we aren't looking back and saying yes this was a watershed moment for financial inclusion, and that cryptocurrency and distributed ledgers played a significant role in opening up access to the financial system in developing economies."



Words
Louise Walsh

...HELP THE 'BOTTOM BILLION'?

The (conspiracy) theory of everything

Elvis is alive, the Moon landings were faked and members of the British Royal Family are shapeshifting lizards.

Not only that: 9/11 was an inside job, governments are deliberately concealing evidence of alien contact, and we are all being controlled by a sinister, shadowy cartel of political, financial and media elites who together form a New World Order.

As a global population we are awash with conspiracy theories. They have permeated every major event, across every level of society; from the French Revolution to the War on Terror. In doing so, they have attracted devotees in their millions; from lone survivalists to presidential nominees such as Donald Trump – who claimed Ted Cruz’s father had links to Lee Harvey Oswald and, by inference, to the murder of President John F. Kennedy.

But what effects do conspiracy theories really have on the public as we go about our day-to-day lives? Are they merely harmless flights of fancy propagated by those existing on the margins of society, or is their reach altogether more sinister? Do runaway conspiracy theories influence politicians, decision-makers and, by extension, the public at large? And what effect has the advent of the internet and mass, instant communication across social media platforms had on the spread of conspiracy theories around the world?

Since 2013, a team of Cambridge researchers and visiting fellows has been examining the theories and beliefs about conspiracies that have become such an enduring feature of modern society. *Conspiracy and Democracy: History, Political Theory and Internet Research* is a five-year, interdisciplinary research project based at CRASSH (Centre for Research in the Arts, Social Sciences and Humanities) and funded by the Leverhulme Trust.

The project brings together historians, political theorists, philosophers, anthropologists and internet engineers as it seeks to understand what additional factors must be at work for conspiracy theories to enjoy such prevalence in the 21st century.

Professor John Naughton who, along with Professor Sir Richard Evans and Professor David Runciman, is one of the three project directors, explains: “Studying conspiracy theories provides opportunities for understanding how people make sense of the world and how societies function, as well as calling into question our basic trust in democratic societies.

“Our project examines how conspiracies and conspiracy theorising have changed over the centuries and what, if any, is the relationship between them? Have conspiracy theories appeared at particular moments in history, and why?

“We wanted to counter the standard academic narrative that conspiracy theories are beneath contempt. We were anxious to undertake a natural history of theorising, to study it seriously from a 21st-century context.”

Despite the onset of the digital age, Naughton and his colleagues do not believe that the internet has necessarily increased the influence of conspiracy theories on society as a whole. Indeed, research suggests that although the spread of conspiracy theories is often instantaneous in the digital world, so too is the evidence to debunk them.

Likewise, the team’s work so far suggests that online, as in life, we largely surround ourselves with people of like-minded views and opinions, effectively partitioning ourselves from a diversity of world views.

“The internet doesn’t make conspiracy theories more persuasive, it actually seems to compartmentalise people,” adds Naughton. “We more efficiently come into contact with those who hold



“The internet doesn’t make conspiracy theories more persuasive, it actually seems to compartmentalise people”

similar views, but we also mostly end up working in echo chambers. That’s the way the internet works at the moment – especially in social media: you end up somewhere where everyone has the same views.

“The effect is a more concentrated grouping of opinions, and that’s the same for everything else, not just conspiracy theories. I follow 800 people on Twitter. Not one of them celebrated Brexit. I was in an echo chamber.”

Dr Alfred Moore, a postdoctoral researcher on the project, adds: “The question of the effect of the internet is a really interesting one. How far can the emergence and success of today’s populist movements be explained in terms of technological changes and especially social media? My first instinct is to say a little bit, but probably not much.

“Technologies have made it less costly to communicate, which means it’s easier to find, talk to and organise supporters without the financial and organisational resources of political parties. Both Corbyn and Trump make heavy use of social media as an alternative to a supposedly biased ‘mainstream’ media and the influence of their parties. It also demonstrates how the internet can promote polarisation by making it easy for people to find information they agree with and to filter out everything else.”

For those reasons, Naughton and Moore believe that some of the most famous conspiracy theories – such as David Icke’s theories about shapeshifting reptiles or feverish claims about the death of Princess Diana – are not particularly dangerous as they don’t appear to generate tangible actions or outcomes in the real world. In fact, the *Conspiracy and Democracy* team question whether these silos effectively disable the capacity for many conspiracy theories to take a firm hold in the public consciousness or threaten our democratic processes.

“A lot remains to be done in researching the history, structure and dynamics of conspiracy theories, their relationships with real conspiracies, and the changes they have undergone through time,” adds Evans. “You might think that conspiracy theories cause anxiety and depression among ordinary people, and undermine trust in our political institutions and the people who run them, but there are plenty of other reasons for this lack of trust apart from conspiracy theories.

