UK Research and Innovation (UKRI) – Supplementary written evidence (FRS0105)

Letter from Rebecca Endean, Strategy Director, UK Research and Innovation (UKRI), following an evidence session on 4 December 2018.

Forensic science

Thank you for inviting UK Research and Innovation to give evidence on forensic science on 4 December. During my evidence I informed the committee that over a ten-year period the research councils and Innovate UK had funded 143 relevant grants with a value of £52 million. I said I would write to the committee outlining what these projects are.

We have now been able to add more projects to that list that are recorded as having a potential benefit to forensics. This brings the number of projects to 150 with a value of £56 million. It remains true that there will be many other funded grants that we have not identified which also have potential benefit to forensics. UKRI’s councils have contributed to these projects as follows:

<table>
<thead>
<tr>
<th>Council</th>
<th>Value</th>
<th>No. of projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arts and Humanities Research Council</td>
<td>£3,375,033</td>
<td>8</td>
</tr>
<tr>
<td>Biotechnology and Biological Sciences Research Council</td>
<td>£5,305,336</td>
<td>19</td>
</tr>
<tr>
<td>Engineering and Physical Sciences Research Council</td>
<td>£28,594,248</td>
<td>37</td>
</tr>
<tr>
<td>Economic and Social Research Council</td>
<td>£12,609,129</td>
<td>39</td>
</tr>
<tr>
<td>Innovate UK</td>
<td>£4,649,057</td>
<td>38</td>
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<tr>
<td>Medical Research Council</td>
<td>£94,169</td>
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</tr>
<tr>
<td>Natural Environment Research Council</td>
<td>£459,308</td>
<td>3</td>
</tr>
<tr>
<td>Science and Technology Facilities Council</td>
<td>£1,006,283</td>
<td>5</td>
</tr>
</tbody>
</table>

I also said we would look at the outputs of the work we funded, including whether the research was published in peer reviewed journals. Researchers should provide us with a summary of the impact of their project which is then publicly available on the Gateway to Research website¹. These demonstrate a range of outcomes to the work outlined above, including peer reviewed papers, commercialisation of products and further research.

Appendix: List of grants

25 January 2019

¹ Gateway to Research is available at: https://gtr.ukri.org
Appendix – List of grants for Forensic Projects

Translation and Asylum Claims: Matters of law, language and silence

**Funder:** AHRC

**Project Reference:** AH/J005576/1

**Start:** 6/18/2012  **End:** 12/17/2013

**Abstract**

Decisions about refugee status are based on an assessment of whether an individual's narrative establishes that they have a "well-founded fear of persecution." While the difficulties associated with reaching reliable decisions in asylum cases are well documented, matters of language, translation and interpretation have in recent years raised particular concerns. Asylum applicants speak a wide range of different languages and come from a variety of cultural backgrounds and this means that their narrative is usually communicated to the decision maker through an interpreter. While "just" decision making would appear to call for precise interpretation of an applicant's narrative, the asylum determination process involves many situations where uncertainty about language exists, and where linguistic precision is unachievable.

In the UK asylum decision-making process, the UK Border Agency (UKBA) have used tools such as forensic linguistic analysis to determine nationality, and they also provide a written (or less frequently an audio) record of the asylum interview which forms the basis of their decision. At the appeal stage, appellants may adduce evidence from language professionals which questions the validity of linguistic analysis as a means of establishing nationality, or which challenges the interpretation provided at interview, or the content of the written interview record. The assessment and ranking of such evidence by judges can be hard to predict. Tensions also arise from the fact that while the centrality of the asylum narrative, combined with time pressures, mean that the applicant has minimal control over the scheduling of their interview with the determining authority, it is also well known that shame, lack of trust and the effects of trauma can make applicants hesitant to disclose experiences such as rape and torture. At the same time, failure to give a full account at the appropriate time can mean that the applicant loses their chance to give a full account, and thus to the refusal of a potentially valid asylum claim. The recounting of any narrative of persecution is bound to cause distress to the applicant, regardless of when it is given, but there is some evidence that the right to silence in the criminal process can enable the individual to give more reliable testimony, insofar as it gives them some control over when to speak (Dennis, 2010).

The use of language evidence, the potential for miscommunication which arises from interpretation and translation, and the impact of those issues at different stages of the asylum process thus present significant challenges for interpreters, translators and other language professionals involved in all stages of the asylum process, as well as for legal representatives and decision-makers, and the literature indicates that language and communication issues are concerns in any country with an asylum process. These practices and protocols rely on a view of language and translation as stable and capable of accurate meaning. In linguistic theory such views of language have been subject to deconstruction and are inherently problematic. Bringing together linguistic theory and legal practice in the context of asylum interviews and decision-making enables a fresh perspective on the difficulties involved in translation.
This project will bring academics and practitioners together in a series of three interrelated workshops in order to map pressing concerns in this area, examine the experience gained in a number of jurisdictions and start to explore ways in which language issues can be addressed, for example through the identification of common areas of concern, and the adoption and implementation of guidelines.

**Funding amount:** £36,041.19
'Fragmented Heritage' From the Kilometre to the Nanometre: Automated 3D Technology to Revolutionize Landscape, Site, and Artefact Analyses

Funder: AHRC

Project Reference: AH/L00688X/1

Start: 10/1/2013   End: 1/31/2019

Abstract
This project aims to revolutionize landscape, site, and artefact analyses by bringing new transformative digital recording methods and computed analysis to fields that are traditionally labour intensive. The scale of the resultant technology and capability will generate a paradigm shift in the way that spatial and functional data are studied in heritage sciences.

Conventional 'refit analysis' requires an expert to study thousands of individual pieces from prehistoric archaeological sites and try to find pieces that fit together, eventually reconstructing objects, such as stone tool cores. Due to the size and complexity of these sites, it makes them important for understanding past human behaviour, however this also makes them the least understood by archaeologists and the public. The amount of effort this requires increases exponentially with assemblage size and generally entire sites can not be studied. Automation of this process will transform working practices bringing rapid and total surveys in reach of many more projects. The implications of such capability are widespread. At a site and landscape level the addition of digital recording, automated capture and processing to augment landscape survey will enhance the ability to archaeologically record and resolve complex surface scatters in landscapes, this will also allow sites that have previously been too remote and inhospitable to be surveyed.

Work can then be done faster and allow areas for targeted survey to be identified easily and safely. At a macro scale, the method will resolve complex associations facilitating interpretation through visualisations and aiding physical reconstruction. The generation of high fidelity digital output will enable closer working of researchers across traditional boundaries and will benefit the specialist and nonspecialist alike. These combined transformative scalable approaches to refit analysis will have broad application to all disciplines working with objects across the arts and humanities - ranging from three-dimensional artists to heritage professionals such as conservators/restorers and even impacting on other disciplines such as forensic science.

Outputs of the project will be highly visual and are tailored to maximise impact with the involvement of a visual artist as an integral part of the project team. The project teams involved in the various work packages involve high profile international co-investigators.

Funding amount: £1,854,691.85
Listening Across Disciplines

Funder: AHRC

Project Reference: AH/N006305/1

Start: 5/2/2016   End: 5/1/2017

Abstract

Listening Across Disciplines responds to the Highlight notice for Cross-Council Enquiry with a strong commitment to cross-disciplinary research by bringing together artists, musicians, scientists, technologists and social scientists as well as scholars and practitioners from the humanities, stakeholders from press, education and health, as well as Early Career Researchers and the general public, to conduct a cross disciplinary research of listening as a methodology of enquiry and communication. It will provide a network in which culture and science can meet to debate and initiate innovative modes of knowledge production that bring value to the arts and humanities as well as to technology and science research, and a general public.

The network brings together significant researchers and consolidates existing initiatives and methods of listening to advance its understanding and application across a wide range of disciplines. It is developed in the context of a recent emphasis on sound in the arts and humanities. And although science too has recently embraced listening, it remains a largely qualitative method of investigation, considered as generally subjective and peripheral to more established data assessment and analysis methods. In response, this network expands the interdisciplinary focus of sound studies, from its origin in arts and humanities, into science and technology, to explore the potential of cross fertilisation between artistic research and practices of listening and its scientific or technological methods and applications.

The project will be realised through three network events, each lasting two days, and two online platforms, a website and a blog site.

While the website serves to document and archive, to produce additional material and to disseminate the research globally, and the blog site enables faster exchanges and plural authorship, the network events will provide application and substance to the online network and enable a real world exchange. These events will feature workshops and technical demonstrations of listening strategies, tools, methods and instruments, as well as presentations of approaches to analysis, evaluation, and communication. They provide an applied forum for knowledge sharing and enable a shared enquiry into the possibilities of listening as a progressive and functional research methodology.

The issues under investigation are:

The scholarly and public understanding of listening as a skill and methodology

The discipline specific applications of listening and how they can be shared

The analytical, data gathering and diagnostic function of listening compared across the disciplines

The legitimacy and evaluation of the heard for the arts and humanities and for science disciplines

The role of listening in the transfer of results and outcomes to other researchers, professionals and a general public.
In order to achieve focused discussions and guarantee relevant outcomes the events are organised in three themes:

Listening to the Environment focuses on ecological, geological, architectural and spatial concerns

Listening to Bodies and Material considers social and medical issues, anthropology and forensics

Listening to Language Culture and Artefacts deliberates on speech and language, technology, museology and curation.

Each event incorporates a public listening workshop that opens the selective forum to a more general audience and offers an immediate opportunity to experience listening as a thoughtful and directed methodology.

The principal and longer term aim of this network project is to establish a research hub that provides the infrastructure and shared terrain to develop and document, educate and disseminate information, guidelines and policies on listening as a methodology of investigation and communication that advances what research can be conducted and what information and outcomes can be obtained in the arts and the sciences.

**Funding amount:** £27,002.28
Language variation in electronic messaging: Stylistic parameters that make a 'linguistic fingerprint' problematic.

**Funder:** AHRC

**Project Reference:** AH/I024895/1

**Start:** 10/1/2011  **End:** 11/23/2013

**Abstract**

This project is an opportunity to undertake ground-breaking research in one of the newest and most exciting areas of linguistics, and the results will attract considerable, national and international attention; from both linguistics researchers as well as legal practitioners and the police. It involves a linguistic investigation into the types of variation that occur in electronic communications and will measure how the chosen forms vary according to a number of contextual factors. The combination of forensic and non-forensic corpus analyses will provide the necessary evidence to enhance the forensic science used in court, in particular, cases that require authorship attribution (i.e., the forensic linguist needs to determine if the suspect is or is not the author of a given legal text). These cases include: murder, (sexual) assault, malicious communications, terrorism and conspiracy (among others): in fact, any case where the authorship of key documents needs to be established. Authorship is established by isolating particular linguistic traits in those document(s) that can also be found in comparative documents where the authorship is known.

A number of researchers in this field argue for a writer's ideolect (or 'linguistic fingerprint') that will always make obvious the true author of a given text (cf., Coulthard 2003); thus enjoying the level of reliability associated with fingerprints. Despite this allure, however; it understates the extent to which a person's linguistic choices are the product of a concert of factors that need to be taken into account. Olsson (2009) has begun research into these factors and has so far shown that much more work is needed, to compare the same author across text types, and the same author in communication with different addresses (possibly contrasting gender and or status relationships) or with different talk objectives (e.g., favour vs. criticism). Olsson’s preliminary findings reveal that when more factors are taken into account, a more robust, reliable and individually identifying account of authorship can be established. This project will gather a substantial corpus of email and telephone SMS (short message service) text messages, in order to investigate which contextual features are most productive for forensic linguistics analysis. An improved set of strategies will improve police accountability; help secure convictions and offer a better protection to the innocent.

The data to be used in this investigation includes: (a) a new corpus of English language, SMS text data, to be collected from a cross-section of discourse contexts as provided by volunteer participants; and (b) a new corpus of email linguistic data. The College Ethics Research Committee approval will be sought before any research commences. In the case that Dr Olsson needs access to the data, he will be required to sign a confidentiality agreement prepared by Bangor University.  

2nd dimension of this research is to include a Welsh and German medium pilots. The student will follow Welsh classes to develop Welsh language skills in the first year of this project, and the data collection will commence in the second year. This part of the project will be supervised in part by Ms Prys (Welsh) and Prof Tully (German) whose expertise will prove invaluable for these pilots. The pilots are to demonstrate the easiness (or difficulty) of applying the attribution strategies identified in the main project, to other language data, which will enhance the international impact of this
In summary, this project is a linguistic study designed to evidence the extent to which sociological and contextual factors must be taken into account to substantiate the plausibility of a speakers' 'linguistic fingerprint'. With this ultimate target, this research is timely, significant and internationally relevant. The results will c

**Funding amount:** £54,250.0
Abstract
Impressions of seal matrices in disks of wax, deliberately preserved with their parent documents as part of the legal and administrative process of authentication, survive in great numbers in British archives. Since, by the later thirteenth century, seals came to be used by almost all levels of society, the imagery and wording on seals, along with sealing practices and techniques, offer great potential for historical research. In the last few years, and in particular as a consequence of the AHRC-funded Seals in Medieval Wales (SiMeW) and British Academy Seals in a Local Context (SiLC) projects, this potential is increasingly being realised. Importantly, the back of the wax on which seal impressions are found often retains the image of unique hand prints (finger, thumb or palm) but although sometimes commented upon these have, until now, been neglected as a source of information. They do, however, provide direct evidence of those involved in the act of sealing. But whose prints are they?

Imprint, which offers a genuine and mutually beneficial collaboration between History and forensic science, will use a range of methods for hand mark identification, including cutting-edge practice in digital imaging and the analysis of marks using both manual and Automated Fingerprint Identification System techniques. Images of c.1,200-1,500 medieval seals which are still associated with their parent documents will be taken to specifications which satisfy both the needs of historical research and forensic analysis. From an historical perspective, the results will enable an innovative investigation of the practice of sealing in a documentary context, and will allow the project team to consider what the identification of these prints can tell us about how sealing practices may have evolved concurrently with administrative and legal practices. More generally, the project will shed new light on social networks, rituals associated with exchange, and the bureaucracies and protocols of authentication and security in medieval England and Wales.

On the forensics side, the study will provide data which is pertinent to on-going areas of research in Identity Science, providing a significant quantity of material from a period long before existing banks of fingerprint data, and contribute to discussions about the uniqueness of fingerprints and their evidential validity. This research is timely in promoting links between the Humanities and Forensic science, as urged in the UK government Silverman Report on Research and Development in Forensic Science (2011) which notes the value of interdisciplinary research using forensic science, to create project Impact as well as scholarly results. It is also a natural progression from the recent work of SiMeW and SiLC, upon whose expertise we are drawing.

A pilot for the project, using seals from Hereford Cathedral Archive, has demonstrated that the methodology is sound: we recovered usable prints from 37% of the material surveyed, and traditional print recognition techniques revealed that particular individuals do recur.

Funding amount: £626,679.39
A multi-methodological approach to the instrumental phonetic and perceptual study of rhotic sounds in varieties of English.

Funder: AHRC

Project Reference: AH/J002151/1

Start: 10/1/2011   End: 2/28/2014

Abstract

Rhotics (‘r’-sounds) have intrigued phoneticians perhaps more than any other class of consonants due to their phonetic complexity, diversity of articulation and susceptibility to rapid and extensive changes over time. This research will focus on the phonetics and phonology of rhotic sounds using a range of phonetic instruments and experimental methods, each of which addresses a different aspect of these sounds. Some look at how they are made in speakers’ vocal tracts, some at their acoustic structures during transmission, and others at how they are perceived and processed by the brain. By combining methods that complement each other, this research hopes to paint a more complete picture of the different r-sounds in English and their similarities and differences than has been available until now. Rhotic sounds are an important group of sounds in the world’s languages for several reasons. They are important for phonetic and phonological theory because, while it is widely felt that they form a distinct class of sounds, it is far from clear what they all have in common, i.e. what defines the class of rhotic sounds. The class is generally held to include such phonetically different sounds as trilled ‘r’ produced with two or three beats of the tongue-tip against the upper gum, the French ‘r-grasseye’ produced with the back of the tongue, and the modern urban British English ‘w’-like sound associated in the media with celebrities such as Jonathan Ross. The class of rhotics is thus seen to cut across the established classifications of traditional phonetic theory which is based on how sounds are made rather than how they are heard. This research will try to ascertain the relationship between the production and perception of these sounds, and whether the defining feature of the class of rhotics might be in the way they are perceived rather than in the way they are produced. Rhotic sounds are important for developmental and clinical reasons because, no matter what language is being learned, children often find them the most difficult sounds to master in their acquisition of pronunciation systems and development of pronunciation skills. People with speech disorders often find that ‘r’ is one of the sounds most affected by their medical condition. The kinds of sounds that children and speakers with speech and/or hearing disorders produce in place of the ‘correct’ r-sound can provide insight into how r-sounds are represented in their speech production systems. The results of this research may prove useful for planning speech therapy intervention with populations affected by developmental and/or acquired speech and/or hearing disorders.

Rhotic sounds are important sociolinguistically because different social groups within the same language often have their own distinct form of r-sound which can function as a group identity-marker. For example, in French and German a back /r/ (articulated with uvular constriction) is considered socially prestigious, while a tapped or trilled /r/ is stigmatised. In English English, both uvular and trilled /r/ are non-standard and may elicit negative perceptions of the speaker. In Scottish English, by contrast, tapped/trilled /r/ is the socially acceptable norm. However, we do not know what the articulatory and acoustic thresholds are that have to be crossed before listeners perceive rhoticity, or how much variation there might be in these thresholds in different varieties of English. These questions are important for our understanding of the social significance of rhotics and have
implications for forensic work in terms of speaker profiling and the evaluation of earwitness evidence where the rhoticity or non-rhoticity of a suspect's speech is at issue.

**Funding amount:** £27,258.59
Voice and Identity: source, filter, biometric

Funder: AHRC

Project Reference: AH/M003396/1

Start: 2/1/2015   End: 9/11/2019

Abstract
The voice has fascinated philosophers, writers and scientists throughout history, especially as a marker of human identity. Formal analysis of voice is conducted in strikingly different frameworks, some developed largely in arts & humanities disciplines (linguistics and phonetics), and others in the sciences (engineering, physics, computer science). These frameworks differ in focus, assumptions, and in methods used to test their performance and reliability. Remarkably little work has sought to integrate them, resulting in only limited understanding of their respective benefits and drawbacks, and of their degree of compatibility. This is of particular importance in the applied domain of forensic speech science, where the individual properties of the voice are treated as a biometric. Forensic voice (or speaker) comparison (FVC) is increasingly called for in courts worldwide. Typically, comparison is made between the voice of a suspect, and a voice recorded in criminal activity (e.g. via covert surveillance of drug deals or terrorist plots). The aim of FVC is to aid the court in assessing the likelihood that the speaker in the recordings is the same person, as opposed to a different person. There is a growing consensus that an integrated approach is needed for significant progress to be made towards a more reliable and robust procedure for FVC.

In this proposal we seek to assess the comparative performance of voice analysis based on linguistic-phonetic methods, and automatic (computational) systems. We will explore the performance of the methods on the same data to assess their relative strengths, the consistency of their results and error patterns, and thus the potential for phonetic and automatic methods to be integrated. The ultimate aim is to improve methods in FVC, taking a major step towards the development of a methodology that is more transparent, validated, and replicable. This outcome will benefit academics and forensic practitioners, the public, judicial systems, and investigative/security agencies. More generally, the project answers recent calls to improve the quality of forensic evidence of all kinds, making forensic sciences more transparent and more carefully regulated (e.g. Law Commission of England & Wales 2011).

The project addresses the AHRC's focus theme, Science in Culture: it (i) explores the capacity of linguistic-phonetic techniques for advancing scientific methods; (ii) explores how methods developed in both the sciences and arts might be integrated; (iii) improves understanding of the comparative roles of expertise from the sciences and humanities in FVC; and (iv) aims to improve public confidence in forensic evidence.

Funding amount: £713,767.8
The Art of Identification

Funder: AHRC

Project Reference: AH/M011143/1

Start: 7/14/2015   End: 7/13/2016

Abstract
The practical identification of individuals has, in the modern period, taken a number of forms - from Early Modern badges and insignia to the contemporary strobe light of a retinal scanner. The term 'identification' can also be taken to mean a number of things, including the determination of individual personhood via paperwork, bodily examination, verbal testimony, and digital recording; the detection of false or forged identities; the creation of offender profiles by forensic psychologists; and the taxonomic (and later genetic) tracing of ethnic 'types'. This subject has been of recent interest in historical, social scientific and biological scholarship. However, what has been neglected to date is the inherent connections that exist between techniques of identification (as defined above) and the intimate personal identity divulged by literary and artistic representation. The question of who we are, in the practical sense of identifying individuals via their documents and bodies, has remained curiously absent from the question of who we are in terms of our intimate portrayal of the self.

This research network will seek to redress this discrepancy by examining the papers of identity documents alongside a range of written and visual media and thereby advance a fresh interpretive model for the consideration of both identificatory practices and the artistic depiction of identity. The broad spectrum of participants speaks to the interdisciplinary nature of the project and its ability to resonate across different areas of study and practice. To achieve its objectives, the network will advance conversation and collaboration via a series of four day-long workshops its website and twitter feed. The online activities will involve the dissemination of research questions, potential reading lists and thematic concerns prior to workshops and the publishing of papers and discussion topics following the workshops. Postgraduate students and early career researchers will form an integral part of the workshop and help to sustain its ongoing existence and development.