“The debate goes on, but it’s not a case of conspiracy theories threatening democracies. By themselves, such theories may reinforce political suspicion and prejudice but they’re not the origin of it. On the whole, I think it’s fair to conclude that the scale of the threat is pretty limited.

“Some varieties, like antisemitism, can cause huge damage, but others are pretty harmless. Does it really matter that some people think the moon landings were faked? In the end, few people believe we are ruled by alien lizards.”

www.conspiracyanddemocracy.org

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PLENTY OF PHISH IN THE SEA

TRICKING PEOPLE INTO HANDING OVER SENSITIVE INFORMATION SUCH AS CREDIT CARD DETAILS - KNOWN AS 'PHISHING' - IS ONE OF THE WAYS CRIMINALS SCAM PEOPLE ONLINE.



Words
Sarah Collins

We've all received the emails, hundreds, maybe thousands of them. Warnings that our bank account will be closed tomorrow, and we've only got to click a link and send credit card information to stop it from happening. Promises of untold riches, and it will only cost a tiny fee to access them. Stories of people in desperate circumstances, who only need some kind soul to go to the nearest Western Union and send a money transfer to save them.

Most of us think we're smarter than these scams. Most of us think that we could probably con the con artist if we tried. But we would be wrong.

Across the world, cybercrime is booming. When the UK government included cybercrime in the national crime statistics for the first time in 2015, it doubled the crime rate overnight. Millions of people worldwide are victimised by online scams, whether it's blocking access to a website, stealing personal or credit card information, or attempting to extort money by remotely holding the contents of a personal computer hostage.

"Since 2005, the police have largely ignored cybercrime," says Professor Ross Anderson of Cambridge's Computer Laboratory. "Reported crime fell by as much as a half in some categories. Yet, now that online and electronic fraud are included, the number of reported crimes has more than doubled. Crime was not falling; it was just moving online."

In 2015, computer scientists, criminologists and legal academics joined forces to form the Cambridge Cybercrime Centre, with funding from the Engineering and Physical Sciences

Research Council. Their aim is to help governments, businesses and ordinary users to construct better defences.

To understand how the criminals operate, researchers use machine learning and other techniques to recognise bad websites, understand what kinds of brands tend to be attacked and how often, determine how many criminals are behind an attack by looking at the pattern of the creation of fake sites and how effective the various defence systems are at getting them taken down.

One way in which studying cybercrime differs from many other areas of research is that the datasets are difficult to come by. Most belong to private companies, and researchers need to work hard to negotiate access. This is generally done through nondisclosure agreements, even if the data is out of date. And once researchers complete their work, they cannot make the data public, since it would reduce the competitive advantage of corporate players, and it may also make it possible for criminals to reverse engineer what was detected (and what wasn't) and stay one step ahead of law enforcement.

One of the goals of the Cambridge Cybercrime Centre is to make it easier for cybercrime researchers from around the world to get access to data and share their results with colleagues.

To open up cybercrime research to colleagues across the globe, the team will leverage their existing relationships to collect and store cybercrime datasets, and then any bona fide researcher can sign a licence with the Centre and get to work without all the complexity of identifying and approaching the data holders themselves.

"Right now, getting access to data in this area is incredibly complicated," says Dr Richard Clayton of Cambridge's Computer Laboratory, who is also Director of the Centre. "But we think

the framework we've set up will create a step change in the amount of work in cybercrime that uses real data. More people will be able to do research, and by allowing others to work on the same datasets more people will be able to do reproducible research and compare techniques, which is done extremely rarely at the moment."

One of the team helping to make this work is Dr Julia Powles, a legal researcher cross-appointed between the Computer Laboratory and Faculty of Law. "There are several hurdles to data sharing," says Powles. "Part of my job is to identify which ones are legitimate - for example, when there are genuine data protection and privacy concerns, or risks to commercial interests - and to work out when we are just dealing with paper tigers. We are striving to be as clear, principled and creative as possible in ratcheting up research in this essential field."

Better research will make for better defences for governments, businesses and ordinary users. Today, there are a lot more tools to help users defend themselves against cybercrime - browsers are getting better at recognising bad URLs, for example - but, at the same time, criminals are becoming ever more effective, and more and more people are getting caught in their traps.