The first workshop, at the University of Cambridge, will focus on the theme of 'image and information' and address the central first question of how identity documents can be interpreted as cultural artifacts that connect with artistic representations of identity. The second workshop, at the University of Illinois, will move on to think more specifically about the site of many identificatory practices - the human body - and consider its relationship to the kinds of bodies depicted in art and literature. The third workshop, at the University of Birmingham, will bring together academics, practitioners of forensic science and a range of creative practitioners in order to consider the ways in which their varying models of identity could be brought to bear on each other. The fourth and final workshop, held at the Library of Birmingham, will comprise a working meeting between key members of the network steering group and museum professionals, curators and archivists. Building on the content of these workshops, the aim of the meeting will be to develop a conceptual framework which will accommodate the various interdisciplinary and professional approaches to identification and identity developed by the network. This framework will actively develop a rationale for reading a host of different identity documents as works of art, thereby realizing a huge potential within various archival material
held in locations such as the Library of Birmingham. The stimulation of new creative work will also be addressed with the inclusion of practicing writers and artists.

**Funding amount**: £35,341.82
**Abstract**

Genome technology is an important part of modern life and is used routinely in medicine, forensic and crop science. However, despite rapid advances in DNA sequencing technology, large regions of genomes, including the human genome, are poorly characterised. In this proposal we aim to develop a new hybrid nanopore technology for DNA analysis and explore the possibility of using this method for improved analysis of these poorly defined or 'dark' genomic regions.

These 'dark' regions are poorly defined largely due to the presence of multiple repeats. These 'repetitive elements' are difficult to analyse with currently available technology. This is because current methods rely on DNA polymerase enzyme activity which is prone to 'stuttering' and 'slipping' on AT rich repeats and 'stalling' on GC rich repeats.

Nanopore technology is a polymerase-independent method for mapping at near-basepair resolution of very long DNA fragments (>100 Kb). Indeed it is hoped that this technology will be advanced towards the de novo sequencing of whole genomes. However, despite great promise, these technologies are still in development and currently are between 60-90% accurate. While protein nanopores, such as the alpha-haemolysin protein, are easily reproducible and tunable, they are generally derivatives of membrane pores. Thus they are supported in relatively fragile lipid-like membranes, requiring detergent for handling and high (micromolar) DNA concentration for signal detection. Conversely, ultra-thin layer solid-state (SS) nanopores are more robust and require only nanomolar quantities of DNA. However, they are difficult to fabricate routinely with the tiny diameter (<4nm) required for high-resolution DNA mapping.

Hybrid nanopores can combine the advantages of both systems: namely (i) the reproducible production of tunable nanopores with diameters of 1-3 nm with (ii) robust properties that results in low (nanomolar) DNA concentrations required for signal detection. However, current protein nanopores require detergent and substantial chemical modification for integration into SS nanopores.

We propose to investigate the suitability of a natural DNA nanopore, the portal protein from a thermophilic virus, for hybrid nanopore production. This protein is the nanopore through which DNA passes during packaging of the viral genome and so naturally processes the characteristics designed for capture and directional transition of dsDNA. Additionally this bionanopore is thermostable, highly soluble, tractable for bioengineering purposes and easy to produce in large highly pure quantities. Furthermore, the available high-resolution X-ray structure of the portal protein allows the design of portal variants with modified DNA transition properties.

In this proposal, we specifically aim to explore and optimise the integration of the portal protein into SS nanopores and define the DNA transition dynamics. Bioengineering methods will be used to optimise the portal protein for 3
microseconds/basepair transition speeds. The hybrid nanopore will be calibrated for accurate analysis of DNA sequences containing multiple repeats.

**Funding amount:** £389,176.05
Hybrid Nanopores for Single-Molecule Sensing

**Funder:** BBSRC

**Project Reference:** BB/M025373/1

**Start:** 10/1/2015  **End:** 9/30/2018

**Abstract**

Stochastic sensing with nanopores is a versatile technology that can be used for the recognition and quantification of a wide range of substances (known as analytes) through the detection of individual molecules. Our partner company, Oxford Nanopore Technologies, has been incorporating stochastic sensing into next-generation hand-held devices. The most highly developed application at Oxford Nanopore is cheap, extremely rapid DNA sequencing, which promises to revolutionise numerous areas of biology including aspects of medicine, ancestry and forensics. Currently, a portable sequencer is being tested at hundreds of sites worldwide.

In stochastic sensing, analytes are detected as they enter and leave a single narrow pore perturbing a current that flows through it. The diameters of the pores, known as nanopores, are similar to those of a small molecule, about one-fifty thousandth of the diameter of a human hair, providing the basis for detection by current perturbation. Typically current changes of the order of one trillionth of an ampere are measured. Analytes have included drug molecules and small molecules found in the body that act as markers for disease. In the case of DNA sequencing, individual bases are detected as an extended DNA strand is threaded through a nanopore.

Protein pores are advantageous for stochastic sensing, because they can be modified for particular applications with atomic precision and prepared in near homogeneous form. Until now, very narrow protein pores have been used and therefore stochastic sensing has been limited to analytes of small size or, in the case of DNA, to extended polymer chains. In the proposed work, we will endeavour to make a new class of functional nanopores, DNA-Protein hybrid nanopores. These pores will be constructed from folded DNA, known as DNA origami, and protein components. The DNA will act as a scaffold for the protein, ensuring that the new pores are up to fifteen times larger in internal diameter than the pores used before. Further, each pore will be of identical size and no incompletes pores will be present, a goal that has not be achieved previously. Finally, it will be possible to modify the new pores at precisely determined sites, which cannot be done with competing technologies, such as solid-state pores.

The DNA-protein hybrid nanopores will enable a critical step forward for stochastic sensing by allowing the detection of a wide range of large biological molecules that can enter the pores, including proteins, DNAs and polymeric sugars. Conversely, it will also be possible to lodge these large molecules within the hybrid pores, where they will act as binding sites for a variety of additional analytes. In a futuristic application, it may prove possible to sequence double-stranded DNAs with hybrid pores, which will provide a significant advantage over the manipulations currently required for nanopore sequencing.

Our industrial partner, Oxford Nanopore, will evaluate and test our most promising DNA-protein hybrid nanopores in their hand-held sensing devices, which are capable of monitoring the outputs of hundreds of pores in parallel, offering the prospect of step changes in sensing technology in areas including
biological warfare defense, food authentication, plant and animal breeding and medical diagnostics.

**Funding amount:** £726,201.74
An electrophysiological investigation of emotion-enhanced recollection

Funder: BBSRC

Project Reference: BB/H001476/2

Start: 9/1/2010  End: 7/31/2013

Abstract

A large part of the world population can remember very vividly and specifically where they were and what they were doing when they learned about the 9/11 terrorist attacks (Curci and Luminet, 2006). Similarly, private emotional memories from our autobiographical past (e.g. loss of a close relative, first day at college, first relationship, etc.) are usually remembered with a wealth of vivid details (Schaefer and Philippot, 2005). We define this phenomenon as 'emotion-enhanced recollection', the fact that emotional memories are more vivid and detailed than neutral memories. The purpose of this proposal is to achieve a significant progress in discovering how it originates in the human brain. It is widely believed that EER is caused by neurophysiological processes happening when events are encoded, i.e. stored in memory. In other words, EER would happen because when an emotional event is experienced, a robust, 'photographic' record of the event is stored in memory. This would enable us to later remember the event in full vivid details, as if we were mentally re-living it. Therefore, the main purpose of this proposal is to investigate brain mechanisms related to how we store emotional events in memory. For that, we propose to record electrical brain activity from electrodes attached on the scalp of human subjects while they are experiencing emotional events that will be later vividly recollected. This method will isolate neural activity specific to the formation of memories leading to EER. We will not only isolate neural activity predicting EER but we will also investigate what are the determinants of this neural activity. For that purpose, several studies will investigate how cognitive processes can change the way we encode emotional events in memory. This approach is fundamentally novel and timely: Despite a recent surge of interest in how emotional memories are formed, no electrophysiological study has ever investigated how we encode memories that lead to the EER phenomenon. Therefore, this project has the potential to produce unique knowledge on how emotional memories are formed in our brains. This could contribute to a comprehensive and integrated neuroscientific theory of emotional memory, which would fill an important gap in a domain which is still largely a-theoretical. As a result, the outcomes of this project could bring a significant potential contribution to the work of both psychologists and neuroscientists trying to understand how memories are formed. For instance, it could speed up the development of computational models of memory by making explicit the rules through which emotional and evolutionary factors constrain the formation of memory traces. In addition, a better understanding of emotional memories can also have long-term potential impacts in a variety of applied fields such as forensic science (the impact of emotion on eyewitness testimony), clinical psychology (emotional memories play an important role in a variety of mood disorders such as post-traumatic stress disorder and depression), and social sciences (how do societies cope with highly emotional collective memories such as terrorist attacks). Curci A, Luminet O (2006) Follow-up of a cross-national comparison on flashbulb and event memory for the September 11th attacks. Memory 14:329-344. Schaefer A, Philippot P (2005) Selective effects of emotion on the phenomenal characteristics of autobiographical memories. Memory 13: 148-160
Funding amount: £258,115.58
An electrophysiological investigation of emotion-enhanced recollection

Funder: BBSRC

Project Reference: BB/H001476/1

Start: 3/1/2010   End: 8/31/2010

Abstract

A large part of the world population can remember very vividly and specifically where they were and what they were doing when they learned about the 9/11 terrorist attacks (Curci and Luminet, 2006). Similarly, private emotional memories from our autobiographical past (e.g. loss of a close relative, first day at college, first relationship, etc.) are usually remembered with a wealth of vivid details (Schaefer and Philippot, 2005). We define this phenomenon as 'emotion-enhanced recollection', the fact that emotional memories are more vivid and detailed than neutral memories. The purpose of this proposal is to achieve a significant progress in discovering how it originates in the human brain. It is widely believed that EER is caused by neurophysiological processes happening when events are encoded, i.e. stored in memory. In other words, EER would happen because when an emotional event is experienced, a robust, 'photographic' record of the event is stored in memory. This would enable us to later remember the event in full vivid details, as if we were mentally re-living it. Therefore, the main purpose of this proposal is to investigate brain mechanisms related to how we store emotional events in memory. For that, we propose to record electrical brain activity from electrodes attached on the scalp of human subjects while they are experiencing emotional events that will be later vividly recollected. This method will isolate neural activity specific to the formation of memories leading to EER. We will not only isolate neural activity predicting EER but we will also investigate what are the determinants of this neural activity. For that purpose, several studies will investigate how cognitive processes can change the way we encode emotional events in memory. This approach is fundamentally novel and timely: Despite a recent surge of interest in how emotional memories are formed, no electrophysiological study has ever investigated how we encode memories that lead to the EER phenomenon. Therefore, this project has the potential to produce unique knowledge on how emotional memories are formed in our brains. This could contribute to a comprehensive and integrated neuroscientific theory of emotional memory, which would fill an important gap in a domain which is still largely a-theoretical. As a result, the outcomes of this project could bring a significant potential contribution to the work of both psychologists and neuroscientists trying to understand how memories are formed. For instance, it could speed up the development of computational models of memory by making explicit the rules through which emotional and evolutionary factors constrain the formation of memory traces. In addition, a better understanding of emotional memories can also have long-term potential impacts in a variety of applied fields such as forensic science (the impact of emotion on eyewitness testimony), clinical psychology (emotional memories play an important role in a variety of mood disorders such as post-traumatic stress disorder and depression), and social sciences (how do societies cope with highly emotional collective memories such as terrorist attacks). Curci A, Luminet O (2006) Follow-up of a cross-national comparison on flashbulb and event memory for the September 11th attacks. Memory 14:329-344. Schaefer A, Philippot P (2005) Selective effects of emotion on the phenomenal characteristics of autobiographical memories. Memory 13: 148-160
Funding amount: £308,287.48
Bridging the gap in recognition memory between unknown and known faces

Funder: BBSRC

Project Reference: BB/L023644/1

Start: 11/30/2014 End: 11/29/2017

Abstract

Recognizing a known face is usually effortless, but most of us experience uncertainty with new acquaintances - is that the person I saw yesterday? Research has shown that such 'unknown' face processing is surprisingly poor and that it is difficult to match a picture, perhaps on a passport, to a person. Error rates of 20% are common. This has serious implications for our security, since it is not possible to be sure of the identity of people entering the country, for example. The aim of this project is to study the process of becoming familiar with a face. Doing so will yield insights into how our memories work, and why they fail, and help to establish the best training to improve performance of those who need to match faces, such as border guards.

An obvious difference between a known face and an unknown one is the amount of experience we have of the face. We interact with friends on a regular basis, seeing them in different situations and from various angles. It seems that this enables us to create a memory for their face, which allows us to recognize it again in other situations, perhaps years later. Previous work has begun to study how we learn new faces, by presenting a variety of images; we propose to draw on the best of this work and, crucially, to study what is happening inside the brain during learning.

Our method of observing brain function uses a measure of the electrical fields generated by the brain called Event-Related Potentials (ERPs). Previous work has suggested that there are two separate processes underlying our memory: familiarity and recollection. Familiarity, in this context, is the all too common experience - I've seen that face before, but where? Recollection brings relief, as you remember who it is and why you know them. Familiarity and recollection produce distinct patterns of electrical activity, which will allow us to monitor the process of developing memory and establish the best ways to encourage it.

We plan a series of experiments to study the process of learning a face, starting with simple repetition and progressing to varied views, methods to encourage thoughtful consideration of each face, and the effects of sleep on helping consolidate memories of new faces. The aim is to assess whether memory performance for unknown and known faces is associated with the same retrieval processes, or whether different retrieval processes are involved. Establishing the involvement of different retrieval processes in memory for known and unknown faces is theoretically important because it would link the poor performance in face recognition for unknown faces to differences in the mental representation underlying memory for different types of face. Clarifying the reason why known and unknown face recognition differs also has important implications for how face recognition can best be improved. Having identified the retrieval processes engaged, various mnemonic strategies will be used to promote face learning and 'bridge the gap' in recognition memory accuracy between the two types of face. Importantly, the analysis of brain activity will reveal exactly how changing the way unknown faces are studied leads to better memory - either by enhancing the deployment of retrieval processes associated with unknown faces, or by actually
changing the processes engaged to match those used for known faces. Answering
this question will provide important insight into the nature of memory
representations that support successful face recognition, with implications for
theoretical accounts of both episodic memory and face identification - informing
future attempts to improve face recognition in real world contexts.

**Funding amount**: £327,072.55
The genetics of human physical appearance

Funder: BBSRC

Project Reference: BB/I021213/1

Start: 5/1/2012   End: 4/30/2015

Abstract

Despite its great biological and social importance the genetic basis of variation in human physical appearance is poorly understood. Identical twins share all of their genes and show striking physical resemblance, while more distant relatives tend to look less alike the less closely related they are. This variation in degree of family resemblance suggests that many genes influence physical appearance. However, few of the genes have been identified. The aim of this proposal is to identify genetic variants influencing a selection of such features: body size and shape, pigmentation (of hair, skin and eyes), facial features, type of hair, baldness and hair greying. To facilitate this task we propose to study Latin American populations which represent a mixture of different continental populations (Europeans, Native Amerindians and Africans). These continental populations have quite differentiated physical features and provide us with higher statistical power for detecting genetic effects. With independent funding we are recruiting over 7,500 Latin American research volunteers (from Mexico, Colombia, Peru, Chile and Brazil) and we are characterizing their physical appearance. We record face features using photographs and specialized imaging processing techniques, skin using an instrument allowing colour measurement and the other features through physical examination. Here we request funding for the genetic analysis of this sample. Initially we propose to examine the entire human genome in 3000 individuals using about ~300,000 genetic markers. This information will be used (together with the human genome sequence) to identify regions showing association with the physical characteristics of the individuals. The regions showing association will then be examined in the rest of the Latin American cohort (an additional 4,500 individuals) and in European cohorts being studied by collaborators (comprising over 20,000 individuals). In this way we will confirm our findings. We will then use statistical techniques to evaluate if these variants can predict the physical characteristics of unknown individuals based only on a DNA sample. Identification of genes involved in physical appearance has a number of important consequences for basic biological research, such as examining the evolution of this traits and optimize their use in studies on human origins and diversification. This work will also have important biomedical implications as the genes identified could be involved in human disorders (of development pigmentation, aging and skin cancer). This work will also lay the foundation for the development of an entire new field of forensic genetics: the reconstruction of an individual's physical appearance based on a DNA sample. Finally, our proposal will inform the public about aspects of the relationship between genetics, ethnic identity and race.

Funding amount: £847,076.43
MSc in Toxicology

Funder: BBSRC

Project Reference: BB/H020586/1

Start: 10/1/2010   End: 9/30/2013

Abstract
The programme consists of 6 taught modules (120 credits) and a research dissertation (60 credits) as outlined in the programme specification. TAUGHT MODULES take place between October and May and are as follows: 1: Metabolism and excretion of xenobiotics: 20 credits Literature retrieval, computer database, communication skills. ADME; metabolic pathways, phase I and II reactions; polymorphisms; effect of age, sex, genotype. Methods used to study drug metabolism including application of molecular biology techniques to drug metabolism and toxicogenetics. Metabolism and distribution as a basis for toxicity of xenobiotics. Drug transporters. 2: Pharmacological and clinical aspects of toxicology: 20 credits Principles and applications of pharmacokinetics, pharmacodynamics, pharmacogenetics. Safety pharmacology. Adverse reactions to drugs; drug development. Forensic toxicology; detection of drugs and toxins, post mortem investigations. Clinical toxicology; diagnosis, complications, management of poisonings. 3: Molecular and cellular mechanisms of toxicity and carcinogenesis: 20 credits Molecular mechanisms of toxicity; necrosis and apoptosis. Application of molecular and cell biology to toxicology; cDNA arrays, stress responses, reporter gene assays. Toxicogenomics, proteomics, metabolomics, bioinformatics. Receptor mediated toxicity. Mechanisms of carcinogenesis; genotoxic vs nongenotoxic. In vitro testing. Immunotoxicology. Nanoparticle toxicology. Computer assisted structure activity relationships. 4: Toxicology in Practice; safety assessment in industry and the environment. 30 credits Pathology of acute and chronic inflammation, degeneration, necrosis, neoplasia, atrophy and hypertrophy. Histology, Haematology. Respiratory toxicity, hepatotoxicity, neurotoxicity, nephrotoxicity, reprotoxicity. Use of animals in toxicology. Safety and risk assessment. Statistics. Occupational, environmental and ecotoxicology: Environmental pollutants; land air and water contamination; monitoring, global effects. Pesticides in food. Ecotoxicology; biological effects and biomarkers from molecules to eco systems, examples and case studies including endocrine disruptors and PCBs. Occupational toxicology, epidemiology, risk assessment. Role of regulators such as HSE, FSA. Impact of REACH 5: Skills 10 credits Improves communication, IT, data handling and team working skills and is embedded throughout the programme. Exercises in literature searching/information retrieval, communication of findings in written, oral and poster formats. Experimental design, statistics, computational techniques including bioinformatics and DEREK. Risk assessment exercises. 6; Synoptic. 20 credits Consolidation and integration: time for directed, student-centred learning. Revision. RESEARCH PROJECT: 60 credits 3 months full time; carried out in an appropriate research environment. All modules are compulsory. In addition students are offered the option of completing Modules 1, 2 and 3 of the Home Office training course during the Easter vacation. The taught component is delivered by a combination of formal lectures, tutorials, workshops, computer exercises, practical classes and demonstrations and is supported by directed reading and course work. The programme specification gives details of learning and teaching methods and assessment methods along with knowledge, understanding, skills and attributes the students are expected to attain. Research projects are carried out over a 12 week period in May - August and are typically
based in industry, research institutes, environmental agencies, hospitals and universities, in the UK and overseas. The project represents the major practical element of the course during which students have the opportunity to plan their work and analyse and interpret data. Some students opt for research projects that are literature or computer based but all give experience of current problems in toxicology.

**Funding amount:** £406,806.0
Towards electrochemically controlled nucleic acid-amplification strategies

**Funder:** BBSRC

**Project Reference:** BB/L01808X/1

**Start:** 3/1/2014   **End:** 2/28/2015

**Abstract**

One of the critical functions of DNA is its ability to undergo conformational change, more precisely the association (hybridisation) and disassociation (denaturation) of the double helix. While not only indispensable inside the cell, many invaluable molecular biology technologies, across many different disciplines, that exploit and detect DNA rely on this reversible function. These include for example the polymerase chain reaction (PCR, DNA biosensor and next generation sequencing for diagnostics for healthcare, biomedical research, forensics, environmental monitoring, and food and agricultural industry.

Many of these DNA-based technologies rely on the large quantities of the genetic material. This can be achieved via various biochemical reactions, such PCR. Technologies exploiting production of large quantities of DNA is a rapidly growing area in life sciences in which the dominating technology is PCR. However, to copy and produce large quantities of DNA, PCR requires considerable technical instrumentation. This is because the biochemical reaction, based on the reversible association and dissociation of DNA, is driven by precise regulation of three distinct elevated temperatures. This prerequisite significantly compromises the use of PCR outside well equipped laboratories. As there is an increasing demand in making DNA-based testing portable and available outside a centralised laboratory setting, the development of these technologies is driven towards miniaturisation and integration of standard laboratory procedures into lab-on-a-chip systems. However, integration of the standard temperature-regulated PCR reaction has proven to be challenging due to the requirement and complexity of the precise temperature regulation to drive the reaction. This has thus far precluded the realisation of truly decentralised miniaturised DNA-based analytical systems.

We have recently demonstrated that we can reversibly control the association and dissociation of DNA, at a constant temperature, by means of electrochemistry. The fundamental control is based on an electrochemically switchable small DNA binding chemical compound named daunomycin. As no extreme conditions were implicated, and the precise temperature-regulation of reversible association and dissociation of DNA was circumvented, this finding has great potential to simplify future developments of miniaturised portable DNA-based analytical systems.

This project proposes a radically new way of controlling the association and dissociation of DNA as a new tool to control all types of biological reactions that rely on reversible DNA hybridisation events. A wide range of biological applications can make use of this new tool and, thus, addresses any of the strategic priorities of BBSRC relying on detection and testing based on DNA. To pump prime these developments and to show the proof-of-principle, we aim to apply this new tool to develop electrochemically controlled PCR (ePCR).

An initial study in our research group showed that the conditions utilised for the electrochemical control of association and dissociation of DNA was compatible with the standard PCR reaction conditions. Furthermore, it proved that the PCR
reaction was not inhibited by the presence of the electroactive DNA binding compound daunomycin.

This early-stage investigation of a novel concept, we believe, is vital for the development and commercial success of a low-energy consuming portable DNA-based analytical platforms. As the current method is based electrochemical control, it offers a simpler, integration-friendly and cost-effective alternative to current technologies.

**Funding amount:** £140,653.17
RAPIER: from RAD sequencing to population genetics and evolutionary modelling

Funder: BBSRC

Project Reference: BB/K004212/1

Start: 10/1/2012   End: 9/30/2013

Abstract

Individual organisms belonging to the same species differ from one another genetically. The pattern of genetic variation, and how it covaries with phenotype, is highly informative about the past evolutionary history of the population, and also provides insights into gene function. Population genetic analysis has been shown to be very useful in a number of different fields; for example in genome-wide association studies to look for disease genes, epidemiological analysis, forensics, and also in elucidating the past history and evolution of human populations. Other than in model organisms such as humans, it has, until recently, been very expensive to analyse a sufficient amount of genome to be able to make accurate estimates of the quantities of interest. The development of Next-Generation Sequencing (NGS) technology has made it possible to analyse a very large number of genes (regions of the genome). However NGS, by itself, is a broad tool more suited to the analysis of whole individual genomes, which is still relatively expensive. For population genetic analysis one requires a sample of genes across the genome to be compared across individuals. The method of RADseq has been developed to do this. It works by sequencing regions of the genome that have a particular motif (such as CCTGCAGG for example). Because fragments originate with the same motif the same region can be compared across individuals. The challenge is that these motifs occur typically many thousands of times in a single genome, yielding many genes, which need to be sorted out. Computer software has been developed to do this, but because the technique is very new, there are a number of problems and biases inherent in the current method. This project aims to fix many of these problems by taking a more rigorously statistical approach. We will develop new publicly available software, making it much easier to apply NGS methods in population genetics.

Funding amount: £84,161.91
Generation of a large family of genetic logic gates for applications in biosensing and information processing

Funder: BBSRC

Project Reference: BB/J020133/1

Start: 12/31/2012 End: 10/31/2013

Abstract

Electronic logic gates are the building blocks of all the digital devices, such as computers and smart phones, on which we have come to rely. Individual logic gates take one or more digital (ON or OFF) inputs, perform a logical operation and produce a single digital output. For example, the output of an AND gate is ON only if both of its inputs are ON, whereas the output of an OR gate is ON if either (or both) of its inputs is ON. Electronic logic gates can be connected together into circuits that can store data, add and subtract numbers, count, and carry out any other logical or mathematical calculation. The microprocessor at the heart of a typical modern digital computer has tens of millions of logic gates, all connected together into complex circuits.

Scientists working on simple bacterial cells have used them to create genetic networks that can reproduce the behaviour of individual logic gates. Just like their electronic counterparts, these biological logic gates can take one or more inputs, perform a logical operation and provide an output. For example, a bacterial AND gate has been engineered to take its input from two natural sensors in the bacterial cell that detect different sugars in the environment. The logic gate combines these two inputs and produces an output, in the form of a fluorescent protein, only when both sugars are present. The hope is that one day these biological logic gates can be engineered into more complex circuits that can perform multiple logical operations, store information, make complex preprogrammed decisions, and have multiple outputs. For instance, a cell could be engineered to detect pollutants and to take action to neutralize the exact cocktail of pollutants present, or to undergo a complex series of metabolic steps to turn agricultural waste into valuable chemical feedstocks or pharmaceutical products.

Each biological logic gate has to be individually built from genetic components known as transcription factors and promoters. Transcription factors and promoters are used by cells to control their own gene expression in response to their environment. To ensure that individual logic gates operate independently of each other in a circuit with multiple logic gates, a different transcription factor must be used for each logic gate. Up until now, transcription factors and promoters had to be sourced from natural systems and characterised one by one, and the lack of a large number of different, well characterised transcription factors has severely limited the complexity of digital genetic circuits that can be built.

In the research proposed here, we will develop a new way to produce a large set of transcription factors and promoters that do not interfere with each other’s action. Unlike other transcription factors that have been used to build genetic logic gates to date, these transcription factors will not cause unwanted side effects by altering gene expression in their bacterial host. Therefore, the set of transcription factors we generate will be ideal for building large genetic circuits, containing multiple logic gates, to carry out complex data processing and storage operations.
Application of biological logic circuits for in-the-field detection of pollutants, toxic agents, pathogens, water contaminants, explosives etc. will depend on miniaturised reliable detectors of their outputs. We will develop a miniature device to detect fluorescent proteins produced as outputs of bacterial genetic logic circuits, and will test this device using a genetic circuit built from our new transcription factors. This should pave the way towards the development of portable, easy to use biological sensors and processors for a whole host of applications.

**Funding amount:** £120,185.17
Phytodetoxification of the explosive 2,4,6-trinitrotoluene

Funder: BBSRC

Project Reference: BB/P005713/1

Start: 6/1/2017    End: 5/31/2020

Abstract
The explosive 2,4,6-trinitrotoluene (TNT) has become an extensive global pollutant over the last 100 years and there are mounting concerns over the toxicity of TNT to biological systems. During World War I and II the toxic effects of TNT were discovered during large scale production, with 475 fatalities and over 17,000 TNT poisoning cases reported at manufacturing facilities. TNT has been shown to severely impact the diversity of soil microbial communities and the establishment of vegetation. In the U.S. alone it is estimated that some 10 million hectares of military land is contaminated with munitions constituents. Unlike similar situations where the environment has become contaminated with toxic agrochemicals and their use subsequently banned, the huge demand for military explosives means that TNT will continue to be manufactured and used globally on a massive scale for the foreseeable future.

Because of the scale of explosives pollution, particularly on military training ranges, there is considerable interest in developing plant based remediation strategies. Plants offer a low cost sustainable solution to containing and remediating explosives pollution. However, a fundamental understanding of the phytotoxicity of explosives, and the enzyme systems plants use to detoxify these compounds, and the rate-limiting steps, are required to enable the development of robust plant systems to contain and remediate explosives pollution effectively in situ. In plants, the majority of TNT remains in the roots, where it inhibits growth and development reducing whole plant biomass.

We have recently discovered that the mitochondria- and plastid-targeted enzyme monodehydroascorbate reductase 6 (MDHAR6) reduces TNT by one electron, forming a nitro radical which reacts with atmospheric oxygen, generating highly reactive superoxide. This futile catalytic cycle only requires catalytic quantities of TNT to continuously generate damaging reactive oxygen species in the mitochondria. We have demonstrated that mutants in MDHAR6 have dramatically enhanced TNT tolerance, and we propose that this reaction accounts almost entirely for TNT toxicity in plants.

The major goal of this research programme is to rigorously and quantitatively establish the fate and effects of TNT on plants. In order to achieve this objective we propose to study mechanisms of TNT toxicity and fully elucidate TNT induced detoxification pathways that include glucosylation, glutathionylation and oxidative activity by cytochromes P450. The fate of the TNT metabolites produced by these enzymes will then be established. We have previously demonstrated that the TNT active glutathione transferase GST-U25 results in the removal of a nitro group which could render the aromatic ring more amenable to biodegradation. We now have detailed structural information on GST-U25 that will allow us to engineer and improve the specificity and activity towards TNT. We hope to use the knowledge gained from this study to develop improved plant systems that will clean up polluted sites and prevent explosives pollution from contaminating water sources.

Funding amount: £500,797.79
Exposing explosives: novel synthetic gene circuits for explosive detection via innovative waveguide sensing

Funder: BBSRC

Project Reference: BB/J019895/1

Start: 12/31/2012 End: 3/31/2014

Abstract
The proliferation of explosives, new technologies, and expertise increases the potential for terrorists to evade our existing countermeasures at points of entry to and exit from the UK. Present methods for the detection of explosives leave much to be desired. To allow analysis to occur in the 'field' there is an urgent need for the development of on-site testing. There is also a need to detect explosives pollution on military sites. Toxic explosives residues are released into the environment on military training ranges as a result of incomplete detonation of munitions. As explosives are toxic it is therefore essential that the MoD consider the fate and transport mechanisms and the subsequent impact of these materials on the terrestrial environment. The availability of benchmark data regarding the transport and fate of the energetic materials will support predictions and modeling to enable the MoD to use best management practices for the stewardship of military sites. The results obtained will provide potential cost savings, since such knowledge will mitigate contamination and alleviate the need for future clean-up operations.

To address these challenge, we are aiming to develop novel inexpensive sensors to rapidly and effectively detect explosives. We intend to construct a proof-of-principle cell-based sensor where the cells specifically respond to the explosive TNT and produce a signal that is detected by an optical device. This requires engineering a genetic regulatory protein that specifically binds TNT. The TNT bound regulatory complex then binds to the promoter region of a reporter gene resulting in the expression of an enzyme alkaline phosphatase which is secreted out of the microbial cell. The secreted enzyme then activates a fluorescent compound and this signal is then detected using an optical waveguide sensor. The development of a genetic regulatory element that specifically recognises explosives would result in a step-change towards the development of a biosensor with strong relevance to the security and defence area.

Funding amount: £74,484.37
A new generation of Crystallographic detector for Multi-user Barkla X-ray laboratory

Funder: BBSRC

Project Reference: BB/R000220/1

Start: 7/4/2017   End: 7/3/2018

Abstract

X-ray crystallography offers the opportunity to observe highest level of details in protein and RNA/DNA molecules. It has delivered unrivalled knowledge of many biological processes including respiration, photosynthesis, cell signalling, receptor’s activation and enzymatic mechanisms. The way we think of biology and biological processes has transformed due to our ability to determine high-resolution structures of even the most complex systems. It also has revolutionized modern drug discovery and structure-based drug/lead-compounds have become a commonplace.

The tremendous success of X-ray crystallography over the last 30 years has largely been due to the availability of highly intense Synchrotron Radiation (SR) facilities. During the last couple of decades, the SR sources have seen tremendous progress in the performance in terms of brightness where the brightness gain has been twice as fast as the rate of improvement in semiconductors (Moore’s law), The increasing X-ray photon density delivered by the increasingly brighter sources has required rapid development in beamlines, optical elements and detectors. A major improvement in detectors from photographic plates to image plate to Charged Coupled Detectors (CCDs) emerged at the end of last century. DIAMOND Synchrotron opened its operation with MX beamlines using large CCDs but all of these have been replaced by photon counting hybrid pixel array silicon detectors (HPC) - in fact DIAMOND set the pace of change capitalizing on the development of HPC detectors that originated at the Swiss Light Source.

The laboratory sources have continued three important roles, namely (i) pre-screening of crystals, their initial characterisation and establishment of soaking conditions of ligands/compounds/inhibitors, (ii) determination of structures of well diffracting systems (in fact the number of structures determined using laboratory sources per annum currently is the same as in the 1980s/90s) and (iii) train and equip PhD students and PDRA with in-depth skills not just in the use (as a user) but acquire in-depth understanding of instrumentation as well as the subtleties of data collection. The laboratory sources (and associated optics) have also improved and detector technology is also advancing but a decade or so behind the synchrotron. Only recently the technology of photon counting hybrid pixel array silicon detectors has become available for laboratory sources at a fraction of the price compared to detectors that are being bought for synchrotrons. This reduction in price has been achieved by matching the specifications of these new generations of HPC detectors to the laboratory sources.

X-ray detectors must collect, quantize and digitize incoming X-rays while preserving highly precise location information. State-of-the-art new generation HPC X-ray detectors can collect X-rays with exceptional (>99 %) quantum efficiency. In recent years reduction of pixel size has increased the quality of the data collected; similar to increasing screen resolution in high definition televisions. Dectris have led the way in hybrid pixel array detectors and their
new EIGER range combine small pixel size with high quantum efficiency and signal to noise. The EIGER R range is tailored for more intense laboratory sources and is capable of high-count rates with continuous readout and have small (75 microns) pixels, similar to our current MAR225CCD, which is now 12 years old. The provision of this latest generation of detector will not only ensure continued successful operation of the Barkla laboratory but also will enhance our capabilities for weekly diffracting systems including membrane protein crystals and multi-component complexes.

**Funding amount:** £219,626.46
Logic-directed evolution of new biosensor molecules in vivo

Funder: BBSRC

Project Reference: BB/J020036/1

Start: 11/12/2012 End: 1/11/2014

Abstract
The ability to rapidly and accurately detect small molecules has widespread use within security and defence contexts such as detection of explosives, biological agents or pathogens. This project will develop a new platform for the development of novel sensors. Sensors require highly specific detection of molecules in very low concentrations. The use of biological approaches for this purpose is attractive since many biological systems have evolved for precisely this purpose. While biological diversity offers a rich source of variety, it is ultimately limited to what can be isolated and characterised. In vitro methods for evolving new biological functionality and diversity have proven useful but are ultimately limited in the range of biological diversity that can be sampled. This project will develop a prototype for the evolution of new biological specificity in vivo, with feedback bio-'logic' circuitry that will enable end-point evolution of biological systems to new specificities. The isolation of new proteins with altered specificity will be essential for the creation of a new generation of biosensors.

Funding amount: £127,392.67
Exposing explosives: novel synthetic gene circuits for explosive detection via innovative waveguide sensing

**Funder:** BBSRC

**Project Reference:** BB/J02046X/1

**Start:** 7/1/2012    **End:** 6/30/2013

**Abstract**
The proliferation of explosives, new technologies, and expertise increases the potential for terrorists to evade our existing countermeasures at points of entry to and exit from the UK. Present methods for the detection of explosives leave much to be desired. To allow analysis to occur in the 'field' there is an urgent need for the development of on-site testing. There is also a need to detect explosives pollution on military sites. Toxic explosives residues are released into the environment on military training ranges as a result of incomplete detonation of munitions. As explosives are toxic it is therefore essential that the MoD consider the fate and transport mechanisms and the subsequent impact of these materials on the terrestrial environment. The availability of benchmark data regarding the transport and fate of the energetic materials will support predictions and modeling to enable the MoD to use best management practices for the stewardship of military sites. The results obtained will provide potential cost savings, since such knowledge will mitigate contamination and alleviate the need for future clean-up operations.

To address these challenge, we are aiming to develop novel inexpensive sensors to rapidly and effectively detect explosives. We intend to construct a proof-of-principle cell-based sensor where the cells specifically respond to the explosive TNT and produce a signal that is detected by an optical device. This requires engineering a genetic regulatory protein that specifically binds TNT. The TNT bound regulatory complex then binds to the promoter region of a reporter gene resulting in the expression of an enzyme alkaline phosphatase which is secreted out of the microbial cell. The secreted enzyme then activates a fluorescent compound and this signal is then detected using an optical waveguide sensor. The development of a genetic regulatory element that specifically recognises explosives would result in a step-change towards the development of a biosensor with strong relevance to the security and defence area.

**Funding amount:** £44,773.89
Generation of a large family of genetic logic gates for applications in biosensing and information processing

Funder: BBSRC

Project Reference: BB/J020133/2

Start: 11/1/2013   End: 10/31/2015

Abstract
Electronic logic gates are the building blocks of all the digital devices, such as computers and smart phones, on which we have come to rely. Individual logic gates take one or more digital (ON or OFF) inputs, perform a logical operation and produce a single digital output. For example, the output of an AND gate is ON only if both of its inputs are ON, whereas the output of an OR gate is ON if either (or both) of its inputs is ON. Electronic logic gates can be connected together into circuits that can store data, add and subtract numbers, count, and carry out any other logical or mathematical calculation. The microprocessor at the heart of a typical modern digital computer has tens of millions of logic gates, all connected together into complex circuits.

Scientists working on simple bacterial cells have used them to create genetic networks that can reproduce the behaviour of individual logic gates. Just like their electronic counterparts, these biological logic gates can take one or more inputs, perform a logical operation and provide an output. For example, a bacterial AND gate has been engineered to take its input from two natural sensors in the bacterial cell that detect different sugars in the environment. The logic gate combines these two inputs and produces an output, in the form of a fluorescent protein, only when both sugars are present. The hope is that one day these biological logic gates can be engineered into more complex circuits that can perform multiple logical operations, store information, make complex preprogrammed decisions, and have multiple outputs. For instance, a cell could be engineered to detect pollutants and to take action to neutralize the exact cocktail of pollutants present, or to undergo a complex series of metabolic steps to turn agricultural waste into valuable chemical feedstocks or pharmaceutical products.

Each biological logic gate has to be individually built from genetic components known as transcription factors and promoters. Transcription factors and promoters are used by cells to control their own gene expression in response to their environment. To ensure that individual logic gates operate independently of each other in a circuit with multiple logic gates, a different transcription factor must be used for each logic gate. Up until now, transcription factors and promoters had to be sourced from natural systems and characterised one by one, and the lack of a large number of different, well characterised transcription factors has severely limited the complexity of digital genetic circuits that can be built.

In the research proposed here, we will develop a new way to produce a large set of transcription factors and promoters that do not interfere with each other’s action. Unlike other transcription factors that have been used to build genetic logic gates to date, these transcription factors will not cause unwanted side effects by altering gene expression in their bacterial host. Therefore, the set of transcription factors we generate will be ideal for building large genetic circuits, containing multiple logic gates, to carry out complex data processing and storage operations.
Application of biological logic circuits for in-the-field detection of pollutants, toxic agents, pathogens, water contaminants, explosives etc. will depend on miniaturised reliable detectors of their outputs. We will develop a miniature device to detect fluorescent proteins produced as outputs of bacterial genetic logic circuits, and will test this device using a genetic circuit built from our new transcription factors. This should pave the way towards the development of portable, easy to use biological sensors and processors for a whole host of applications.

**Funding amount:** £69,912.94
Novel strategies for single step molecular diagnostics assays with full
dynamic range quantitation

Funder: BBSRC

Project Reference: BB/L022346/1

Start: 6/1/2014   End: 11/30/2017

Abstract
Molecular diagnostics is the most sensitive technique to detect specific organisms, pathogens or other biological material that contains DNA, and is widely used in diagnostic laboratories worldwide. It relies on specific primers to recognize target DNA sequences unique to the organism being detected, making it highly specific. Most molecular diagnostics uses the polymerase chain reaction (PCR), which involves repeated rounds of heating and cooling to make many copies of the target DNA, amplifying it so it can be detected. However the need for temperature cycling, and for sophisticated fluorescence-based systems to detect the amplified DNA, means that it is largely restricted to laboratory use. Moreover PCR is rather sensitive to inhibition by a number of common chemicals found in the environment and body fluids, requiring samples to be extensively purified before analysis.

As a result the instruments required for PCR are vulnerable and relatively expensive to engineer. Molecular methods are therefore largely confined to large and expensive equipment within diagnostic laboratories requiring skilled operators. The limited equipment available for out-of-laboratory use is expensive, relatively large and unsuited to widespread application.

The best solution to these problems is a recently developed approach based on amplification at a constant temperature, so-called isothermal amplification, coupled with a read-out of light as the specific target DNA sequence is amplified. This "bioluminescent assay in real-time" or BART results in a emission of a continuous light signal that reaches a peak at a time proportional to the amount of DNA present. BART was invented by the applicant and the CEO of the company started to commercialise such assays, Lumora Ltd. BART has been licensed by Lumora to the global partner 3M, who have commercialised assays for detecting food pathogens. This demonstrates the effectiveness and robustness of the approach.

BART produces a light output that is simple and cheap to monitor using a camera chip or photodiodes in a solid-state device. This substantially reduces instrument costs and open up new applications for diagnostics and disease monitoring in resource-poor settings such as in the developing world, where there are extensive requirements for cheap molecular assays for disease diagnosis.

A major challenge in molecular diagnostics remains the accurate measurement of the numbers of disease organisms (and hence target DNA molecules) in the sample. This can be done both by PCR and using BART, but the ability to accurately determine the number of molecules of the target becomes much more difficult below about 50 copies for both techniques. For certain diseases and situations, it is critical to be able to accurately measure the numbers of targets at this level. The proposed project is based on new methods discovered by the applicant and the company partner which are able to accurately determine the number of molecules down to a single molecule of target DNA. Moreover, remarkably they can distinguish between numbers of copies accurately in the range 1-10. The proposal is to test and develop these new approaches, and to
use them with fluidic chips that would allow accurate measurement of numbers of molecules from 1 up to 100’s of billions in a single set of assays carried out on a single plastic chip simultaneously- a so-called full dynamic range assay. Purpose designed algorithms will be developed and explored to analyse the data allowing the numbers to be quantified throughout the dynamic range using the most appropriate combination of methods for each part of the range.