"You don't actually have to be as clever as people once thought in order to fool a user," says Clayton when explaining how fake bank websites are used to 'phish' for user credentials. "It used to be that cybercriminals would register a new domain name, like Barclays with two Ls, for instance. But they generally don't do

3915 8236
3727 6677
3634 9433
6163 0118
6212 6905
0126 4369
4380 3037
3017 4744
0311

"YOU DON'T ACTUALLY HAVE TO BE AS CLEVER AS PEOPLE ONCE THOUGHT IN ORDER TO FOOL A USER"

that for phishing attacks anymore, as end users aren't looking at the address bar, they're looking at whether the page looks right, whether the logos look right."

The Centre is also looking at issues around what motivates someone to commit cybercrime, and what makes them stop.

According to Dr Alice Hutchings, a criminologist specialising in cybercrime, cybercriminals tend to fall into two main categories. The first category is the opportunistic offender, who may be motivated by a major strain in their lives, such as financial pressures or problems with gambling or addiction, and who uses cybercrime as a way to meet their goals. The second type of offender typically comes from a more stable background, and is gradually exposed to techniques for committing cybercrime through associations with others.

Both groups will usually keep offending as long as cybercrime meets their particular needs, whether it's financial gratification, or supporting a drug habit, or giving them recognition within their community. What often makes offenders stop is the point at which the costs of continuing outweigh the benefits: for instance, when it takes a toll on their employment, other outside interests or personal relationships.

"Most offenders never get caught, so there's no reason to think that they won't go back to cybercrime," says Hutchings. "They can always start again if circumstances in their lives change.

"There is so much cybercrime happening out there. You can educate potential victims, but there will always be other potential victims, and new ways that criminals can come up with to social engineer somebody's details, for example. Proactive prevention against potential offenders is a good place to start."

Criminologist Professor Lawrence Sherman believes the collaboration between security engineering and criminology is long overdue, both at Cambridge and globally: "Cybercrime

is the crime of this century, a challenge we are just beginning to understand and challenge with science."

"We're extremely grateful to the people giving us this data, who are doing it because they think academic research will make a difference," says Clayton.

"Our key contribution is realising that there was a roadblock in terms of being able to distribute the data. It's not that other people couldn't get the data before, but it was very time-consuming, so only a limited number of people were doing research in this area – we want to change that."

"Our Cybercrime Centre will not only provide detailed technical information about what's going on, so that firms can construct better defences," says Anderson. "It will also provide strategic information, as a basis for making better policy."

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COMPUTER SAYS YES (BUT IS IT RIGHT?)

Computers that learn for themselves are with us now. As they become more common in 'high-stakes' applications like robotic surgery, terrorism detection and driverless cars, researchers ask what can be done to make sure we can trust them.

There would always be a first death in a driverless car and it happened in May 2016. Joshua Brown had engaged the autopilot system in his Tesla when a tractor-trailer drove across the road in front of him. It seems that neither he nor the sensors in the autopilot noticed the white-sided truck against a brightly lit sky, with tragic results.

Of course many people die in car crashes every day – in the USA there is one fatality every 94 million miles, and according to Tesla this was the first known fatality in over 130 million miles of driving with activated autopilot. In fact, given that most road fatalities are the result of human error, it has been said that autonomous cars should make travelling safer.

Even so, the tragedy raised a pertinent question: how much do we understand – and trust – the computers in an autonomous vehicle? Or, in fact, in any machine that has been taught to carry out an activity that a human would do?

We are now in the era of machine learning. Machines can be trained to recognise certain patterns in their environment and to respond appropriately. It happens every time your digital camera detects a face and throws a box around it to focus, or the personal assistant on your smartphone answers a question, or the adverts match your interests when you search online.

Machine learning is a way to program computers to learn from experience and improve their performance in a way that resembles how humans and animals learn tasks. As machine learning techniques become more common in everything from finance to healthcare, the issue of trust is becoming increasingly important, says Zoubin Ghahramani, Professor of Information Engineering in the Department of Engineering.



Images

Machines like SegNet can now be taught to identify components of a road scene in real time

Sky

Building

Pole

Bike

Road

Pavement

Tree

Sign Symbol

Fence

Vehicle

Pedestrian

Road Marking

Faced with a life or death decision, would a driverless car decide to hit pedestrians, or avoid them and risk the lives of its occupants? Providing a medical diagnosis, could a machine be wildly inaccurate because it has based its opinion on a too-small sample size? In making financial transactions, should a computer explain how robust is its assessment of the volatility of the stock markets?

“Machines can now achieve near-human abilities at many cognitive tasks even if confronted with a situation they have never seen before, or an incomplete set of data,” says Ghahramani. “But what is going on inside the ‘black box’? If the processes by which decisions were being made were more transparent, then trust would be less of an issue.”

His team builds the algorithms that lie at the heart of these technologies (the “invisible bit” as he refers to it). Trust and transparency are important themes in their work: “We really view the whole mathematics of machine learning as sitting inside a framework of understanding uncertainty. Before you see data – whether you are a baby learning a language or a scientist analysing some data – you start with a lot of uncertainty and then as you have more and more data you have more and more certainty.

“When machines make decisions, we want them to be clear on what stage they have reached in this process. And when they are unsure, we want them to tell us.”

One method is to build in an internal self-evaluation or calibration stage so that the machine can test its own certainty, and report back.

Two years ago, Ghahramani’s group launched the Automatic Statistician with funding from Google. The tool helps scientists analyse datasets for statistically significant patterns and, crucially, it also provides a report to explain how sure it is about its predictions.

“The difficulty with machine learning systems is you don’t really know what’s going on inside – and the answers they provide are not contextualised, like a human would do. The Automatic Statistician explains what it’s doing, in a human-understandable form.”

Where transparency becomes especially relevant is in applications like medical diagnoses, where understanding the provenance of how a decision is made is necessary to trust it.

Dr Adrian Weller, who works with Ghahramani, highlights the difficulty: “A particular issue with new artificial intelligence (AI) systems that learn or evolve is that their processes do not clearly map to rational decision-making

pathways that are easy for humans to understand.” His research aims both at making these pathways more transparent, sometimes through visualisation, and at looking at what happens when systems are used in real-world scenarios that extend beyond their training environments – an increasingly common occurrence.

“We would like AI systems to monitor their situation dynamically, detect whether there has been a change in their environment and – if they can no longer work reliably – then provide an alert and perhaps shift to a safety mode.” A driverless car, for instance, might decide that a foggy night in heavy traffic requires a human driver to take control.

Weller’s theme of trust and transparency forms just one of the projects at the newly launched £10 million Leverhulme Centre for the Future of Intelligence. Ghahramani, who is Deputy Director of the Centre, explains: “It’s important to understand how developing technologies can help rather than replace humans. Over the coming years, philosophers, social scientists, cognitive scientists and computer scientists will help guide the future of the technology and study its implications – both the concerns and the benefits to society.”

He describes the excitement felt across the machine learning field: “It’s exploding in importance. It used to be an area of research that was very academic – but in the past five years people have realised these methods are incredibly useful across a wide range of societally important areas.

“We are awash with data, we have increasing computing power and we will see more and more applications that make predictions in real time. And as we see an escalation in what machines can do, they will challenge our notions of intelligence and make it all the more important that we have the means to trust what they tell us.”

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Smartphone-based system that teaches machines to see

Machine learning techniques have been used to teach a smartphone or camera to recognise their surroundings.

SegNet is a technology that can identify the components of a road scene in real time and could be used for the development of driverless cars and autonomous robotics.

It can take an image of a street scene it hasn’t seen before and classify it in real time, sorting objects into 12 different categories – including roads, street signs, pedestrians, buildings and cyclists.

It was ‘taught by example’ by a group of Cambridge undergraduate students, who manually labelled every pixel in each of 5,000 images. Once the labelling was

“the more effective and accurate we can make these technologies, the closer we are to driverless cars”

finished, the researchers then took two days to ‘train’ the system before it was put into action.

“It’s remarkably good at recognising things in an image, because it’s had so much practice,” says Alex Kendall, a PhD student in the Department of Engineering who designed the segmentation system with Professor Roberto Cipolla and Vijay Badrinarayanan. “However, there are a million ‘knobs’ that we can turn to fine-tune the system so that it keeps getting better.”

SegNet labels more than 90% of pixels correctly. Previous systems using expensive laser or radar-based sensors have not been able to reach this level of accuracy while operating in real time.

“In the short term, we’re more likely to see this sort of system on a domestic robot – such as a robotic vacuum cleaner,” explains Cipolla. “It will take time before drivers can fully trust an autonomous car, but the more effective and accurate we can make these technologies, the closer we are to the widespread adoption of driverless cars and other types of autonomous robotics.”

Demo available:
<http://bit.ly/1RubiG5>



MAKING THE HIDDEN VISIBLE

Despite being founded on ideals of freedom and openness, censorship on the internet is rampant, with more than 60 countries engaging in some form of state-sponsored censorship. A research project at the University of Cambridge is aiming to uncover the scale of this censorship, and to understand how it affects users and publishers of information.

For all the controversy it caused, *Fitna* is not a great film. The 17-minute short, by the Dutch far-right politician Geert Wilders, was a way for him to express his opinion that Islam is an inherently violent religion. Understandably, the rest of the world did not see things the same way. In advance of its release in 2008, the film received widespread condemnation, especially within the Muslim community.

When a trailer for *Fitna* was released on YouTube, authorities in Pakistan demanded that it be removed from the site. YouTube offered to block the video in Pakistan, but would not agree to remove it entirely. When YouTube relayed this decision back to the Pakistan Telecommunications Authority (PTA), the decision was made to block YouTube.