If successful, this would represent a breakthrough in molecular diagnostics with significant implications as a full dynamic range quantification method, which would see widespread application in research, medical diagnostics, disease monitoring, and environmental protection, with potential economic, health and societal benefits.

**Funding amount:** £393,245.1
Engineered security systems for environmental synthetic biology

Funder: BBSRC

Project Reference: BB/J019720/1

Start: 9/1/2012   End: 11/30/2013

Abstract
This research seeks to provide crucial parts needed to advance the exciting new topic of synthetic biology in order to safely and securely realise biotechnology applications for health, environment and energy needs. Since 2000, the new field of synthetic biology has advanced the existing science of genetic modification by applying principles of engineering; design, simulation and testing. This approach has allowed us to predictably create exciting new technologies by modifying safe microbes to perform new tasks including computation, multi-input environmental sensing and efficient production of medicinal drugs and bioenergy. While research success in synthetic biology has been rapid, the transfer of this work into real applications used by society has been limited; we can build excellent cell biosensors for explosives, arsenic and other environmental pollutants but none have actually been put to use. Largely this is because synthetic biology creates genetically modified organisms (GMOs) and these are a regulatory hazard to deploy. The major concern is that engineered DNA of these GMOs will be transferred to natural microbes by a process called horizontal gene transfer (HGT) and that this will disrupt natural ecosystems. This concern is particularly apt when we work with bacteria such as E. coli, as in these organisms synthetic biologists typically engineer their systems to be maintained on DNA circles called plasmids, which are easy to work with but also rapidly shared among bacteria and usually confer resistance to antibiotics. To overcome this hurdle and allow safe application of synthetic biology in the environment, this research aims to use synthetic biology techniques to construct a new kind of plasmid system that is secured to the intended cell, does not confer antibiotic resistance and resists horizontal gene transfer into natural bacteria. The development of this will include an assay to measure HGT and a model simulation to predict the key factors involved.

Funding amount: £120,073.4
NanoLiquid

**Funder:** BBSRC

**Project Reference:** BB/L018152/1

**Start:** 6/1/2014  **End:** 12/31/2015

**Abstract**

All biochemical processes, chemical reactions and physical transitions obey the laws of thermodynamics. Therefore, calorimetry provides a universal means for monitoring the rate of any chemical, physical or biological processes. A range of applications of calorimetry exceeds that for virtually any other modern analytical technique. The general tendency in modern calorimetry and thermal analysis is the reduction of the size of sample and the increase in sensitivity and resolution of measuring time and temperature. Calorimetry has been applied to a highly diverse range of targets used at a variety of scales from whole-body calorimetry down to sub-nanoliter sample volumes. Despite the general tendency towards miniaturisation, simply scaling down traditional calorimetric techniques, although beneficial for material sciences, may not work well for biological objects, which cannot always be scaled down to suit instrument size or taken out of their natural environment. One of the key challenges is therefore to be able to probe the thermodynamics of biological objects, e.g. individual cells, cell compartments or individual organelles and, ultimately individual molecules, such as enzymes, without removing them from their macroscopic environment and preferably remotely, without using artificially introduced markers or inserting any sensors into such cells or organelles.

In this project we aim to develop a high frequency hybrid AC/DC modulated liquid nanocalorimeter instrument capable of real-time and label-free analysis and suitable for the analysis of ultra-small quantities of biological material (of the order of few nanograms and below, which is orders of magnitude improvement over currently available commercial instruments) or the material localised within 10-100 nm of the surface of sensor chip even in bulk samples. Such capability should enable studying cellular metabolic processes and thermodynamics of molecular interactions and biochemical processes at cellular and sub-cellular levels, in the locality of the sensor even in the bulk samples. Such capability has not been achieved or reported previously.

Our approach is fundamentally different from the general trend followed by many researchers and instrument manufacturers where the aim is to MINIATURISE THE SAMPLE and then to conduct bulk calorimetry measurements (of the whole of the miniaturised sample). Such approach suits well material sciences but is not suitable for liquid biological samples. Contrary to that general trend we aim to build an instrument for measuring local thermal properties in the defined vicinity of the miniaturised sensor, irrespective of the overall sample/object size. Our approach is therefore ultimately suitable for biological objects, which cannot be taken out of their native biological environment or be miniaturised to suit instrument limitations. The instrument will be suitable for a wide range of applications in fundamental and applied biosciences, biomedical research. Our measurement principle should allow the development of universal miniaturised implantable calorimetric sensors.

**Funding amount:** £147,293.68
High Spec Raman Spectrometer Regional Facility

Funder: EPSRC

Project Reference: EP/M022749/1

Start: 8/26/2015   End: 8/25/2018

Abstract
The most common spectroscopic methods for providing chemical fingerprints of molecules and materials are Raman and Infra-red (IR) spectroscopy. Raman and IR spectroscopy are complementary techniques; generally when a material is Raman active it is IR inactive and vice versa. Advantages of using Raman over IR include the minimal sample preparation required, the increased spatial resolution achieved and the fact that analysis of wet samples is possible since water is not significantly Raman active but water features are dominant in IR when present.

Commonly available Raman spectrometers consist generally of one or two laser lines, restricting the type of characterisation that can be carried out. The instrument proposed here will provide a Raman microscope-spectrometer with lasers that cover the spectrum from the deep UV into the Infra-red. This allows the widest range of sample materials to be analysed. Additional features of the proposed system will allow temperature controlled studies, and high speed Raman chemical imaging of large area samples.

By providing chemical fingerprints of materials, Raman spectroscopy, can offer sample identification down to submicron spatial resolutions. Information on sample composition, interactions between materials, distributions within composites, and charge distribution can be provided non-invasively. The programme of work enabled by the proposed facility spans the areas of: energy conversion technologies such as reverse electrodialysis and fuel cells, energy storage (e.g. batteries and supercapacitors), electrocatalysts, nuclear fuel recycling, heterogeneous catalysis, CO2 conversion, forensic analysis, sensors, and biochemistry.

Funding amount: £23,577.88
Example-based Inverse Rendering

**Funder:** EPSRC

**Project Reference:** EP/N028481/1

**Start:** 1/6/2016   **End:** 4/5/2016

**Abstract**

"Rendering" is the computer graphics process of producing an image from a 3D model. Huge progress has been made on this problem over the past 50 years as evidenced by the photorealistic visual effects in Hollywood movies and highly engaging realtime graphics in video games. "Inverse rendering" is the much harder computer vision process of recovering shape and material properties of an object or scene from one or more images. Progress in this area has been much slower than for forward rendering and very few methods exist that are applicable to real world data. The exception is the estimation of 3D shape where techniques such as multiview stereo do allow accurate 3D models to be recovered from relatively uncontrolled imagery.

However, it is the material properties of a surface that determine the way in which light is reflected and, hence, its appearance. Once these are known, it is possible to predict what an object will look like under any illumination condition - a so called "relightable" model. This dramatically expands the range of applications for which the model could be used. In the specific case of faces, relightable models find application in many areas including animation, gaming, forensic imaging, biometrics and visual effects.

In this project, the PI will visit the world-leading Centre for Visual Computing at the University of California, San Diego to collaborate on an "example-based" approach to the problem of inverse rendering for faces. The idea is to use a database of faces for which the intrinsic reflectance properties have been measured. Given images of a face to inverse render, the approach will be to select patches from the database that are consistent with the observations (via a forward rendering process) and which are also locally consistent to ensure plausible face appearance.

**Funding amount:** £12,862.45
Academic Centre of Excellence in Cyber Security Research - Queen's University Belfast

Funder: EPSRC

Project Reference: EP/R007187/1

Start: 10/1/2017   End: 9/30/2022

Abstract
Our world has become increasingly digitised, affecting how we communicate, manage our finances, access healthcare and even interact with household devices. With more of our information held digitally and connected across multiple devices as well as in the cloud, significant new cyber security challenges are emerging. How can we process and transmit large volumes of information created by citizens, enterprise and government securely? How do we meet the demand for innovative technologies and solutions to counter the threat? How do we produce the next generation of industry leaders, new ventures and a skilled workforce to sate the ever growing appetite for cyber security experts globally? These are some of the global challenges being tackled by CSIT every day.

CSIT was awarded the a Queen's Anniversary Prize for Higher and Further Education in 2015 for its work in strengthening global cyber security and protecting the online activity of billions of internet users around the world. It is already internationally recognised as performing state-of-the-art research in a number of key areas. These include:

Device authentication - Development of Post-quantum cryptographic solutions, low power cryptosystems for RFID and IoT devices, high speed integer based fully homomorphic encryption

Secure ubiquitous networking - Securing real-time connectivity between devices, sensors and cloud resources. Mobile malware detection methods to counteract advanced evasion technologies such as polymorphic and metamorphic obfuscation. Securing highly distributed networks for critical infrastructures. Securing software defined and highly virtualised networks.

Security analytics and event management - Forensic data clustering and anomaly detection. Online graph-based mining algorithms to process data in real-time. Data mining approaches to learn inference rules about events and engage multi-criteria decision making for autonomous cyber security threat assessment

A key aspect of the Centre is the commercialisation of the research through a dedicated team of commercial and business development staff. This includes mechanisms such as the CSIT Membership programme, spin outs, a cyber security incubator programme (CSIT Labs), licensing, knowledge transfer partnerships and contract research and development.

Funding amount: £81,965.12
Ambient Pressure Mass Spectrometry at the Sub Micron Scale

Funder: EPSRC

Project Reference: EP/I036516/1


Abstract

This proposal aims to develop a new ambient pressure mass spectrometry imaging system. It will use a beam of ions accelerated to MeV potential energy - velocities of the order of 5% the speed of light or less. The beam will be focussed using a set of quadrapole magnetic lenses to less than a micron in size and will be passed out of the vacuum system through a 100nm thick silicon nitride window into air where it will be able to travel between 0.5-1.0cm before stopping. A sample placed in front of this beam of ions will be sputtered (eroded) by the interaction of the ions with the electrons in the system (electronic energy loss). Previous experiments in vacuum have demonstrated that if the sample is a molecular material it is possible to extract large (~45kDa) molecular species from the surface and that these can be detected in a Time of Flight mass spectrometer to determine their molecular mass. Fragments that are removed at the same time give indications about the bonding arrangements of the molecules sputtered and can be used to determine the probable molecular arrangement.

The beam itself can be raster scanned using an electrostatic field so that a molecular map of the surface of the material can be determined at the micron scale. The ions as they enter the surface of the material are moving fast enough that they will also cause electrons in the outer shells of the atoms that they pass to become exited and in relaxing back will give out a characteristic X-ray. These X-rays can also be collected and analysed using a technique known as Partical Induced X-ray Emmision (PIXE) to give trace element maps as well.

This will be the worlds first scanning mass spectrometer capable of imaging at the sub micron scale in air.

Applications for this equipment range from forensics to biomedicine taking in geology and the environment as well as helping to understand the origins and manufacture of art and archeological remains. These applications will be encouraged over the period of the project.

Funding amount: £1,278,390.51
The colours, or RGB pixels, recorded by a digital camera are the result of the interaction of the prevailing light in the scene striking and being reflected by objects and the characteristics of the camera itself. The complexity is such that different cameras see differently and no cameras see the world exactly as we do. You will have noticed this when looking at photos where sometimes the colours don't look right or the pictures captured by one camera look 'better' than another. Moreover, sometimes we see colours change dramatically. We have all probably observed that white clothes can look bluish under ultra violet light (say in a night club). But, in fact the colours we see change subtly, all the time, as we move from one light to another (which is why it is always a good idea to check the colour of your clothes outside the shop). Here, even small changes can lead to poor customer satisfaction or, potentially, in a medical imaging application the wrong diagnosis.

Good pictures, by which we might mean accurate 'colour measurement' are possible if we know the spectral colour characteristics of a camera and/or the spectrum of light in a scene. While we can, in principle, measure these quantities the measurement is not easy to do so and is expensive (not easy as it requires considerable (Physics) lab time and expensive because spectral measurement devices cost many thousands of pounds). When measurement is not feasible, there do in fact exist methods for estimating (say) the spectrum of light in a scene. Yet, these methods only tend work if the camera is accurately calibrated first (a sort of chicken and the egg situation). Our 'Rank Based Spectral Estimation' Project aims to make it much easier to calibrate a camera or measure the illuminant in situ (and as such also make it easier to measure reflectance too)

So, how does our method work. Well suppose we gave you 50 grey tiles all of which appeared to have a different brightness. It would be an easy task for you to rank them from darkest to brightest. But, now suppose we change the colour of the light. Depending on the spectral shape of the grey reflectances, the ranking order can change (sometimes considerably). No problem, it is a simple matter to reorder the tiles. Remarkably, for specially chosen reflectances, the rank order will strongly correlate with the spectral shape of the light. Thus a simple ranking experiment gives us a strong clue to the colour of the light. (And, if we knew the colour of the light we could, for example predict whether the colour of our clothes might change when we go outdoors.)

The Rank Based Spectral Estimation project aims to take this simple ranking idea and provide simple, and accurate, estimation tools for deriving the spectral shape of the prevailing light, the spectral characteristics of a camera and the spectral reflectances of surfaces. At the heart of our method is a specially designed reflectance target containing many reflectances (whose design is part of the proposed research). Ranking these reflectances will allow us to accurately estimate the light spectrum and the spectral attributes of a camera. Accurate spectral estimates are required in many applications from photography, through, visual inspection to forensic imaging and telepresence (e.g. remote diagnosis).
Remarkably, we believe the methods we develop will also prove useful in understanding how we see. Indeed, it is very likely that you see the world a little differently than I do. Yet estimating an individual's spectral response is notoriously difficult. To the extent it can be done at all, it requires many hours of (tedious) detailed visual experiments. Through ranking it will be possible to uncover an observer's spectral response (technically called 'colour matching curves') quickly and simply. We simply ask the observer to carry out a simple ranking of the kind mentioned above.

**Funding amount:** £57,270.63
**UV light sources based on solid silica fibres**

**Funder:** EPSRC

**Project Reference:** EP/L01243X/1

**Start:** 4/30/2014  **End:** 10/29/2017

**Abstract**

Optical fibre lasers offer significant benefits in comparison to other laser sources, such as extremely low thermal lensing, extraordinary good beam quality and very high plug efficiency. Optical fibre lasers have worldwide sales in excess of $300M and a predicted annual growth rate of 20-40%, thus are rapidly replacing other types of more conventional lasers. Indeed, the increasing deployment of high power fibre lasers in manufacturing has improved consumption efficiency.

Up to date only near-IR sources have been manufactured in fiberized forms. The challenge is to develop new fiberized sources in the mid-UV. The successful manufacture of optical fibre lasers would have numerous applications which include, amongst others, water purification, insulators (such as plastics or glass) marking and processing, explosive detection, forensics and counter measures.

This project aims to demonstrate the possibility to use solid silica fibres to efficiently generate light in the UV. The proposed programme spans from the manufacture of specialty silica fibres transparent to the UV, doped with novel lasing elements, the design of fiberized laser pumps, and their combination in suitable systems to produce a new generation of affordable higher performance lasers.

A variety of lasers with wavelength in the range 170nm to 330 nm will be developed and their applications in Raman spectroscopy and supercontinuum generation will be investigated.

**Funding amount:** £419,559.92
Abstract
This proposal addresses joint tracking and enhancement of signals received from a target which admits an acoustic signature. Processing of real-world analogue signals measured using a variety of sensors, such as microphones, and which propagate in multipath or reverberant environments such as any building, is fundamental to a variety of applications. Within civilian and domestic settings it is important for teleconferencing and hands-free audio enhancement applications. Within the homeland security and defence sectors it is crucial in a wide variety of fields such as forensics and surveillance, and a number of problems requiring target detection and identification -- for example outdoor gunshot detection and localisation in urban environments. Any signal radiated in a confined space exhibits reverberation, also known as multipath propagation, due to reflections off surrounding obstacles. However, many existing signal processing technologies fail to explicitly model the multipath response. Consequently, multipath causes significant problems in signal enhancement and separation, signal detection, high-resolution source localisation, and joint detection, classification, and localisation technologies -- these are all technologies with which consumers are becoming familiar through every day devices such as mobile telephones and audio playback devices. Blind multipath equalisation can be improved with accurate modelling of the acoustic distortion which, in turn, depends on knowledge of the target-position, thereby requiring target tracking. However, many passive target tracking methods -- those which do not actively emit a signature signal, such as active radar and sonar -- suffer from the presence of multipath leading to substantial errors in tracking. Target tracking can thus be improved by modelling the effect of, or even equalising, the acoustic reverberation from the observations, thereby allowing identification of the true source from signal reflections. Target tracking and blind multipath equalisation should therefore be solved jointly rather than separately. The objective of this 12-month research programme is to address the detrimental effect of multipath mitigation by developing algorithms for joint blind enhancement and passive source localisation of speech sources in an indoor multipath environment.

Funding amount: £95,379.85
Nanoconjugates for the detection of forensic residues

**Funder:** EPSRC

**Project Reference:** EP/G005850/1

**Start:** 4/3/2009    **End:** 10/2/2010

**Abstract**
This research proposal builds on previous EPSRC funded work which focused on the fabrication of nanoparticles for the acquisition of forensic evidence. The goal here is to make simple metal and metal oxide nanoparticles that will be coated with biological molecules. These bio-molecules will specifically bind to residues in forensic evidence which will prove the presence or absence of illicit substances. The work programme combines end-user partners who will provide project focus in law enforcement and security fields.

**Funding amount:** £100,046.87
Interdisciplinary Centre for Finding, Understanding and Countering Crime in the Cloud

Funder: EPSRC

Project Reference: EP/M020320/1

Start: 10/1/2015   End: 9/30/2020

Abstract
The Cambridge Interdisciplinary Centre for Crime in the Cloud (CICCC) will combine the diverse range of skills available in the Institute of Criminology, the Faculty of Law and the Computer Laboratory at the University of Cambridge. Our approach will be multidisciplinary, including researchers with expertise in computer science, criminology, cybersecurity, economics, psychology, forensics and law.

Our approach will be data driven. We have negotiated access to some very substantial datasets including large feeds of data such as spam email messages and technical information about the operation of cloud services from several major cloud providers and public bodies. Together, they will constitute the largest data resource available anywhere outside of classified systems on abuse online; we will have more, and more diverse, data than almost all service firms or law enforcement agencies, creating a unique opportunity for research to develop new tools for cloud crime detection and forensics.

We will mine and correlate these datasets to extract information about criminal activity. Our analysis will enhance our understanding of crime in the cloud, enable us to devise identifiers of such criminality, allow us to build systems to detect crime when it occurs, and ensure we collect evidence of wrongdoing to a high standard. We will work closely with law enforcement to ensure appropriate interventions can be undertaken.

Our overall objective is to create a sustainable and internationally competitive centre for academic research into cybercrime. The primary aim of the centre is to improve the security of users of cloud services, and to improve outcomes for those who would be affected by their misuse. We will develop a strong legal framework to operate in, and maintain high ethical standards in everything we do. We will incorporate this into APIs for abuse data sharing that support appropriate authentication, nonrepudiation and privacy mechanisms, and feed these back to the industry.

We aim to provide the police with an enhanced ability to search large amounts of data related to cybercrime in the cloud, improved forensics, better chain-of-custody mechanisms for evidence, additional training, and meaningful statistics on cybercrime. We have strong relationships with industry, and we will provide them with important data and insights on how, when and why criminality in the cloud occurs, thus enabling cloud providers to improve security for the users of cloud services by cracking down swiftly on abuse. We will also work closely with other academics, providing sanitised datasets to researchers generally, and enable trustworthy researchers access to our full dataset on the same basis as ourselves. This will solve the main problem faced by most academics who want to do research on cybercrime, namely the difficulty of getting access to real data on actual abuse.

Funding amount: £1,975,496.12
Chemical Applications of Velocity and Spatial Imaging

Funder: EPSRC

Project Reference: EP/L005913/1

Start: 1/8/2014   End: 9/30/2019

Abstract

Ion imaging, first demonstrated just 25 years ago, is already having a major impact on the way we explore molecular change (the very essence of chemistry) in many gas phase systems. The technique has features in common with mass spectrometry (MS). Both start by removing an electron from the target species, generating ions, i.e. charged molecules or fragments, which are then 'sorted' by their mass. In traditional MS, the species of interest is characterised by its spectrum of ion yield versus mass. Electron removal in most ion imaging experiments is induced by a short pulse of laser light; the resulting ions are then accelerated towards a time and position sensitive detector. Heavier ions travel more slowly, so one can image ions of just one particular mass by ensuring that the detector is only ‘on’ at the appropriate time. The spatial pattern of ion impacts that builds up on the detector when the experiment is repeated many times is visually intuitive, and provides quantitative energetic information about the reaction(s) that yields the monitored product. However, the read out time of current ion imaging detectors is too slow to allow imaging of ions with different mass formed in the same laser shot, and many species are not readily amenable to ionisation in current ion imaging schemes. Imaging all products from a given reaction is therefore time consuming (at best) and, at worst, impossible.