Although Pakistan has been intermittently blocking content since 2006, a more persistent blocking policy was implemented in 2011, when porn content was censored in response to a media report that highlighted Pakistan

as the top country in terms of searches for porn. Then, in 2012, YouTube was blocked for three years when a video, deemed blasphemous, appeared on the website. Only in January this year was the ban lifted, when Google, which owns YouTube, launched a Pakistan-specific version, and introduced a process by which governments can request the blocking of access to offending material.

All of this raises the thorny issue of censorship. Those censoring might raise objections to material on the basis of offensiveness or incitement to violence (more than a dozen people died in Pakistan following widespread protests over the video uploaded to YouTube in 2012). But when users aren't able to access a particular site, they often don't know whether it's because the site is down, or if some force is preventing them from accessing it. How can users know what is being censored and why?

"The goal of a censor is to disrupt the flow of information," says Sheharbano Khattak, a PhD student in Cambridge's

[REDACTED]

[REDACTED]

Computer Laboratory, who studies internet censorship and its effects. “internet censorship threatens free and open access to information. There’s no code of conduct when it comes to censorship: those doing the censoring – usually governments – aren’t in the habit of revealing what they’re blocking access to.” The goal of her research is to make the hidden visible.

[REDACTED]

She explains that we haven’t got a clear understanding of the consequences of censorship: how it affects different stakeholders, the steps those stakeholders take in response to censorship, how effective an act of censorship is, and what kind of collateral damage it causes.

Because censorship operates in an inherently adversarial environment, gathering relevant datasets is difficult. Much of the key information, such as what was censored and how, is missing. In her research, Khattak has developed methodologies that enable her to monitor censorship by characterising what normal data looks like and flagging anomalies within the data that are indicative of censorship.

She designs experiments to measure various aspects of censorship, to detect censorship in actively and passively collected data, and to measure how censorship affects various players.

[REDACTED]

The primary reasons for government-mandated censorship are political, religious or cultural. A censor might take a range of steps to stop the publication of information, to prevent access to that information by disrupting the link between the user and the publisher, or to directly prevent users from accessing that information. But the key point is to stop that information from being disseminated.

[REDACTED]

Internet censorship takes two main forms: user-side and publisher-side. In user-side censorship, the censor disrupts the link between the user and the publisher. The interruption can be made at various points in the process between a user typing an address into their browser and being served a site on their screen. Users may see a variety of

different error messages, depending on what the censor wants them to know.

“The thing is, even in countries like Saudi Arabia, where the government tells people that certain content is censored, how can we be sure of everything they’re stopping their citizens from being able to access?” asks Khattak. “When a government has the power to block access to large parts of the internet, how can we be sure that they’re not blocking more than they’re letting on?”

What Khattak does is characterise the demand for blocked content and try to work out where it goes. In the case of the blocking of YouTube in 2012 in Pakistan, a lot of the demand went to rival video sites like Daily Motion. But in the case of pornographic material, which is also heavily censored in Pakistan, the government censors didn’t have a comprehensive list of sites that were blacklisted, so plenty of pornographic content slipped through the censors’ nets.

[REDACTED]

Despite any government’s best efforts, there will always be individuals and publishers who can get around censors, and access or publish blocked content through the use of censorship resistance systems. A desirable property, of any censorship resistance system is to ensure that users are not traceable, but usually users have to combine them with anonymity services such as Tor.

“It’s like an arms race, because the technology which is used to retrieve and disseminate information is constantly evolving,” says Khattak. “We now have social media sites which have loads of user-generated content, so it’s very difficult for a censor to retain control of this information because there’s so much of it. And because this content is hosted by sites like Google or Twitter that integrate a plethora of services, wholesale blocking of these websites is not an option most censors might be willing to consider.”

In addition to traditional censorship, Khattak also highlights a new kind of censorship – publisher-side censorship – where websites refuse to offer services to a certain class of users. Specifically, she looks at the differential treatments of Tor users by some parts of the web. The issue with services like Tor is that visitors to a website are anonymised, so the owner of the website doesn’t know where their visitors are coming from. There is increasing use of publisher-side censorship from site owners who want to block users of Tor or other anonymising systems.

“Censorship is not a new thing,” says Khattak. “Those in power have used censorship to suppress speech or

writings deemed objectionable for as long as human discourse has existed. However, censorship over the internet can potentially achieve unprecedented scale, while possibly remaining discrete so that users are not even aware that they are being subjected to censored information.”

Professor Jon Crowcroft, who Khattak works with, agrees: “It’s often said that, online, we live in an echo chamber, where we hear only things we agree with. This is a side of the filter bubble that has its flaws, but is our own choosing. The darker side is when someone else gets to determine what we see, despite our interests. This is why internet censorship is so concerning.”

“While the cat and mouse game between the censors and their opponents will probably always exist,” says Khattak. “I hope that studies such as mine will illuminate and bring more transparency to this opaque and complex subject, and inform policy around the legality and ethics of such practices.”

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“censorship over the internet can potentially achieve unprecedented scale”

When is a book not a book?

The ebook has made continued inroads into the publishing world but the printed book has defied predictions of its death. Research by Professor John Thompson focuses on the challenges facing the publishing industry as it embraces the opportunities afforded by the digital revolution.

In his book *Merchants of Culture*, Professor John Thompson recounts a conversation with the head of media asset development at a large US publishing house. The topic is the impact and future of digital publishing.

His interviewee, anonymised as Steve, has come from the music industry, where he has seen the digital revolution disrupting traditional models. Tasked with shaping the future of a leading publishing house, Steve is struggling to convince his colleagues to think differently about books and to embrace the digital revolution. He says: "A book is not a book. Books are categories. Books are types. Books are different styles of things."

Thompson is interested in the changing structure of the book publishing industry as the digital revolution transforms the processes and products of the publishing business in ways that are both visible and invisible to the consumer. The outcome of his present research will be a book that is due to be published in 2017, in which he will describe the volatile, contested environment responsible for delivering texts to millions of readers in an ever-increasing range of formats.

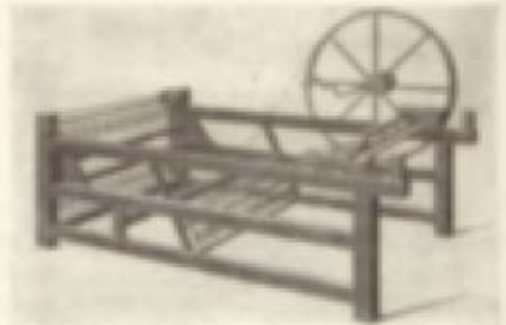
At the heart of Thompson's conversation with Steve is a discussion about the thousands of files that are the publisher's most valuable assets – literally its lifeblood. Having digitised its backlist of top sellers, the company holds an archive of 40,000 titles, a figure that is constantly expanding. How these files are archived, managed and protected so they can be delivered to readers in the most suitable formats is vital to the continuing health of the publishing house. The archiving process has been far from simple, requiring the retrieval of files from printers and opening up heated debates about copyright. And the sheer flexibility offered

by digitisation introduces new challenges.

Steve explains that, while paper books are relatively simple to deliver ("you're delivering tree"), the delivery of digital goods is much more complicated. "The thing that people always hoped was the digital world would get simpler and it's actually a whole lot more complicated because your end result isn't the same. The end result is a database, the end result is a PDF, it's an image-based PDF, it's an XML file, it's an ad-based, Google-search-engine toolset – we're going to have many more properties digitally than we possibly could have physically. We have seven physical properties [for our books]... and online we have hundreds of formats and types and styles."

Few of these challenges were foreseen in the feverish hype of the 1990s that the days of the book were numbered. Paper

A GREAT INVENTOR



The spinning-jenny of Hargreaves.

the two men making the first spinning-frame, which one of them, named Richard Arkwright, had invented.

Up till that time cotton-spinning had been done by hand; the work was slow and the output small. Then one day a man called Hargreaves invented the spinning-jenny, which made the work go much quicker; and almost at the same time Richard Arkwright invented a much better machine called the spinning-frame.

These two inventions of more than a century and a half ago helped cotton-spinning to become one of the great industries of England, giving work to hundreds of

texts were clunky and old fashioned; digital versions were smart and sleek.

Many new start-ups were launched, seeking to create new forms of the book that exploited the multimedia potential of new technologies. But, despite the hype, sales of ebooks remained sluggish and many start-ups failed.

Ebooks finally began to take off in autumn 2007 when Amazon launched the Kindle, which allowed readers to download books and other content directly onto their devices. Sales of ebooks soared: in 2010 one large publisher saw its ebook sales rise from 12% to 26% of its revenue over Christmas week.

Industry pundits had predicted that ebook sales would be driven by business books and by businessmen, but it didn't work out like that – far from it. "The real areas of growth were commercial fiction

A GREAT INVENTOR

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James Watt, inventor.

Watt invented the "flywheel," which greatly altered the conditions of working, during the years before Hargreaves and Arkwright started their spinning. Like Arkwright's invention, that of Watt was very important; and here Watt is seen standing beside the machine which he has invented; his wife is seated in the foreground.

and genre fiction – categories like sci-fi, mysteries and crime, romances and thrillers,” says Thompson. “This was a revolution being driven largely by women reading commercial and genre fiction on their Kindles.”