We seek to solve both these limitations. Two of the team have already demonstrated new, much faster, time and position sensitive sensors capable of imaging multiple masses in a single shot experiment. This multimass imaging capability will be developed further and rolled-out for use and refinement across the team. We also propose new multiphoton ionization schemes as well as 'universal' ion formation methods based on use of shorter laser wavelengths or short duration pulses of energy selected electrons. The following over-arching scientific ambitions will proceed in parallel, and exploit the foregoing advances in ion imaging technology at the earliest possible opportunity:

(i) We will use the latest ion imaging methods to explore molecular change in the gas phase, focusing on key families of (photo)chemical reactions: addition, dissociation, cyclisation and ring opening reactions of organic molecules, and metal-ligand and metal-cluster interactions. These choices reflect the importance of such reactions in synthesis, catalysis, etc., their amenability to complementary high level theory, and our ability to explore the same reactions in solution (using a new ultrafast pump-probe laser spectroscopy facility). Determining the extent to which the mechanisms and energetics of reactions established through exquisitely detailed gas phase studies can inform our understanding of reactivity in the condensed phase is a current 'hot' issue in chemical science, which the team is ideally placed to address.

(ii) We will develop and exploit new multi-dimensional analytical methods with combined mass, structural and spatial resolution. Mass spectra usually show many peaks attributable to fragment ions, but the paths by which these are formed are often unclear. Imaging MS is proposed as a novel means of unravelling different routes to forming a given fragment ion; distinguishing and characterising such pathways can offer new insights into, for example, peptide
structure. Yet more ambitious, we propose to combine multimass and spatial map imaging with existing laser desorption/ionisation methods to enable spatially resolved compositional analysis of surfaces and of samples on surfaces. Such a capability will offer new opportunities in diverse activities like tissue imaging (e.g. detection of metal ions within tissue specimens of relevance to understanding the failure of some metal-on-metal hip implants), forensic analysis (e.g. 'chemical' imaging of fingerprints, inks, dyes, pollens, etc) and parallel mass spectrometric sampling (e.g. of blood samples).

**Funding amount:** £4,663,077.1
Accelerated Real-Time Information Extraction System (ARIES)

Funder: EPSRC

Project Reference: EP/J020540/1

Start: 10/1/2012   End: 9/30/2013

Abstract

Technological advances in CMOS semiconductor technology paved the way for the digital revolution. As predicted by Moore, silicon integration capability has been doubling every 18 months over the past four decades, providing the foundation for low-cost computing and memory technology.

The digitisation of information and communication technologies sparked a number of innovations revolutionising the way we compute and communicate. Ubiquitous high-bandwidth communication, enabled by WiFi and 3G/4G technologies, facilitates on-demand access to a vast amount of application and location specific information including multimedia and broadcast content, video and voice communications, email and SMS/MMS. Furthermore, it has enabled on-demand access to personalised storage and computing resources, providing the foundation for the development of cloud computing infrastructures and a wide range of online web-based services and applications. With the decreasing cost of communication and storage the Internet has also become the global communication infrastructure for a wide range of autonomous sensor technologies, referred to as the "Internet of things". Key application areas include monitoring/surveillance, smart grid, smart homes and smart cities.

Monitoring internet traffic and mining meaningful information from both the online traffic and the stored information has emerged as essential for many critical applications and services. For example resource management, market intelligence, physical and cybercrime investigations and forensics, cyber space policing, situation awareness and the monitoring of malicious behaviour for criminal and terrorist intent. As the scale, diversity and distributed nature of current and emerging data assets increases and as data becomes ever more ubiquitous and critical to decision making, effective real-time mining of useful information becomes essential.

Considering the exponential increase of internet traffic and stored data, traditional software based approaches have become inadequate and unsustainable. Performance gain achieved due to Moore's law does not keep up with the required computing bandwidth of current and near future generated data assets. Internet traffic bandwidth is doubling every 12 months while the emerging content diversity is significantly increasing mining complexity. As the enterprise becomes more data centric, with a significant increase in data assets within the public and private cloud, traditional scaling by increasing the number of computing resources can no longer be sustained due to cost and power dissipation.

Most data mining algorithms are derived by the software community and are optimised for data structures for platforms based upon the Von-Neumann architecture. An effective solution now requires a paradigm shift in the way we process data and also how we extract meaningful information from a large amount of distributed, constantly changing data that is partially stored or in-transit.

Funding amount: £252,523.05
Abstract
The current proposal is submitted in response to an invitation by EPSRC wrt. the Academic Centre of Excellence in Cyber Security Research (ACE-CSR) scheme. It complements a concrete proposal for the University of Bristol (UoB) to be recognised as an ACE-CSR. The long term goal is to coordinate existing world-class research (including, for example, cryptography and quantum key distribution, digital forensics and computer virus/malware analysis) under a UoB-wide research centre termed the Bristol Security Centre (BSC); the BSC will, for example, capitalise on internal research synergies, deliver training cyber security, and foster strategic links between research groups and various external stakeholders (including but not limited to CESG, EPSRC, other ACE-CSRs, and industrial partners).

In short, the proposal outlines various activities that require modest funding (by EPSRC) for said ACE-CSR to fully engage with the scheme and meet the goals outlined above (and expanded upon the case for support).

**Funding amount:** £47,775.51
Abstract
The colours, or RGB pixels, recorded by a digital camera are the result of the interaction of the prevailing light in the scene striking and being reflected by objects and the characteristics of the camera itself. The complexity is such that different cameras see differently and no cameras see the world exactly as we do. You will have noticed this when looking at photos where sometimes the colours don't look right or the pictures captured by one camera look 'better' than another. Moreover, sometimes we see colours change dramatically. We have all probably observed that white clothes can look bluish under ultra violet light (say in a night club). But, in fact the colours we see change subtly, all the time, as we move from one light to another (which is why it is always a good idea to check the colour of your clothes outside the shop). Here, even small changes can lead to poor customer satisfaction or, potentially, in a medical imaging application the wrong diagnosis.

Good pictures, by which we might mean accurate 'colour measurement' are possible if we know the spectral colour characteristics of a camera and/or the spectrum of light in a scene. While we can, in principle, measure these quantities the measurement is not easy to do so and is expensive (not easy as it requires considerable (Physics) lab time and expensive because spectral measurement devices cost many thousands of pounds). When measurement is not feasible, there do in fact exist methods for estimating (say) the spectrum of light in a scene. Yet, these methods only tend work if the camera is accurately calibrated first (a sort of chicken and the egg situation). Our 'Rank Based Spectral Estimation' Project aims to make it much easier to calibrate a camera or measure the illuminant in situ (and as such also make it easier to measure reflectance too)

So, how does our method work. Well suppose we gave you 50 grey tiles all of which appeared to have a different brightness. It would be an easy task for you to rank them from darkest to brightest. But, now suppose we change the colour of the light. Depending on the spectral shape of the grey reflectances, the ranking order can change (sometimes considerably). No problem, it is a simple matter to reorder the tiles. Remarkably, for specially chosen reflectances, the rank order will strongly correlate with the spectral shape of the light. Thus a simple ranking experiment gives us a strong clue to the colour of the light. (And, if we knew the colour of the light we could, for example predict whether the colour of our clothes might change when we go outdoors.)

The Rank Based Spectral Estimation project aims to take this simple ranking idea and provide simple, and accurate, estimation tools for deriving the spectral shape of the prevailing light, the spectral characteristics of a camera and the spectral reflectances of surfaces. At the heart of our method is a specially designed reflectance target containing many reflectances (whose design is part of the proposed research). Ranking these reflectances will allow us to accurately estimate the light spectrum and the spectral attributes of a camera. Accurate spectral estimates are required in many applications from photography, through, visual inspection to forensic imaging and telepresence (e.g. remote diagnosis).
Remarkably, we believe the methods we develop will also prove useful in understanding how we see. Indeed, it is very likely that you see the world a little differently than I do. Yet estimating an individual's spectral response is notoriously difficult. To the extent it can be done at all, it requires many hours of (tedious) detailed visual experiments. Through ranking it will be possible to uncover an observer's spectral response (technically called 'colour matching curves') quickly and simply. We simply ask the observer to carry out a simple ranking of the kind mentioned above.

**Funding amount**: £465,217.62
Regression methods, interpreted broadly, enable the user to measure dependence of a response variable of interest on a set of covariates, i.e. measurable variables that are expected to affect the response variable. The power of this approach is due to the fact that, given the covariate values, the regression model can be used to predict a likely range of values of the response variable, and to assess which covariates are the main drivers in the behaviour of the response. This project is concerned with types of response variable which have complicated nonlinear structure (in mathematical terminology, the response is manifold-valued). For such data, no general framework for regression modelling exists. An example of the type of response variable that we wish to consider is the shape of an object; shape is a highly nonlinear entity.

There are numerous potential applications of the regression methodology that we will develop, many (but not all) of which are in biology and medicine. For example, within the foreseeable future we expect the outputs of our project to assist surgeons in making decisions in the following situation. Suppose a patient has a tumour and the surgeon wishes to decide which type of operation (if any) would be best. A suitable regression model would enable prediction, under each type of operation, of the growth trajectory of the tumour after the operation. Relevant covariate information would include variables such as size-and-shape of the tumour before the operation, location of the tumour, age and gender of the patient. The surgeon would then be able to assess which trajectory, and therefore which type of operation, would be most favourable for the patient.

A second application, this time for neuroscience, relates to diffusion tensor imaging. One output of the project will be methodology for interpolating manifold-valued data in a spatial setting. In the context of diffusion tensor imaging of the brain, spatial interpolation of the diffusion tensor data will provide more accurate maps of the brain which will give improved and more soundly-based interpretations of the white matter fibre structure to help understand brain function.

A third application is in forensic science. The models we develop will allow prediction of the development of the shape of a face, depending on covariate information, such as the shapes of the parents' faces, and other information such as gender and age. This methodology will be useful in child abduction cases for example. While it is certainly the case that methods for extrapolating face shape currently exist, they do not incorporate covariate information in the model.

There are many other research areas in which manifold-valued response data arise naturally and where we expect the project outputs to have a major impact, including plant biology (of relevance, ultimately, to food security) and protein modelling.

The practical problems which highlight generic issues in regression modelling for manifold-valued data have all arisen from our work with collaborators in other fields. Therefore the successful implementation of the novel and exciting ideas in
this proposal will provide a framework for addressing not only the problems that motivated this proposal, but also have a major impact on research in many scientific disciplines, in addition to being of methodological and theoretical interest to researchers in statistics, computer science, mathematics and related fields. The proposed research will also add in a substantial way to the available pool of UK expertise and to maintain its position as internationally-leading in the statistical analysis of shape and, more generally, object data.

**Funding amount:** £611,044.57
Hummingbird: Human-machine integration for biometric authentication

Funder: EPSRC

Project Reference: EP/R030839/1

Start: 3/1/2018   End: 8/31/2019

Abstract
We live in a technological age in which we can use our voice as a password to access online banking, and our children can pay for school lunches with a fingerprint. Biometrics, which reflect our physiological or behavioural characteristics, are now common as a way to prove our identity in order to access secure information, services or spaces. Given the important uses associated with biometrics, there is a fundamental need for accuracy in biometric analysis in order to encourage trust amongst both citizens and service providers. The feasibility study undertaken within the HUMMINGBIRD project will provide a human-inspired framework to address both needs.

The recent publication of two high profile report converge to make this endeavour timely and necessary. The first is the UK Governmental review on 'Future Identities', which recognised the transformative effect that digital technologies are having on identity. In particular, it noted the myriad of ways we now have to convey our identity, and to have it spoofed. The second is the UK Parliamentary Select Committee review on 'The Current and Future Uses of Biometrics' which highlighted two necessary future steps for biometric analysis: Analysis should draw on behavioural as well as physiological measures; and it should take full advantage of the combination of data across multiple biometrics and across decision makers in order to improve decision-making.

To address all factors, we propose an exciting project that will deliver a human-inspired multi-expert, multi-modality framework for biometric analysis. This will satisfy three aims: First, it will deliver enhanced algorithms for automated biometric analysis by incorporating successful strategies used by humans. Second, it will deliver a method of combining decisions made by humans and (enhanced) algorithms in order to boost accuracy. Third, it will deliver the potential to combine multiple biometrics, providing resilience in scenarios in which a single modality may be sub-optimal.

The HUMMINGBIRD project team possesses a unique combination of skills to explore this idea and indeed, we build on recently published theoretical work on this topic. In this proposal, we examine two biometrics - face and voice - which reflects the move to combine static physiological measures (facial images) and dynamic behavioural measures (temporal voice samples). We also concentrate on two decision-makers - the human and state-of-the-art automated algorithm - providing direct relevance to scenarios in which the human must be part of the decision-process (such as in forensic decisions). Our work will establish the fundamental performance levels of humans and machine algorithms when recognising faces and voices under optimal and sub-optimal presentation conditions. It will then seek to enhance the machine algorithms through incorporation of human rules and heuristics. Such a move offers the potential to boost accuracy and efficiency by streamlining automated solutions. More importantly, it exploits the fact that humans can outperform machine algorithms under some conditions, such as when trying to recognise a face under dim light, or a voice amidst noise. Finally, our work will apply an innovative data fusion model to combine the decisions of humans and machine algorithms from one
biometric, and then from multiple biometrics. This novel and creative element of our work addresses issues of accuracy, disagreement resolution, and resultant confidence in an identity decision, when the situation is inherently uncertain.

Arguably, biometrics reflect identity more directly than token or password systems because they rely on who we are rather than what we have or know. As such, biometric analysis is likely to remain a mainstay of identity management. The HUMMINGBIRD project presents real promise as a way to improve accuracy and confidence in that analysis, enabling accuracy of, and trust in, identity management as technology advances.

**Funding amount:** £288,333.91
Aperiodic Lattices for Photonic Engineering of Terahertz Quantum Cascade Lasers

Funder: EPSRC

Project Reference: EP/G064504/1


Abstract

Optical wavelength-scale photonic lattices (i.e. lattices formed from a spatially-varying refractive index) offer a very powerful mechanism to define and modify the photon resonance characteristics in a range of optical devices. Although highly successful up to now this approach has only been based on periodic lattices (with only a single, underlying spatial frequency, and associated with only a single colour of light) and so does not provide the ability to control the colour of the confined photons. In this proposal, we describe the use of aperiodic lattices (ALs) to provide significantly advanced spectral functionalities, e.g. to give just one example, multi-coloured lasing at user-defined frequencies. In this proposal, we aim to apply AL concepts to a terahertz (THz) quantum cascade laser (QCL) so as to enable tunability. This proposal is highly timely, since it takes advantage of recent important advances in THz QCL fabrication technologies and combines them with new theoretical insights into the properties of aperiodic structures. In particular, this proposal proposes the first ever active photonics device exhibiting an AL integrated into its opto-electronic structure. Recent years has seen THz technology (frequency: 1-10 THz, wavelength: 30-300 micron) the focus of much attention owing to its important impact in a wide range of commercial and security applications, for example, in medicine, microelectronics, security imaging, biotoxin detection, agriculture, gas sensing and environmental monitoring, and forensic science, etc. The development of the THz QCL has been a key development in the burgeoning of these technology areas. However, lack of THz QCL tunability has also acted as a major constraint. Hence, the demonstration of a compact, coherent, tunable THz QCL arising from this proposal will act as a significant enabler in the advance of THz photonics. The THz QCL employs sophisticated techniques for the control of electron propagation, with an active region comprising a repeated superlattice of only a few atoms thick of one semiconductor material, interleaved with similarly thin barrier layers of another material. In these semiconductor nanostructures, the energy bands split into subbands and minibands, with energy separations of several tens to a few hundreds of millielectronvolts, which determine electronic transport and also enable new optical transitions. When a bias voltage is applied across the material, a periodic cascade of such intersubband transitions is established. The population inversion necessary for lasing is then achieved through electrical injection. Adjusting the specific sequence of quantum wells and barriers to form an electronic AL allows both the electronic and optical properties of the THz QCL to be tailored at will. A photonic AL, on the other hand, provides arbitrary filter responses in a user-defined way, for example, to provide high transmission and high-resolution output at single or multiple wavelengths. The novel filtering functionality available from the photonic AL in conjunction with the gain spectrum available from the electronic AL provides far greater control of single or multiple laser wavelengths than with conventional methods. A combined approach to integrate both electronic and photonic ALs within a single THz QCL device is therefore another important aspect of this proposal. Such integration gives photons a strongly enhanced interaction time with the host material, and creates significant opto-electronic nonlinear and quantum effects.
**Funding amount:** £389,690.11
**Matrix-Assisted DOSY**

**Funder:** EPSRC

**Project Reference:** EP/H024336/1

**Start:** 9/1/2010  **End:** 11/8/2013

**Abstract**

Nuclear magnetic resonance (NMR) spectroscopy is the single tool most widely used by chemists for determining the molecular structures of unknown compounds. It is a wonderfully versatile and sensitive tool, but it has one major drawback: it is poor at analysing mixtures, so it is mostly used on carefully purified single compounds. Because many of Nature’s most challenging problems - and many of those posed by synthetic chemists and by industry - are presented to us as mixtures, a great deal of effort goes into separating mixtures into their individual components so that they can be identified. Diffusion-ordered spectroscopy (DOSY) tries to get around this limitation by separating the NMR signals of different molecules, so that the signals from different species can be distinguished. Over the last decade our research group and others have developed the technique and applied it with great success - but almost always to simple solutions. In this project, a postdoctoral research fellow will investigate separating the spectra of mixture components more effectively by adding substances such as surfactants (the active ingredients of soaps and detergents), gels and soluble polymers to solvents to make a solution (a matrix) that changes the way that molecules diffuse. These substances diffuse very slowly, but they also attract other molecules. The result is that the rates at which solute molecules diffuse in such a matrix are changed, by an amount that depends on how strong the attraction is. By tuning the properties of the matrix we should be able to optimise the separation of the NMR signals of different species, even resolving the spectra of isomers that cannot be separated by normal DOSY experiments. Initially DOSY was used largely by chemists, but it is now being applied in fields as varied as food science, forensic medicine, and environmental science. Using different matrices for DOSY will give such users much greater control over how signals of different species in a mixture are separated, opening up new applications.

**Funding amount:** £329,730.69
Temporal forensic analysis of digital Camera sensor imperfections for picture dating

**Funder:** EPSRC

**Project Reference:** EP/L006812/1

**Start:** 8/31/2014  **End:** 2/28/2016

**Abstract**

The research proposal aims to investigate the temporal variations of camera sensor imperfections in order to establish, for any given digital camera, a theoretical model that allows the analyst to estimate the acquisition date of digital pictures. This will advance the field of forensic science, with the potential for applications in high profile cases that require the extraction of evidential information for courtroom purposes. In this project, the analyst is assumed to have the camera device or a set of trusted pictures taken by the same camera and whose acquisition time is known. The goal is then to date one or more images supposedly obtained from the same source and whose acquisition time is unknown. This application will obviously help forensic investigators analyse incidents and link different events.

The novelty of the proposed approach lies in (i) New techniques for efficiently estimating the sensor pattern noise for the purpose of temporal analysis (ii) Classification and temporal analysis of three types of pixels, namely, normal pixels, abnormal but not yet defective pixels, and defective pixels. (iii) Use of machine learning techniques to model the temporal behaviour of camera sensor imperfections.

**Funding amount:** £95,000.46
Commercialisation of Lab-on-a-Chip technology for DNA profiling

Funder: EPSRC

Project Reference: EP/H007385/1

Start: 8/1/2009  End: 7/31/2010

Abstract

DNA profiling represents one of the most important and growing techniques currently used in the UK to investigate and fight crime. Established in 1995 the UK data base, which is the world’s largest per head of population, currently holds just under 5 million individual profiles, based on short repeating DNA sequences, offering a discriminating power of one in 50 million. At present DNA profiling is being used to solve around 50,000, or one in every 300 recorded crimes per year, in the UK. The effectiveness and use of the technique in supporting police investigations could however be significantly improved if the unit cost and time taken from collecting a sample to obtaining a profile could be shortened from the current days to hours. In July 2006 an ambitious three year project, funded by the EPSRC under its ‘Think Crime’ initiative (EP/D040930), was undertaken at the University of Hull to develop a micro fluidic based Lab-on-a-chip system which could be used to obtain DNA profiles at the scene of a crime. The work has seen the successful design and fabrication of micro fluidic chips and associated control system, that is able to extract DNA from a range of sample types (note cell lysis performed off chip to release DNA), perform PCR amplification of a multiplex sample and then separate and detect products in approximately 2 hours. The chip used to perform this analysis has no moving parts (reagents and sample are pumped by electric fields) and contains all the reagents in gels on chip, avoiding the possibility of contamination as once the sample is placed on the chip and sealed nothing enters or leaves the device. The micro fluidic device which is the subject of a UK patent application submitted in October 2008 (Application No. 0818609.0) is made of glass (120mm long, 60mm wide and 2 mm deep) and fits into a custom built instrument, about the size of a domestic microwave (60cm long, 30cm wide and 40 cm high), that controls the generation of the DNA profile (movement, amplification and separation/detection). However having reached the proof of principle stage in the current project the applicants are now very keen to make the technology accessible to the police in their fight against crime. Having carried out an initial market and IP evaluation in conjunction with the Forensic Scientific Service the idea of adapting the methodology to provide a custody suite based technology, allowing DNA profiling in under two hours from a buccal (mouth) swab sample, has been identified as a significant need which is realistically achievable following minor modifications to the current control instrument and chips. The DNA profile would be achieved at a competitive price due to the very small amounts of reagents required. An initial evaluation of market competitors and potentially blocking IP has indicated that a good opportunity exists to develop the proposed technology which will address a unique market slot. Accordingly funding will be used to support the technical modifications required to convert the current technology into a demonstrator system for custody based use. The Follow-on proposal will also allow retention of key research personnel with specialised practical skills and technical knowhow, who will gain additional skills in commercialisation and product development. Furthermore a more comprehensive freedom to operate study and business plan will be produced to carry the work forward into a full commercially-based activity. In the context of this proposal it is important to stress that given the current strong emphasis being place on a growing DNA database the UK
represents an ideal location in which to launch the proposed new technology. It is clear also that internationally, DNA fingerprinting and biometric analysis represents an emerging field and early market dominance will clearly offer the potential to develop a major UK product base to address a growing global arena for forensic and related applications.

**Funding amount:** £171,162.88
Academic Centre of Excellence in Cyber Security Research - University of Surrey

Funder: EPSRC

Project Reference: EP/R006938/1

Start: 7/1/2017   End: 6/30/2022

Abstract

Research within the Surrey Centre for Cyber Security falls into the following principal themes:

- Security through Hardware: design and use of secure hardware such as Trusted Platform Modules (TPMs) as the basis of security mechanisms and designs
- Trusted Systems: applied cryptography, modelling and security analysis of systems, verification
- Privacy and Authentication: privacy-preserving computing, passwords, multi-factor authentication, personal data privacy
- Secure Communications: Internet of Things, 5G, connected vehicles, communications protocols, ultra-high-speed mobile and wireless connectivity
- Multimedia Security and Forensics: cybercrime and law enforcement

Within each theme there is a foundational element developing understanding, theory and new technologies, together with applications to specific problem domains and to building practical solutions. Application areas cover a wide range across the cyber-security spectrum, include new cryptographic schemes, security protocols, hardware-enhanced security, network security issues at different layers, formal security modeling and verification, human factors, secure electronic voting, key management, digital rights management and watermarking, image and video forensics, security economics, and biometrics.

The application domains we work in include transportation (automotive, rail), democracy (e-voting), telecommunications, digital economy, health, and law enforcement.

The technical core of the centre includes academics from the Departments of Computer Science, and the 5G Innovation Centre,. The centre also has a number of associates from a wide range of disciplines across the University whose research overlaps with security, and who are involved in interdisciplinary security research. These areas include Artificial and Machine Intelligence, Communication Systems, Vision, Speech and Signal Processing, as well as Surrey Business School, Sociology, Psychology, Law and Economics.

The Centre maintains strong collaborative links with its internationally renowned research partners, participates in technology transfer from academic to small and large businesses, shares knowledge and offers consultancy to government agencies, and is active in cyber-security education and security awareness raising campaigns for the industrial and public sectors.

Funding amount: £81,966.04
CRITiCaL - Combatting cRiminals In The CLOud

Funder: EPSRC

Project Reference: EP/M020576/1

Start: 9/1/2015   End: 8/31/2020

Abstract

The Cloud is an emerging technology that offers democratic access to computing power, data storage, software and services often for a small pay-per-use cost. Like any new technology the Cloud has potential for great good, but in the wrong hands can facilitate criminal activity. Within this project we seek to understand the different types of crime that can happen in the Cloud, build systems that will allow the detection of this criminal behaviour and enable the use of digital evidence to lead to successful prosecution of Cloud crime perpetrators.

In order to achieve this goal we are forming a truly inter-disciplinary research centre leveraging the strengths of both Durham and Newcastle Universities. Bringing together the strengths of Durham in criminology, law and ethics along with the strengths of Newcastle in the areas of (computer) systems security, artificial intelligence, data mining and psychology. We are convinced that Cloud crime can only be detected and tackled by such a truly inter-disciplinary centre. Such a centre will actively create the research foundations for successful computational methods in crime detection combined with good user engagement, generating research that can cross disciplines and directly inform public policy, police and prosecution practices and transform public understanding of Cloud crime.

This will involve development of a true understanding of what crime can be conducted on the Cloud. Facilitated through the development of cloud crime scripts, defining the activities of a criminal act, which will aid discussion between the different disciplines and must be presentable in a format understandable by our key stakeholders: Cloud providers/users/developers, law enforcement agencies and the criminal justice system.

The detection of criminal activity in the cloud requires the integration of heterogeneous sensors, aggregation and analysis techniques, where we draw upon existing expertise in cloud security assurance (Gross, IBM), host monitoring and anomaly detection Ben-ware (McGough, Wall, DSTL), and fuzzy search on unstructured data, intrusion detection and analysis (Nifty, Yan). We propose combining the systems expertise with complementary techniques in artificial intelligence, including data mining (McGough), behaviour machine learning, anomaly detection (Ploetz) and hierarchical machine learning and knowledge extraction (Bacardit).

This portfolio gives raise to multiple means to derive and combine intelligence, present bespoke visualizations, situational awareness, grammar or language generation for the cloud crime scripts. Thus allowing the centre to tailor the intelligence, and its presentation, to a given stakeholders needs. We propose using additional human computation and crowd sourcing techniques to reduce the number of situations where the system incorrectly identifies a criminal act. The use of human computation and crowd sourcing will also allow us to hone the machine learning system, developing a suite of hybrid techniques that, together, will improve cloud crime detection but will frame the results in such a way as to support subsequent crown prosecution processes. This latter achievement will require expertise in the disciplines of criminology, forensic sciences, law and
ethics and will require collaboration with police forces throughout the UK and Action Fraud.

In addition we will bring in relevant work around (i) forensic psychology (Oxburgh) that will deliver case-sensitive interview and investigative procedures for witnesses, victims and investigators; (ii) prosecution procedures that will ensure that evidence going to court is not compromised by intelligence gathering methodologies and (iii) prevention of underreporting of Cloud crime and improvement of public understanding and confidence.

**Funding amount:** £2,027,645.8
Quantifying Digital Forensic Investigations and their Evidence

Funder: EPSRC

Project Reference: EP/J004189/1

Start: 2/1/2012   End: 4/30/2012

Abstract
With the growth of the world-wide web (WWW), there has been a corresponding growth in crimes that use the WWW. Specialist law enforcement investigators are ever more frequently required to examine PCs, laptops, mobile phones, sat-navs, and personal digital assistants (PDAs) for look for incriminating (or exonerating) evidence. This has led to a situation where there is a severe shortage of digital forensic examiners with long backlogs of work, leading to even longer delays within the judicial process.

At the same time, lawyers are becoming ever more savvy in finding ingenious alternative explanations for the recovered digital evidence which, if accepted by the court, would allow their client to be acquitted.

This research project aims to address both these issues.

The former issue will be tackled by devising one or more digital forensic triage schemes in which a digital forensic technician filters or screens each digital device for the expected traces of evidence and the 'probative value' or weight of the recovered evidence is accumulated. Only if this accumulated weight of evidence meets one or more prescribed criteria is the device passed on to an experienced forensic investigator for a full digital examination.

The latter issue is to be addressed by using the notions of likelihoods and odds to determine how plausible it is that the recovered digital evidence was in fact formed by the process that the prosecution suspects, rather than by some alternative process that the defence might suggest. If the prosecuting authority performs such an analysis it will aid their decision as to whether to go to trial, and if the expert witnesses are armed with this data it will enable them to be more authoritative than previously regarding the strength of the available digital evidence.

Funding amount: £14,222.49
**SID: An Exploration of Super-Identity**

**Funder:** EPSRC

**Project Reference:** EP/J004995/1

**Start:** 10/1/2011  **End:** 3/31/2015

**Abstract**

The capacity to identify one another is paramount. It underpins social dialogue, commercial transactions, individual entitlements to goods and services and issues of legal and criminal responsibility. In today’s society, each of these activities can take place both within the real world and the cyber world making the concept of identity, and the process of identification, more challenging than ever before. The SID project addresses this challenge through an ambitious and innovative programme of work, bringing together experts from a diverse spectrum of scientific domains ranging from automated biometrics, cyber-psychology, forensic anthropology, human-computer interaction, mathematical modelling, and complex data visualisation. In addition, the project is backed by key industrial and governmental stakeholders, represented through an Advisory Group and providing direct input throughout the project.

The first stage of the project is to define the set of identity measures of interest and to gather relevant datasets either from existing resources, or through active data collection from participants across diverse demographic populations. Our measures of interest will fall into four categories: static and behavioural measures in the real world; and static and behavioural measures in the cyber world. These measures will be the basis for our model of Super-Identity, and their selection will be informed by the input of analysts, and end-users within intelligence, e-commerce and forensic sectors. At this early stage, and throughout the life of the project, we explicitly examine the social, legal and ethical considerations associated with data privacy and data protection. Work Package 1 addresses these issues.

Once this framework is in place, extensive testing will be conducted to determine the accuracy and reliability of automated and human identification from each measure. This will determine (i) the confidence that should be attributed to each measure, (ii) the effect that changing contexts may have on that measure and (iii) the potential relationship between measures. The results of this phase of work will continually update our Super-Identity model enabling measures to be combined, cross-referenced, and weighted according to their individual confidence estimates. Work Package 2 addresses these issues.

Consideration of how to present the information to the end user is the crucial next stage. With the benefit of expertise in human computer interaction and data visualisation, and the participatory engagement from end-users, the model will be refined with specific attention to its visual presentation in a flexible yet intuitive format. Work Package 3 addresses these issues.

In combination, SID provides fusion of known measures, revelation of unknown measures, and quantification of certainty associated with each measure, and thus the identification decision overall. In this way, it provides a step-change in the way that we think about identity and identification, and in the value that it might hold for the real world.

**Funding amount:** £1,905,242.39
Academic Centre of Excellence in Cyber Security Research - University College London

**Funder:** EPSRC

**Project Reference:** EP/K004433/1

**Start:** 8/15/2012  **End:** 8/14/2017

**Abstract**

Security is one of UCL's four strategic research areas; and Cyber Security research is a major area within that. Having acquired many top-class researchers and major grants over the past years, we have the resources to significantly increase our research output in core topics in computer, network and software security, as well as more complex topics, which require collaborations across research groups and departments. These include: effectively securing complex systems built on legacy software, support for real-time monitoring on forensics, and many more.

The Academic Centre of Excellence in Cyber Security Research will bring together all of UCL's Cyber Security research and coordinate our efforts in addressing the big security challenges facing the UK. Through the ACE-CSR we will expand our existing network of partnerships with government and industry to ensure we tackle the most important problems and that our solutions work in the real world.

**Funding amount:** £50,914.88
Responsive surfaces: Lanthanide based Langmuir-Blodgett mono-layers for the sensing of chemical warfare agent mimics

**Funder:** EPSRC

**Project Reference:** EP/N009185/1

**Start:** 1/25/2016   **End:** 1/24/2017

**Abstract**

Sensors play an important role in society, with applications in a variety of circumstances including environmental monitoring, clinical biology (e.g. disease marker detection), food safety (e.g. detection of contaminants), defence (e.g. real-time biological and chemical warfare agent (CWA) detection, explosives detection), the nuclear industry (e.g. radiation and temperature sensors), and engineering/avionics (e.g. temperature and pressure sensors, surface damage sensors) to name just a few. In all cases the early detection, or sensing, of change is paramount. One particularly important application of sensor development is in the field of CWA sensing. The highly toxic nature of the organophosphonate (OP) family of nerve agents and the potential for exposure to both military and civilian populations represents a real danger. Understandably, there is a clear requirement for adequate real-time detection capabilities for both military personal and civilian populations where advanced warning of exposure will help prevent casualties.

Current analytical technologies for sensing organophosphonates, whilst being highly sensitive, have some clear limitations including complex instrumentation, inconvenient sample preparation, lack of portability, and high cost. These drawbacks somewhat hinder the development of cost-effective field based portable devices that are easily integrated into personal protective equipment (e.g. smart textiles) and non-invasive detectors for use in public areas.

One approach that has been developed to overcome these problems is to measure signal change through interaction with responsive materials that undergo changes in chemical, electrical, optical or magnetic properties on exposure to chemical derivatives. Luminescence as a responsive medium for general sensor development has received significant attention and in particular some elegant luminescent supramolecular systems have been developed over the last 5 - 10 years for the detection of CWAs and their mimics. The majority of these have been solution based sensors (this limits the use in devices - solutions are inconvenient to store, often suffer from instability and sample preparation can be troublesome - see above), and with field based applications in mind, there is a need to move from solution responsive systems to surface immobilised receptor-reporter based sensors. This represents a significant gap in the field as luminescence sensing offers an attractive medium for immobilised sensors with potential to develop small portable devices from simple components. As such, we will use an alternative approach to overcome some of the above drawbacks. By utilising thin film (mono-layers) lanthanide based sensors where the sensor is deposited (immobilised) onto a surface (using the Langmuir-Blodgett technique) and undergoes a change in light emitting properties on exposure to low levels of CWA mimics we will overcome the limitations listed above. Throughout this research project we will explore this alternative approach for selectivity and sensitivity towards CWA mimics and ultimately assess its applicability for inclusion into functional devices. Therefore, our approach of combining the superior photophysical properties of the lanthanides, and the control over deposition afforded by the Langmuir-Blodgett technique will generate designer
lanthanide luminescent sensors that can be immobilised easily and reliably, potentially transforming the field of on-surface molecular sensing.

**Funding amount:** £99,203.46
Novel vibrational spectroscopic techniques: long-range order in amyloid fibrils

Funder: EPSRC

Project Reference: EP/I026657/1

Start: 9/1/2011    End: 9/30/2015

Abstract
Amyloid diseases are a major health problem and include neurodegenerative diseases such as Alzheimer's, Parkinson's, and Huntington's disease, as well as type II diabetes and infectious prion diseases, such as Creutzfeldt-Jakob disease (CJD). They are characterised by the deposition of large fibrillar aggregates of protein, both within cells and in the extra cellular matrix, that were thought to cause cell death and result in the observed pathology. The constituent fibres of these fibrils have a common beta-sheet architecture with long-range order despite being able to form from many different proteins. More recently, attention has shifted to precursor soluble oligomer species as the toxic agents in these diseases. However, the precise structure and degree of long-range order in these oligomers has not yet been determined and is difficult to probe using existing biophysical techniques, hampering the development of drugs targeted at this stage of the disease. My Fellowship will make use of terahertz frequency time-domain spectroscopy (THz-TDS) to study long-range order of amyloid fibrils and their precursors. This will be complemented by Raman spectroscopy and molecular modelling calculations to gain an understanding of the inter- and intra-molecular interactions within this important class of biological molecules. THz-TDS is an emerging technique that is proving to be of particular importance for the investigation of organic crystalline compounds. This is because THz spectroscopy has been shown to excite inter-molecular vibrations, thus not only probing chemical composition, but also proving to be extremely sensitive to small changes in crystalline structure. During the Fellowship, I will develop new THz frequency spectroscopic techniques. For example, the inclusion of polarisation sensitive detection will, for the first time at THz frequencies, allow spectroscopic information to be obtained related to the chirality of the molecules, including the secondary structure of proteins and small peptides.

Funding amount: £382,792.99
Underpinning Multi-User Equipment At UCL

**Funder:** EPSRC

**Project Reference:** EP/P030084/1

**Start:** 4/1/2017  **End:** 3/31/2018

**Abstract**

This is a UCL-wide bid for investment in state-of-the-art underpinning multi-user equipment which will help us to maintain a cutting-edge in internationally leading research. Each piece of equipment included in this proposal contributes to one or more strategic themes, in which UCL, as well as national and international funders, has invested significantly in recent years: materials fabrication and characterisation; healthcare technologies; and imaging, for both medical and heritage science applications. UCL has considerable strengths in these areas, and we have experienced significant growth in terms of staff and student numbers, and breadth and impact of research activity. This additional investment will therefore provide an ideal platform to ensure the sustained growth of the highest quality research, as well as supporting and training early career researchers.

Each piece of equipment underpins a range of research activities, reaching across department and discipline boundaries, which are of strategic importance for UCL and EPSRC. The UCL equipment items were chosen via a competitive internal selection process, led by Deans and Vice-Deans for Research, with evaluation based on scientific excellence, potential for impact, and alignment to UCL and EPSRC strategies. Each piece of equipment has a Lead Investigator(s) who will be responsible for regular reporting to the Vice-Provost for Research on progress against objectives.

The requested UCL equipment items are: (A) a photoelectron spectrometer; (B) surgical X-ray imaging and robotics for a mock interventional suite; (C) a 3D nanoprinting facility; and (D) a 3D hyperspectral imaging facility for science and engineering in heritage.

**Funding amount:** £1,997,855.94
Lanthanide complexes as chiral probes and labels

Funder: EPSRC

Project Reference: EP/P025013/1

Start: 8/1/2017   End: 7/31/2020

Abstract

Ever since Faraday first declared that ‘polarised light was a most delicate investigator of molecular condition’, scientists have sought to exploit the intrinsic handedness of light. Light that is polarised in a plane is the sum of left handed and right handed circularly polarised components. The exploitation of the circular polarization of light is rare, yet it offers unique opportunities in areas such as the development of optical robes for the biosciences, in the creation of new security labelling/tagging features and in the development of image contrast, based on the relative intestines of the left and right handed components of polarised light. Circularly polarised luminescence (CPL) is the emission analogue of circular dichroism (CD), that has been used for some time to examine chiral systems by virtue of the differential absorption of left and right handed light. Intrinsically, CPL is a much more sensitive optical technique, but is has not really been used at all in life or material science applications.

In Durham very bright compounds of the rare earth element europium have been created recently, that are not only the brightest emitters of red light that have been devised but also emit light with a preferential handedness. Using these new compounds, it is much faster and easier to detect their CPL, and new instrumentation has been developed in tandem, that allows their CPL behaviour to be studied both in spectroscopy and in microscopy. The project will examine how these bright red-emitting emitters of light can be used to tag or label documents or printed labels, thereby opening up the possibility of their use in security applications for validation of true identity. Examples might include bank notes, legal documents, high end branded labels for designer clothing or official documents, such as passports.

In addition, new molecules will be designed and created that bind to a wide range of enzymes in the body that are involved in the transfer of a phosphate group. For example, the protein tyrosine phosphatases account for 0.05% of the total phosphorylation in cells, but play a key role in the regulation of critical biological functions, e.g. adhesion, cell cycle control and the ways that cells grow and differentiate. Antibodies specific to phosphorylated tyrosine sites are commonly used for many practical applications, involving monitoring enzyme activity, but their use is hampered by high cost and poor stability. Chemical probes that can directly visualise the activity of this specific range of enzymes activity are required and could be used in drug screening applications, as the inhibitors of these key enzymes are of great interest to the pharmaceutical sector. Using europium compounds that interact selectively with these sites where tyrosine has been phosphorylated, a chiral CPL signature can be observed, that identifies the site and the nature of the amino-acids around that site. Thus the europium compounds can serve as selective chemical probes to signal, by an induce CPL response, whether the tyrosine is phosphorylated and where in the biomolecule it has been modified. These properties will be studied in detail and their scope and utility evaluated.

Funding amount: £582,867.68
Privacy-Protected Human Identification in Encrypted/Transformed Domains

Funder: EPSRC

Project Reference: EP/P009727/1

Start: 5/14/2017   End: 5/13/2019

Abstract
Biometrics has been widely utilized in the past two decades in many areas such as healthcare, banking, surveillance, and security control. Given the increased uptake of internet and mobile computing globally, many companies have been turning to biometric privacy and security to ensure secure communication. However, biometric verification over third-party or public network servers may be abusively exploited in an unauthorized way. To protect the privacy and improve the security, it has been advocated to carry out biometric verification in encrypted or transformed domains, where privacy and security can be more effectively guaranteed.

The basic idea behind the project is that the biometrics in the irreversible encrypted/transformed domains contains exactly the same amount of information as its original one, and hence one can establish a pattern recognition methodology to determine/extract useful information from chaotic signals in encrypted/transformed domains. This First Grant Scheme project aims to investigate how to discover and evaluate the information from chaotic signals for discriminative power, and develop robust pattern recognition schemes for biometric/multi-biometric verification in encrypted/transformed domains. The proposed methods/schemes will be vigorously validated over typical wild face/speech/gait datasets, and two practical demo systems (biometric banking and pedestrian profiling) will be designed and tested in real world environments.

The project will focus on both theoretical understanding of chaotic information and application-specific exploitation of chaotic pattern recognition. Considering multiple data structures hidden beneath a set of given chaotic signals, I will develop a robust way to find out the underlying various data structures for data understanding, clustering and classification. On the other side, given a specific issue such as encrypted/transformed biometric verification, one need to examine the generic theoretic findings in this specific topic and develop a robust scheme for biometric human identification.

The work of this project is within the areas of signal processing, machine learning and pattern analysis. The research on encrypted/transformed biometric verification has come from the practical new needs of the UK’s emerging new businesses. The project will provide the understanding needed to allow the future development of robust biometric verification methods with novel applications.

Funding amount: £98,160.6
SEEK (Steganalytic vidEo-rEsearch frameworK)

Funder: EPSRC

Project Reference: EP/N024192/1

Start: 4/21/2016  End: 4/20/2019

Abstract
The proposed research project aims to discover whether videos uploaded and exchanged by terrorists and sympathizers contain hidden data, and to recover any such data if this was the case for gathering intelligence on their plans and operations.