Much has happened since Thompson’s interview with Steve took place in New York, but Thompson has maintained the many publishing contacts who give him first-hand access to the latest industry developments. He is now mid-way through an ambitious project to revisit publishers on both sides of the Atlantic in order to discover “what is happening while it’s happening” in an industry that suddenly finds itself at the centre of a major disruptive transformation.

From 2008 to 2012, ebooks grew from less than 1% of total US trade sales to over 20%; this was phenomenal growth

in an industry where overall sales remain largely static. Many people working in the industry worried that publishing would go the same way as the music industry. But then something dramatic happened: the growth slowed and levelled off at around 22%, forming a classic S-curve. “When you dig beneath the surface, however, you see that the simple S-curve is misleading because it conceals a great deal of variation between different kinds of books. In the case of romance fiction, the growth begins to level off at around 60%, whereas many categories of nonfiction plateau at between 15% and 25%,” says Thompson.

“By looking at what is happening inside the industry, we can see that some of the fears about the future of the publishing industry were misplaced. Many observers thought that developments in book publishing would follow those in the

music sector but that hasn’t happened. There isn’t a single model that describes the impact of the digital revolution on the creative industries – there are multiple models, and the impact varies from industry to industry and sector to sector.”

While no one can be sure how the pattern of ebook sales will develop in the future, the digital revolution has already had an enormous impact on the way the publishing industry works. In what Thompson calls “the hidden revolution”, the processes involved in taking a text through the supply chain, from author to reader, have been thoroughly transformed. Print-on-demand means that a book never goes out of print, and with the advent of self-publishing anyone can publish.

“This means that the numbers of books being published, and the number available, have risen dramatically. But how do readers get to know about what’s out there? New platforms have emerged to supplement the traditional model of the newspaper review,” he says.

The rise of Amazon has played a major part in these developments. “Amazon is part and parcel of the digital revolution. The company started in a garage as a classic internet start-up and its ascendancy took everyone by surprise,” says Thompson. Publishers have benefited from Amazon’s growth but they now find themselves locked in a power struggle with the retail giant, who controls around 67% of all ebook sales in the USA and over 40% of all new book unit sales, print and digital.

Relations have become increasingly fraught, he says. Publishers have tried to retain control of pricing by selling ebooks on an ‘agency model’, which allows them to fix the price, while Amazon has used its growing market share to try to extract better terms of trade from publishers. The struggle ebbs and flows and at times becomes vicious, as it did during the 2014 standoff between Amazon and Hachette (one of the Big Five US trade publishers).

Thompson is determined to get to grips with the fine detail of what goes on behind the scenes in the day-to-day publishing processes. “Fifteen years ago I knew little about trade publishing, but we can only understand how this industry works and how it’s changing by immersing ourselves in it and looking carefully at what happens when new technologies collide with the old world of the book.”

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Words
Alex Buxton

Extreme sleepover: Welcome to the alien world of data



Credit: Alex Taylor

**2.5 billion
gigabytes of data
being produced
every 24 hours**

Alex Taylor provides a sensory snapshot of his fieldwork in high-security subterranean data centres exploring fears of technological failure in our data-dependent society.

I'm standing 100 feet underground in the middle of a fluorescent-white room. In the middle, stand four rows of server cabinets. I'm following Matej, a data centre technician, as he carries out some diagnostic tests on the facility's IT equipment. To get here we had to go through several security checks, including a high-tech biometric fingerprint scanner and a good old-fashioned, low-tech massive door.

The IT equipment is distributed over multiple floors, each going deeper and deeper below ground into the seemingly infinite depths of the data centre. There is a constant hum of electrical voltage down here; it's the kind of vibratory, carcinogenic sound you would normally associate with pylon power lines and it makes you think you're probably being exposed to some sort of brain-frying electric field. I ask Matej about this and he tells me, "it's probably ok."

When Matej is finished in this room we head downstairs. Our footsteps sound hollow and empty on the elevated metallic walkways. A complex highway

of thick, encased cables runs above our heads, along with large pipes circulating water around the data centre for cooling purposes. As we descend the galvanised steel stairway, it's like boarding a spaceship that's buried deep beneath the Earth's surface.

The room we enter is almost completely white. The only other colour down here comes from thousands of server lights blinking rapidly like fireflies behind the electro-zinc-coated 'Zintec' doors of the server cabinets. We have entered the realm of data, an alien world of tiny, undulating lights that seem almost alive. These iridescent lights flash as data travels to and from the facility through fibre-optic cables at speeds of around 670 million miles per hour, close to the speed of light.