For that, we will create a high performance and scalable video steganalysis tool called SEEK (Steganalytic vidEo rEsearch frameworK).

The tool will be at the core of a system capable of locating, collecting, analyzing, and sanitizing videos shared on the Internet by terrorists or their affiliates.

While primarily aimed at helping counter terrorism and law enforcement, with a primary objective of significantly enhancing UK security, the outcomes of the SEEK proposal will also benefit a number of other disciplines and activities.

We will contribute to the UK digital economy by improving the security of companies in general and video hosting or sharing sites in particular.

For instance, some of SEEKs outputs will directly help companies eliminate any hidden data in any video, and detect and stop data loss when video steganography is used by cyber criminals to exfiltrate stolen data stealthily, which is becoming an increasingly common practice.

SEEK also has some potential as a business venture expanding as steganalysis as a service (including analysis of other media), which could create jobs and bring unique technological expertise in the UK.

Funding amount: £273,996.04
Multi-activity 3D pose estimation on real environments

Funder: EPSRC

Project Reference: EP/N030540/1

Start: 11/1/2016  End: 5/31/2018

Abstract
Human-machine interfaces, video surveillance, sport performance enhancement, physical therapy, smart environments, to name a few, are important societal challenges that require better automatic behaviour analysis to be fully addressed. In order to move closer to the level of human proficiency, fully automatic understanding of a scene requires a whole range of capabilities: reliable extraction of each actor involved, its pose and their activities. This involves the combined application of pose estimation, multi target tracking and activity recognition. While impressive progress has been made in those fields in isolation, reliable methods, able to be applied to real world and unconstrained environments, are still a challenge. In this project we will focus on the intermediate components of behaviour analysis, by disregarding the traditional cascade pipeline, where pose estimation frequently plays a secondary role or it is completely obliterated due to its complexity, and proposing a novel architecture which has 3D pose estimation as the key central component with feedback between each of the other components.

In this project, we propose to investigate the automated 3D pose estimation and tracking of multiple people in realistic scenarios. This research is suggested on the basis that all current methods perform under strong limitations and assumptions that preclude their application to real-world situations. Thus, while some methods require multiple high-resolution sensors, thereby ruling out the use of current and near future sensor network infrastructures, others struggle with scenes containing multiple persons, or they succeed on the basis of the subjects not interacting and also knowing the activity performed beforehand. This last assumption reduces the practical application of the pose estimation and prevents it use for activity recognition and/or behavioural analysis.

To address this limitation, in this project we propose to extend the assumption from one of a single known activity as prior model, to one where a class of multiple activities is assumed, e.g., walking, running, fighting, shaking hands etc. This requires us to develop a novel multi-activity model that could be used as prior information to accurately and robustly estimate the 3D pose under complex and real world conditions. This multi activity model will avoid presuming the performed activity by each of the subject in the scene among the given set of activities. The development and use of such a model is the key novel contribution of this proposal, and is a first step towards a fully activity-agnostic 3D pose estimation for real environments.

Furthermore, we propose a paradigm change to the conventional behaviour analysis chain, where pose estimation becomes the cornerstone of the system, and the feedback loops with tracking, to address occlusions and interactions, and activity recognition, to switch between a set of plausible activities during the estimation, allows us to deal with the aforementioned issues. By modelling transitions between this set of activities, and observing how predicted poses propagate in time through the activity space, the current activity can be recognised and used as feedback for refining the pose estimation. This is the
second novelty of this proposal. Lastly, inaccuracies in the pose estimation, caused by occlusion and multiple persons interacting, can be overcome by using information from the tracker to determine image regions that provide reliable pose estimation information. Similarly, by knowing the pose and activity of subjects in the scene, the tracking performance can be improved. This is the third novel aspect of the proposal.

**Funding amount:** £98,942.92
Electrotrotunable Molecular Alarm

Funder: EPSRC

Project Reference: EP/L02098X/1

Start: 5/30/2014    End: 2/28/2018

Abstract

We propose to create an electrochemical self-assembling, self-healing and renewable nano-plasmonic system for the ultrasensitive Raman spectroscopy detection of a wide class of toxins, narcotics, and explosives, as well as environmental pollutants. The platform is based on the electrotuneable assembly of nanoparticles at electrochemical liquid|liquid and/or solid|liquid interfaces. Preliminary experiments performed at liquid|liquid interface with spontaneous assembly of nanoparticles, published in Nature Materials (2013), proved extraordinary high sensitivity of such sensor, which allowed to detect in some cases down to 10-15 molar concentrations of analyte molecules. This proposal aims to build on this work by introducing electrovariable assembly for fine tuning of the signal. But why such tuning is needed and how it could be possible to realize it?

The principle of the enhancement of the Raman signal by nanoparticle arrays lies in the resonance enhancement of the electric field of incident and scattered radiation in the so called 'hot spots' near the nanoparticles, emerging due to excitation in them of localised plasma oscillations. Because Raman signals are proportional to the fourth power of electric field, even a modest enhancement of the field can increase the signal. The position of nanoparticles relative to the interface and with respect to each other has a dramatic effect on the intensity of the field in the hot spots.

Passive assembly of nanoparticles at the liquid-liquid interface is driven by a trend to replace the unfavorable oil | water interface, balanced by the electrostatic repulsion between nanoparticles that are charged with dissociating acidic functional groups. As we have shown in our previous work, the structure of the nanoparticle arrays can be managed by controlling the repulsion via variation of the charge on nanoparticles or salt concentration which affects the Debye screening length. More difficult is to precisely control the position of nanoparticles relative to the interface. However, using the interface of two immiscible electrolytic solutions (ITIES), with fat organic ions dissolved in oil, one create the so called ITIES liquid-electrode system. At ITIES one can concentrate the voltage drop within two back-to-back electrical double layers on the two side of the interface. Turning on and off this voltage will govern the position of NPs relative to the interface or will move them away, letting them to scan more volume and bringing more analyte to the interface. We intend to realize this and also another originally suggested electrochemical platform. The latter uses a transparent solid electrode (ITO on glass) in an ordinary electrolytic solution, covered by a self-assembled monolayer to prevent irreversible adsorption of nanoparticles. In such system negatively charged nanoparticle will be drawn to the electrode and will form a self-assembled monolayer there at a mild positive voltage. Changing the sign of the voltage will repel the nanoparticles from the interface.

This project will comprise of closely related theoretical, experimental, and even engineering parts, lying at the interface of physical chemistry, electrochemistry, physics, and electrochemical engineering. We intend to build a theory of voltage
controlled localisation of nanoparticles at the corresponding interfaces, calculate the maps of hot spots in nanoparticle arrays of different structure and composition. We will build the liquid-liquid and solid-liquid setups, using nanoparticles, nanoparticle architectures and their functionalisation, and electrolytes that will provide, subject to the theoretical analysis, the strongest Raman signals. We systematically investigate a series of proxy analytes, the dangerous versions of which will be studied in a partnering DSTL laboratory. Based on the achieved results we will build a prototype device for further development by interested industrial partners.

**Funding amount:** £641,422.79
SEEK (Steganalytic vidEo rEsearch frameworK)

**Funder:** EPSRC

**Project Reference:** EP/N028554/1

**Start:** 4/21/2016  **End:** 9/30/2019

**Abstract**
The proposed research project aims to discover whether videos uploaded and exchanged by terrorists and sympathizers contain hidden data, and to recover any such data if this was the case for gathering intelligence on their plans and operations.

For that, we will create a high performance and scalable video steganalysis tool called SEEK (Steganalytic vidEo rEsearch frameworK).

The tool will be at the core of a system capable of locating, collecting, analyzing, and sanitizing videos shared on the Internet by terrorists or their affiliates.

While primarily aimed at helping counter terrorism and law enforcement, with a primary objective of significantly enhancing UK security, the outcomes of the SEEK proposal will also benefit a number of other disciplines and activities.

We will contribute to the UK digital economy by improving the security of companies in general and video hosting or sharing sites in particular.

For instance, some of SEEKs outputs will directly help companies eliminate any hidden data in any video, and detect and stop data loss when video steganography is used by cyber criminals to exfiltrate stolen data stealthily, which is becoming an increasingly common practice.

SEEK also has some potential as a business venture expanding as steganalysis as a service (including analysis of other media), which could create jobs and bring unique technological expertise in the UK.

**Funding amount:** £331,178.41
An Integrated Vision and Control Architecture for Agile Robotic Exploration  

Funder: EPSRC  

Project Reference: EP/M019284/1  

Start: 9/1/2015   End: 8/31/2019

Abstract
Autonomous robots, capable of independent and intelligent navigation through unknown environments, have the potential to significantly increase human safety and security. They could replace people in potentially hazardous tasks, for instance search and rescue operations in disaster zones, or surveys of nuclear/chemical installations. Vision is one of the primary senses that can enable this capability, however, visual information processing is notoriously difficult, especially at speeds required for fast moving robots, and in particular where low weight, power dissipation and cost of the system are of concern. Conventional hardware and algorithms are not up to the task. The proposal here is to tightly integrate novel sensing and processing hardware, together with vision, navigation and control algorithms, to enable the next generation of autonomous robots.

At the heart of the system will be a device known as a 'vision chip'. This bespoke integrated circuit differs from a conventional image sensor, including a processor with each pixel. This will offer unprecedented performance. The massively parallel processor array will be programmed to pre-process images, passing higher-level feature information upstream to vision tracking algorithms and the control system. Feature extraction at pixel level results in an extremely efficient and high speed throughput of information. Another feature of the new vision chip will be the measurement of 'time of flight' data in each pixel. This will allow the distance to a feature to be extracted and combined with the image plane data for vision tracking, simplifying and speeding up the real-time state estimation and mapping capabilities. Vision algorithms will be developed to make the most optimal use of this novel hardware technology.

This project will not only develop a unique vision processing system, but will also tightly integrate the control system design. Vision and control systems have been traditionally developed independently, with the downstream flow of information from sensor through to motor control. In our system, information flow will be bidirectional. Control system parameters will be passed to the image sensor itself, guiding computational effort and reducing processing overheads. For example a rotational demand passed into the control system, will not only result in control actuation for vehicle movement, but will also result in optic tracking along the same path. A key component of the project will therefore be the management and control of information across all three layers: sensing, visual perception and control. Information share will occur at multiple rates and may either be scheduled or requested. Shared information and distributed computation will provide a breakthrough in control capabilities for highly agile robotic systems.

Whilst applicable to a very wide range of disciplines, our system will be tested in the demanding field of autonomous aerial robotics. We will integrate the new vision sensors onboard an unmanned air vehicle (UAV), developing a control system that will fully exploit the new tracking capabilities. This will serve as a demonstration platform for the complete vision system, incorporating nonlinear
algorithms to control the vehicle through agile manoeuvres and rapidly changing trajectories. Although specific vision tracking and control algorithms will be used for the project, the hardware itself and system architecture will be applicable to a very wide range of tasks. Any application that is currently limited by tracking capabilities, in particular when combined with a rapid, demanding control challenge would benefit from this work. We will demonstrate a step change in agile, vision-based control of UAVs for exploration, and in doing so develop an architecture which will have benefits in fields as diverse as medical robotics and industrial production.

**Funding amount:** £858,323.78
DAPM: Detecting and Preventing Mass-Marketing Fraud (MMF)

Funder: EPSRC

Project Reference: EP/N028112/1


Abstract

Fraud can be broadly defined as trickery used to gain a dishonest advantage, usually financial, over another person or organisation. Mass-marketing fraud (MMF) is a type of fraud that exploits mass communication techniques (e.g., email, Instant Messenger, bulk mailing, social networking sites, telemarketing) to con people out of money. It is a scam that targets victims in most countries. The 419 or 'Nigerian' scam is one example. In this scam the fraudster requests upfront fees with the promise that the victim will recover large sums of money in return for little effort. However, not all mass-marketing frauds con the victim with the promise of making large sums of money. In the romance scam, for example, the criminal pretends to develop a romantic relationship with the victims and later requests money to help them, especially in a crisis. In the charity scam, victims believe they are giving money to a genuine charity.

The proposed project will develop novel techniques to detect and prevent MMF. Through its multi-disciplinary approach and close focus on co-designing the solutions with its range of project partners and testing them in-the-wild during live MMF-detection settings, the project will lead not only to new scientific understanding of the anatomy of MMF but also to tools and techniques that can form the basis of practical interventions in tackling such fraud.

Working with partners outside of academic is crucial to the success of this project. Over the years various types of organisations have worked hard to detect and prevent MMF (often in silos) - with some methods appearing to be somewhat effective. Nonetheless, the numbers of victims do not appear to be dissipating. Awareness campaigns have succeeded in alerting the public to this particular crime; however, it is difficult to know if they have reduced the potential number of victims (especially, given that many victims are aware of the crime prior to becoming victims; see Whitty, 2013, in press). Prosecution for this particular crime is very resource intensive, and its effects on crime reduction are unknown. We have chosen partners (national and international) who have specialities in different fields including: law enforcement, intelligence, third sector, and industry. They have different knowledge to share and also can potentially tackle the problem using different methods (e.g., industry can screen out and detect fraudsters, law enforcement can trace criminals and raise awareness, third sector can implement methods to protect citizens and to make them more resilient).

From an academic perspective, a multi-disciplinary approach increases our chances of detection and prevention of this crime. Understanding the types of people susceptible, the situational conditions that make a person more vulnerable, and the methods and materials (e.g., online profiles, messages, communication methods) used to convince the target that the interaction is authentic and persuade them into giving up their money to a fraudster is crucial in the development of methods to combat this problem. Combining this knowledge with more technical knowledge provides us with a much greater capability to detect and prevent. For example, technical indicators, such as phone numbers, IP addresses, links to stolen identity material, stylistic patterns
of persuasive messaging provide a much richer understanding of the crime and provides a greater number of variables to assist in detection. In addition, any tool developed in detection of MMF needs to convince the end-user of the likelihood that they are being scammed (which is especially difficult when the criminal is attempting to persuade the victim to believe otherwise). Given this an HCI approach is crucial when developing usable approaches and messages that persuade the potential victim that they are interacting with a criminal. Finally, we need to consider the ethics of the type of personal data we might utilise to detect and prevent MMF.

**Funding amount**: £845,176.86
DAPM: Detecting and Preventing Mass-Marketing Fraud (MMF)

Funder: EPSRC

Project Reference: EP/N028112/2

Start: 9/1/2016   End: 12/31/2018

Abstract

Fraud can be broadly defined as trickery used to gain a dishonest advantage, usually financial, over another person or organisation. Mass-marketing fraud (MMF) is a type of fraud that exploits mass communication techniques (e.g., email, Instant Messenger, bulk mailing, social networking sites, telemarketing) to con people out of money. It is a scam that targets victims in most countries. The 419 or 'Nigerian' scam is one example. In this scam the fraudster requests upfront fees with the promise that the victim will recover large sums of money in return for little effort. However, not all mass-marketing frauds con the victim with the promise of making large sums of money. In the romance scam, for example, the criminal pretends to develop a romantic relationship with the victims and later requests money to help them, especially in a crisis. In the charity scam, victims believe they are giving money to a genuine charity.

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**Funding amount:** £841,964.94
Face Matching for Automatic Identity Retrieval, Recognition, Verification and Management

Funder: EPSRC

Project Reference: EP/N007743/1

Start: 1/1/2016    End: 12/31/2020

Abstract
In the past, when the majority of people were born, lived and died in the same locality where everybody knew each other, there was no need for biometrics. However, nowadays, with the society moving rapidly towards Digital Economy, and the people mobility within the country and across borders reaching unprecedented levels, efficient, robust and effective ways of recognising and verifying individuals automatically, based on biometrics, is emerging as an essential requirement and element of the fabric of the information infrastructure. Identity verification is required to facilitate commerce, and remote working, to enable access to remote services and physical sites in smart cities, as well as contributing to a safer society by fighting crime and terrorism through automatic surveillance. In this context face biometrics is a preferred biometric modality, as it can be captured unobtrusively, even without subjects’ being aware of being monitored and potentially recognised. It is also the modality used by humans and thus, when needed, it supports a seamless transition and cooperation between machine and human face recognition.

Although face biometrics is beginning to be deployed in several sectors, it is currently limited to applications where a strict control can be imposed on the process of face image capture (frontal face recognition in controlled lighting). However, automatic face recognition in uncontrolled scenarios is an unsolved problem because of the variability of face appearance in images captured in different poses, with diverse expressions, under changing illumination. Furthermore, the image variability is aggravated by degradation phenomena such as noise, blur and occlusion.

The project will develop unconstrained face recognition technology, which is robust to a range of degradation factors, for applications in the Digital Economy and in a world facing global security issues, as well as demographic changes. The approach adopted will endeavour to devise novel machine learning solutions, which combine the technique of deep learning with sophisticated prior information conveyed by 3D face models. The scientific challenge will be to develop a face image representation, which is invariant to various imaging factors. This will necessitate gaining better understanding of the effect of natural face appearance variations and face image degradation phenomena on face image representation. The work will be carried out by a multidisciplinary team constituted by three academic partners, University of Surrey, Imperial College London and University of Stirling, which has extensive experience in biometrics and face modelling, and jointly possesses the necessary expertise, including psychology of human face perception. The research direction will be regularly reappraised and if necessary revised, with steering provided by a team of external experts representing the biometrics industry, government agencies, and potential users of the unconstrained face recognition technology. The progress of the project will be measured by extensive evaluations of the solutions developed using challenging benchmarking tests devised by the biometrics community and compared with evolving commercial offerings.
Funding amount: £6,104,264.85
Using BIG data to understand the BIG picture: Overcoming heterogeneity in speech for forensic applications

Funder: ESRC

Project Reference: ES/N003268/1

Start: 2/15/2016   End: 2/14/2019

Abstract

Forensic speech science (FSS) - an applied sub-discipline of phonetics - has come to play a critical role in criminal cases involving voice evidence. Within FSS, Forensic speaker comparison (FSC) involves the comparison of a criminal recording (e.g. a threatening phone call), and a known suspect sample (e.g. a police interview). It is the role of an expert forensic phonetician to advise the trier of fact (e.g. judge or jury) on the likelihood of the two samples coming from the same speaker. There are two important elements involved in making such a comparison. First, the expert will carry out an assessment of the similarity of the speech characteristics in the criminal recording and the suspect sample. Second, the expert will assess the degree to which the same speech features for the criminal sample can be considered to be typical for a given speaker group. The speaker group will typically be defined by age, sex and geographical region (or accent). This second element is critical in providing context for the first; the suspect could have speech very similar to that in the criminal recording but this could be purely coincidental if they exhibit speech characteristics that are common to their speaker group. In contrast, if the criminal and suspect are observed as having speech features considered as being atypical for their speaker group then this would provide strong evidence for it being the same speaker.

One complication associated with FSC is that data to estimate whether a speech feature is typical or atypical for the given speaker group, commonly known as population data, are scarcely available. Population data are typically obtained by collecting a set of recordings containing the voices of a homogeneous group of speakers similar in age, sex, and geographical region (or accent). Unfortunately, the time and expense involved in the collection of population data means that forensic phoneticians face a huge challenge in obtaining such data for casework. This problem is further complicated by the high degree of variation that exists in speech across different speaker groups. Methodological research in the field of FSS has demonstrated that identifying the correct population for a FSC is vital in accurately representing the strength of evidence. It is largely for these reasons that experts argue that the biggest problem facing the field is the limited availability of population data.

The primary aim of this research is to explore a novel set of proposed methods that seek to remedy the aforementioned problems. The current lack of a platform on which to exchange data means that population data for a specific speaker group might have already been collected, unbeknown to experts in need of such data. This project intends to bring an end to this type of scenario by developing an international platform on which to share data, and also encouraging fellow researchers and experts to participate in data sharing. In addition, the project will explore the extent to which population data are generalizable; specifically, this will entail identifying the geographical (or regional accent) level at which speaker groups can be defined. For example, an expert might define a population group as having a Leeds accent, when in actuality a population defined more
generally as West Yorkshire would suffice. This would clearly have implications for the way in which population data would be collected.

In order to explore the issue of defining the population data, a West Yorkshire (WY) database of 200 male speakers will be collected (including 50 speakers from each of the four urban areas: Huddersfield, Leeds, Bradford, and Wakefield). The database will be used to test the sensitivity of the strength of evidence when FSC cases are simulated using varying definitions of accent for the population data. In addition to serving methodological purpose, the WY database will also serve as a practical resource for casework and research in its own right.

**Funding amount:** £280,689.73
Variability as a route to understanding face recognition

Funder: ESRC

Project Reference: ES/J022950/1

Start: 11/1/2012   End: 12/31/2014

Abstract
This project represents a new way to look at the problem of human face recognition. Despite a large amount of research on this topic, we still do not understand the most fundamental aspect of face processing: how can we identify the people we see? This is a key problem in human perception, but it also has practical implications in forensic and security settings. This project has its roots in a simple observation: pictures of the same face can look very different indeed.