This building has been designed with the sole purpose of providing optimal living conditions for data growth and survival. An ambient room temperature of around 20–21°C and a humidity level of 45–55% must constantly be maintained. In this sterile, dustless world of brushed metal surfaces, data live and thrive like precious crystals. Server cabinets become stalagmite formations sparkling frenetically with the digital activity of millions of people doing their daily things in that exact moment all around the world.

Virtually all our daily activity – both online and offline – entails the production of data, with 2.5 billion gigabytes of data being produced every 24 hours. This is stored in the 8.6 million data centres that have spread across the globe. Yet, few of us realise that we are using data centres.

Data centres now underpin an incredible range of activities and utilities across government, business and society, and we rely on them for even the most mundane activities: our electricity and water accounts are located in data centres, a single Google search can involve up to five data centres, information from the train tickets we swipe at turnstiles are routed through data centres. These places process billions of transactions every day and extreme efforts are made to ensure that they do not fail.

One such effort is the increasingly common practice of storing data underground in 'disaster-proof' facilities – in the same way that seed and gene banks store biological material that is essential for human survival. What does this say about the importance of data to our society? This is what I am down here researching. Working with data centres, IT security specialists, cloud computing companies and organisations that are

trying to raise awareness about the vulnerabilities of digital infrastructures, I am exploring the cultural hopes, fears and imaginations of data as it pertains to what many are calling our 'digital future'.

My fieldwork has led me to focus on the fears of disaster and technological failure that motivate data centre practices and discourses, from routine Disaster Recovery plans to storing hard drives in Faraday cages to protect them against electromagnetic threats. The current mass exodus into 'the cloud' is raising important questions about our increasing societal dependence upon digital technology and the resilience, sustainability and security of the digital infrastructure that supports our online and offline lives. Fears of a 'digital' disaster occurring in the future are also reflected in cultural artefacts such as TV shows about global blackouts and books about electromagnetic pulse events. In an age of constant and near compulsory connection to computers, tablets and smartphones, how would we survive if they all suddenly and simultaneously ceased to function?

Data centres are being configured as infrastructures critical not only for supporting our data-based society, but also for backing up and even potentially re-booting 'digital civilisation', if it should collapse. My fieldwork is not all doom and disaster, though. In fact, sometimes it's quite spectacular. Right now I am standing in a heavily air-conditioned aisle flanked on each side by large, monolithic cabinets of server racks.

"This is one of my favourite things," Matej says, as he flicks the overhead lights off and plunges us into an abyssal darkness punctured only by server lights, flashing like phytoplankton all around us. For a moment, we watch these arrhythmic lights flickering, beautiful and important, some vanishingly small.

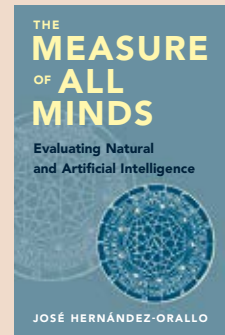
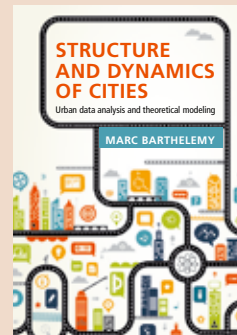
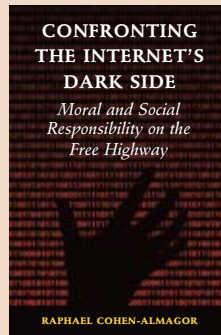
But these little lights have immense significance. Something huge is happening down here. It feels like you are witnessing something incomprehensibly vast, something so massively distributed, complex and connected to all of us that it's hard to even know what you are seeing take place. It's like looking at the stars.

Alex is a PhD student with the Division of Social Anthropology. His research is supervised by Dr Christos Lynteris, and is funded by the Cambridge Home and EU Scholarship Scheme.

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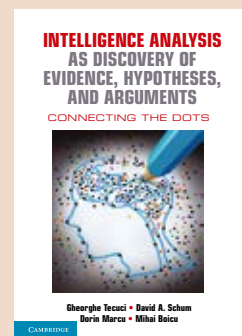
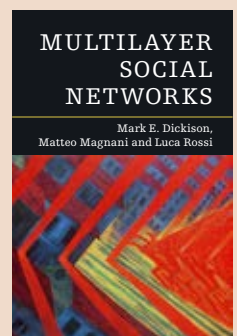
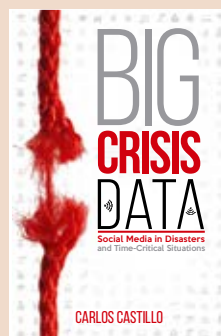


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