In the standard approach to face recognition, this commonplace fact is treated as an inconvenience. Differences between pictures of the same person are regarded as 'noise', and either ignored or eliminated by systematically controlling the images used for research. This research programme takes exactly the converse approach. Instead of trying to control away this variability, it will be studied explicitly. Under this approach, the problem of face recognition is not how to 'tell people apart', but instead how to 'tell people together' - how to bring together superficially different images into a coherent representation. Early work suggests that a very important component of familiar face recognition is the ability to generalize over superficial image differences - differences which tend to fool unfamiliar viewers, as well as automatic computer-based systems. The current failure to address this variability may account for the slow progress in face identification - progress which has fallen behind the understanding of other aspects of face processing such as social perception. This research comprises three components. First, a systematic examination will be conducted of the physical differences between images of the same person. Applying statistical techniques to graphical data, the aim is to specify what aspects of face images vary commonly, and what aspects vary idiosyncratically to that person. Second, a series of behavioural experiments will examine the nature of our representations of familiar faces - the hypothesis is that this representation needs to incorporate variability. Third, a series of studies will address practical face recognition by human observers (e.g. for security purposes). Computer-based approaches will also be examined in this strand - as these systems remain very poor, despite the claims of vendors. This novel approach to face identification has the potential to make a significant contribution to an area which has progressed rather slowly in recent years.

Funding amount: £406,814.78
Eyewitness testimony by adults with autism spectrum disorder

Funder: ESRC

Project Reference: ES/J003379/1

Start: 4/2/2012   End: 9/30/2013

Abstract

Eyewitness testimony is central to the Criminal Justice System (CJS), and this often includes the testimony of individuals with Autism Spectrum Disorder (ASD). A number of risk factors suggest that people with ASD are at greater danger of victimisation, meaning that their 1% prevalence in the general population is likely to be over-inflated in the CJS. In addition to this, they have well-documented memory difficulties, yet scarcely any research has examined how they fare as eyewitnesses. My PhD research explored this issue. I examined the effectiveness of one of the most widely accepted police interviewing techniques, the Cognitive Interview (CI), for use with adults with ASD. One of the main components of the CI, context reinstatement, encourages the witness to relive the event mentally by focusing on contextual details such as the sights, sounds, smells etc. I found that the CI failed to aid the recall of witnesses with ASD, and actually reduced their accuracy. My subsequent work suggests that it is the mental time travel required by context reinstatement that individuals with ASD find difficult: when they were physically back in the same room in which the event was witnessed, their recall improved. These findings have important implications for investigative interviewing procedures with witnesses with ASD.

In the fellowship year I intend to re-examine these findings from a different perspective. The coding system used in my PhD work coded details as correct or incorrect, but did not explicitly examine whether these details were reported in the correct order. This is essential if police investigators are to understand the chain of events as they unfolded, and could mean the difference between whether the chief suspect left the scene before or after the attack was carried out. Therefore the first aim of the proposed work is to examine how well individuals with ASD recall the chronological order of events details; previous research suggests that they have difficulty with this. However if this is the case, there may be appropriate supportive interview strategies which can help - an area which subsequent research proposals developed during the fellowship would address. Secondly, in my PhD work, none of the to-be-remembered events were ones in which the witness was an active participant. Previous work suggests that individuals with ASD find it harder to recall events in which they were actively engaged then events which they passively observed. Again if this is the case it has immediate forensic implications, and would provide a focus for more substantial funding applications to develop appropriate supportive interviewing strategies.

This work will constitute two papers. During this fellowship year I intend to publish a third paper reviewing research on eyewitness testimony in ASD. This is very novel work and a review paper would disseminate findings further and generate new interest. The fellowship year would also enable me to develop both new research skills and proposals which would establish a more substantial program of work in the area, including the development of effective interviewing strategies, which in the case of context reinstatement might involve more supported procedures such as revisiting the scene where the event was witnessed or using photographs as a context aid. I would also like to extend my
current work to the wider autism spectrum from high-functioning adults to children and those with intellectual impairment.

This work should be of interest to a wide audience, from individuals with ASD themselves, the police and other legal officials, policy makers, and academics. Findings may also have implications for the educational sector in terms of effective learning strategies in school. The fellowship will allow me the opportunity I need to improve my publication track record and apply for longer-term funding which I hope will allow me to develop an academic career in this important but under-researched area.

**Funding amount:** £83,916.8
Re-emerging Past: Forums for Truth-telling in Contemporary Argentina and Chile

Funder: ESRC

Project Reference: ES/N007433/1

Start: 10/1/2015  End: 9/30/2017

Abstract

This research project studies how - by what processes, according to what criteria, and subject to what kinds of verification? - truths emerge about the political violence that took place in the 1970s and 1980s in Argentina and Chile. Although that period of violence is now 'past', many facets of it are still unresolved. Beyond the legal mechanisms that continue to unearth truths about the last military dictatorship in Argentina (1976-83) and the Pinochet dictatorship in Chile (1973-1990), there are several sites at which these unresolved issues emerge for debate and verification. There is a need to address the unresolved and still controversial nature of many questions as the presentation of the story of what happened becomes a focus of new memorial spaces and Memory museums, as well as at other sites where truths are tested, including where biological identities are tested via DNA or where human or material remains require forensic testing.

The research will take place at a range of diverse sites that we call 'forums for telling'. Its premise is that truths about the past are of different kinds because they have to pass through different processes of hypothesising, 'testing' and reflection before they are affirmed and allowed to emerge as true. Thus the production of truth at a museum of memory differs both in process and in terms of the truths it seeks and can affirm, from the production of truth by the law courts, or by the Argentine Forensic Anthropology Team's attempts to establish identities through the testing of human remains or DNA.

The research concerns how the different forums and spaces approach this task differently, how they involve different material and human witnesses, different procedures and place different constraints on the objects of their interrogations. In studying these processes we will ask: What candidates emerge to tell the truth about the past? Which truths are allowed to emerge at the different sites? How are they understood as relevant to the forum that debates their status? What 'tests' must they pass in order to attain their status as true? How are emergent truths presented, arranged and mediated for consumption? How is their status challenged? The importance of these questions becomes apparent when one considers the pedagogic dimensions of the activities at stake. We will highlight the pedagogic and inter-generational dimension. What do the different forums understand as the relation between the production of truth and the presentation or curation of the story of the past as a wider societal imperative? How do they agree to present their work domestically and internationally, including digitally? How do they seek to overcome the dangers of making a spectacle of the past, or else using it within a strategic instrumentalisation that insists that listening repeatedly to horrors of past violence will inoculate us from ever repeating the past wrongs?

The research will use observation, interviews and documentary data gathered from significant sites chosen for their potential to speak to these interests. In Argentina, we will visit the largest and most notorious of the ex-clandestine centres for detention, torture and extermination (ex-cdte), the ESMA in Buenos
Aires, now an official Site for Memory, and where debates about the use of the space have raged for several years, but where new changes to the use and especially the pedagogic aspects of the site are presently coming to fruition. Additionally we will visit two ex-ccdte sites further afield, in Cordoba and Tucuman. In Chile, we will also visit ex-centres of detention in Santiago (Londres 38, Villa Grimaldi) and one further afield in Chacabuca in the north. In each country we will also be visiting important newly opened Museums of Memory (in Santiago and Rosario). To complement these, we will observe and interview members of the important Argentine Forensic Anthropology Team, as well as following key legal cases that are on-going.

**Funding amount:** £184,398.81
Abstract
The research project proposed is an extremely rare research opportunity and is, what we believe, to be an ideal example of 'urgent' research. We make this proposal in order to respond rapidly to an unexpected and transient event in Lac-Mégantic, Quebec. On July 6th 2013 an oil train derailed and exploded in Lac-Mégantic, Quebec. This is Canada's deadliest rail disaster in 20 years: the scene remains a crime scene, attempts to confirm involvement of residents through forensic means such as the use of dental comparisons and DNA and other technological 'solutions' (the 'Disaster Victim Identification process') is now underway, and responders are working with families to link the tiniest fragments of evidence to their missing loved ones with support from organisations including the International Commission of Missing Persons, Sarajevo and Office of Chief Medical Examiner, New York.

In response to this incident and the Pilot Urgency Grants call the investigators have designed a qualitative methodology, a framework for analysis and a series of necessary outputs in consultation with a number of 'users' who have identified a need for the outputs.

This study will ask a number of questions; what does it mean 'to identify'? What are the implications of never identifying? How are, what we will define as the 'technologies of identification', used and applied in the field? How are those at the heart of the process, the bereaved families, 'allowed' to participate in the identification process? When and how is the decision that identity may remain ambiguous taken? It will allow social science research to address a key omission in UK resilience and emergency planning; There is currently very limited research on this from a social science perspective and there is also no 'Framework of Understanding' to scaffold and advise policy makers. The implications for UK society of this omission means that there is a lack of evidence based practices, a lack of clarity on the scale of resources and a limited public engagement or discussion.

The outputs of this study will present new concepts and new methods of understanding forensic un/certainty and the way that identification processes are constructed and defined, in communities and in laboratories, and how they are implemented/put into practice. The final case study and Framework of Understanding that will be produced will allow for a much deeper understanding of this complex, difficult societal challenge, which is vital for the informing of future governmental responses to such incidents and directly influencing policy and planning. When realised, the impacts of this study will influence a diverse set of beneficiaries including social science researchers, policy makers, practitioners and ultimately the public - all from one set of outputs.

Without research such as this, conducted as expeditiously as possibly, opportunities for vital learning, outputs, examination and archive will be lost to the social science research field and the wider community. The project is also an exemplar of interdisciplinary and institutional approaches. We believe the approach taken by the investigators illustrates the aim of the ESRC to influence society through research; we have responded directly to an issue raised by UK
government stakeholders as a societal issue and providing a theoretical framing to document and analyse our findings.

The urgency grant has been designed in consultation with a number of potential stakeholders and specifically developed with the UK DVI response team and Cabinet Office Civil Contingencies Secretariat.

**Funding amount:** £56,368.44
Seminar series on genetics, technology, security and justice. Crossing, contesting and comparing boundaries

**Funder:** ESRC

**Project Reference:** ES/N008626/1

**Start:** 10/1/2015   **End:** 9/30/2017

**Abstract**

Security concerns - about crime, terrorism, mass death atrocities and disasters - are a key driver for the development of new technologies, and human genetics research has played an important contribution here. DNA technologies provide vital resources for the identification of human remains and the production of information that can help to provide evidence in complex crimes.

Sometimes, new forensic technologies have been adopted rapidly while their adequate regulation has been delayed until, in specific instances, unintended uses and impacts have emerged after deployment (e.g. indefinite storage of DNA samples from children in criminal DNA databanks). In other cases, extensive legislative deliberations have preceded, and sometimes rejected, technology implementation. There is a need to collate existing knowledge about the opportunities and challenges that accompany the adoption of forensic genetic technologies to ensure that they respect privacy and human dignity.

Three linked observations will shape the focus of the seminar series.

(1) **Comparing DNA uses in security and health contexts:** Seminars will identify differences in aims, responsibilities, obligations, and underlying values between the two domains of security and health. For example, whilst issues of informed consent may be central to the use of genetics in healthcare and health insurance, justice and security contexts prioritise speedy identification of dangerous offenders, the production of credible evidence in court, or the unequivocal identification of victims. This prepares participants for the following work.

(2) **Identifying issues in the use of medical data in security contexts:** Seminars will explore the actual and potential issues that arise when medical data become available to security efforts via the use of novel forensic genetic technologies. Forensic uses of DNA have so far consisted of matching samples from crime scenes, unidentified persons, or volunteers, with existing DNA profiles (e.g. on a DNA database). Novel technologies are anticipated to provide much more information about the donor of a sample, for example their appearance, age, even behaviour. This can impact on the way society understands and treats health data, especially when information is vital in the face of serious criminal, terrorist or mass disaster threats. Seminars will also explore how such novel technologies have already been used, and compare the legal and ethical contexts of their application.

(3) **Comparing uses of forensic genetic technologies across countries:** DNA technologies and data are increasingly used across national borders. National variation in criminal laws, privacy legislation and police practices render this process very complex. For example, there are differences in who can be asked to give a DNA sample by police forces. Seminars will, by inviting leading scholars from Europe and the USA, compare practices and public and professional debates across a variety of jurisdictions. The development of good practice in the UK can be informed by learning from experience elsewhere, and expectations and
misunderstandings in the cross-border use of these technologies can be addressed.

The seminars will bring together academic researchers, policy makers and practitioners from policing organisations, commercial forensic service providers, public sector organisations and civil society groups, in the UK and abroad, to discuss how such technologies can be used to support security while respecting freedom. A network of those involved will be established to disseminate existing and to design new research to inform UK policy and practice on the uses of genetic information to address the societal challenges of justice and security.

**Funding amount:** £30,283.64
What aspects of paedophilic sex offenders' neuropsychological profile differentiate them from other types of sex offender?

**Funder:** ESRC

**Project Reference:** ES/L002337/1

**Start:** 1/2/2014    **End:** 1/1/2017

**Abstract**

Sexual offending is a major problem with over 50,000 sexual crimes recorded in England and Wales in 2010-2011. Two thirds of these offences were committed against women while the other third involve offences against children. Sex offenders often show specific personality characteristics. How these relate to the nature of their offending, however, is unclear. Our approach to resolving this issue is to study the performance of offenders, with different offence histories, on neuropsychological tests that are sensitive to these personality characteristics. This will be achieved by bringing together the combined expertise of a forensic psychologist, a neurobiologist and a cognitive neuroscientist.

The motivations driving sex offending against women and children will vary greatly. We hypothesise that sexual offences against women may be committed by men who show characteristics of anti-social personality disorder or psychopathic traits. Sexual offences against children, by contrast, can be perpetrated by individuals with paedophilic tendencies, i.e., individuals with intense sexually arousing fantasies and urges involving sexual activity with children 13 years old or less. Paedophiles typically appear socially inadequate and may seem socially anxious. It is important to note, however, as few as 40% of child abusers may have a primary paedophilic sexual interest in children. Thus, the motivations to offend may vary greatly across child sex offenders and these need to be explored using objective measures.

Generic treatment programmes based on CBT can reduce re-offending although recidivism rates of around 20% are reported, and the true incidence of reoffending may be higher. The effectiveness of treatment could potentially be increased by tailoring the programme to the psychological characteristics which underlie the drive to offend in individuals as expressed in the Risk, Needs Responsivity initiative of the Ministry of Justice. Consequently there is a need to be able to categorise sex offenders in a manner which goes beyond offence history. The current project aims to determine the psychological profile of a large sample of sex offenders using self-report questionnaires to assess personality traits in conjunction with more objective cognitive neuropsychological testing.

We will use neuropsychological tests that are known to reveal differential patterns in response to psychopathic and social anxiety traits. Psychopathic traits are associated with deficits in identifying the facial expression of fear whereas highly socially anxious individuals tend to interpret neutral facial expression with a negative bias. Eye scan paths will also be analysed as high psychopathic traits are associated with avoiding the eyes when judging emotions whereas social anxiety is linked with focussing on the eyes. A distractor task, where the ability to identify a target is affected by its appearance being preceded by a potentially distracting image, will be used. Social anxiety is linked with difficulties in disengaging attention from distractors which are related to negative emotional faces, while those with high psychopathic traits show minimal distraction. The ability of the participant to look away from an emotional stimulus (make an antisaccade) will also be tested as social anxiety is linked with trouble looking
away from negative stimuli. Our selected battery of tasks will thus allow offenders to be differentiated on the basis of objective measures that are directly related to the personality traits of relevance.

The work will enable a rich description of the psychological profile of different types of sex offender to be established based on both personality traits and more object cognitive neuropsychology tests. This is an essential prerequisite to the tailoring of treatment programmes to match the drives to sexually offend in different individuals. The findings may, therefore, feed directly into treatment programmes for sex offenders.

**Funding amount:** £302,196.82
Abstract
This project represents a new way to look at the problem of human face recognition. Despite a large amount of research on this topic, we still do not understand the most fundamental aspect of face processing: how can we identify the people we see? This is a key problem in human perception, but it also has practical implications in forensic and security settings. This project has its roots in a simple observation: pictures of the same face can look very different indeed. In the standard approach to face recognition, this commonplace fact is treated as an inconvenience. Differences between pictures of the same person are regarded as 'noise', and either ignored or eliminated by systematically controlling the images used for research. This research programme takes exactly the converse approach. Instead of trying to control away this variability, it will be studied explicitly. Under this approach, the problem of face recognition is not how to 'tell people apart', but instead how to 'tell people together' - how to bring together superficially different images into a coherent representation. Early work suggests that a very important component of familiar face recognition is the ability to generalize over superficial image differences - differences which tend to fool unfamiliar viewers, as well as automatic computer-based systems. The current failure to address this variability may account for the slow progress in face identification - progress which has fallen behind the understanding of other aspects of face processing such as social perception. This research comprises three components. First, a systematic examination will be conducted of the physical differences between images of the same person. Applying statistical techniques to graphical data, the aim is to specify what aspects of face images vary commonly, and what aspects vary idiosyncratically to that person. Second, a series of behavioural experiments will examine the nature of our representations of familiar faces - the hypothesis is that this representation needs to incorporate variability. Third, a series of studies will address practical face recognition by human observers (e.g. for security purposes). Computer-based approaches will also be examined in this strand - as these systems remain very poor, despite the claims of vendors. This novel approach to face identification has the potential to make a significant contribution to an area which has progressed rather slowly in recent years.

Funding amount: £107,750.82
SPeech Across Dialects of English (SPADE): large-scale digital analysis of a spoken language across space and time

**Funder:** ESRC

**Project Reference:** ES/R003963/1

**Start:** 8/31/2017  **End:** 8/30/2020

**Abstract**

Obtaining a data visualization of a text search within seconds via generic, large-scale search algorithms, such as Google n-gram viewer, is available to anyone. By contrast, speech research is only now entering its own 'big data' revolution. Historically, linguistic research has tended to carry out fine-grained analysis of a few aspects of speech from one or a few languages or dialects. The current scale of speech research studies has shaped our understanding of spoken language and the kinds of questions that we ask. Today, massive digital collections of transcribed speech are available from many different languages, gathered for many different purposes: from oral histories, to large datasets for training speech recognition systems, to legal and political interactions. Sophisticated speech processing tools exist to analyze these data, but require substantial technical skill. Given this confluence of data and tools, linguists have a new opportunity to answer fundamental questions about the nature and development of spoken language. Our project seeks to establish the key tools to enable large-scale speech research to become as powerful and pervasive as large-scale text mining. It is based on a partnership of three teams based in Scotland, Canada and the US. Together we will exploit methods from computing science and put them to work with tools and methods from speech science, linguistics and digital humanities, to discover how much the sounds of English across the Atlantic vary over space and time.

We will develop an innovative and user-friendly software which exploits the availability of existing speech data and speech processing tools to facilitate large-scale integrated speech corpus analysis across many datasets together. The gains of such an approach are substantial: linguists will be able to scale up answers to existing research questions from one to many varieties of a language, and ask new and different questions about spoken language within and across social, regional, and cultural, contexts. Computational linguistics, speech technology, forensic and clinical linguistics researchers, who engage with variability in spoken language, will also benefit directly from our software. This project will also open up vast potential for those who already use digital scholarship for spoken language collections in the humanities and social sciences more broadly, e.g. literary scholars, sociologists, anthropologists, historians, political scientists. The possibility of ethically non-invasive inspection of speech and texts will allow analysts to uncover far more than is possible through textual analysis alone.

Our project will develop and apply our new software to a global language, English, using 43 existing public and private spoken datasets of Old World (British Isles) and New World (North American) English, across an effective time span of more than 100 years, spanning the entire 20th century. Much of what we know about spoken English comes from influential studies on a few specific aspects of speech from one or two dialects. This vast literature has established important research questions which can be investigated for the first time on a much larger scale, through standardized data across many different varieties of English. Our large-scale study will complement current-scale studies, by enabling
us to consider stability and change in English across the 20th century on an unparalleled scale. The global nature of English means that our findings will be interesting and relevant to a large international non-academic audience; they will be made accessible through an innovative and dynamic visualization of linguistic variation via an interactive sound mapping website. In addition to new insights into spoken English, this project will also lay the crucial groundwork for large-scale speech studies across many datasets from different languages, of different formats and structures.

**Funding amount:** £160,991.7
Learning from the expert: Can observing the oculomotor behaviour of expert face processors improve training of face matching?

Funder: ESRC

Project Reference: ES/J002925/1

Start: 8/28/2012   End: 8/27/2013

Abstract

Face recognition and face matching are crucial to forensic investigations and security, in jobs such as checking passports at border control, searching CCTV footage for suspects of a crime, and in trying to identify people who have been missing either a short time or for many years. It is important to identify methods to improve face recognition and face matching.

Face recognition of unfamiliar people is surprisingly difficult in the best of circumstances. Factors that can make it more difficult include changes in age (as when the observer is trying to identify someone from an old photograph), changes in variable characteristics (as when trying to identify someone in disguise), and differences in lighting and viewpoint from when the face was learned.

One way to develop new methods is to find out why some people are better at face matching than others. As such, the first part of the proposed project tests a cross-section of the public until we identify people particularly good at face matching. We then observe how they compare faces, focusing on the eye movements they make, and ask them about the strategies they use.

The knowledge gained will then be tested to see if explicit training about strategies or implicit training through demonstrating expert's behaviour while they do the task will be effective training. Previous research in other perceptual tasks has suggested that showing the eye movements of those skilled at the task to novices as part of training will improve the rate of training. This is done by showing the trainee the image being evaluated superimposed by a dynamic representation of the eye movements a skilled person made when inspecting the image. The trainee is simply told to follow the gaze of the skilled person during this presentation. The effectiveness of this simple technique may be because people innately attend to other people's gaze to understand what in the environment those other people consider important. This following of another's gaze toward objects, called "joint attention," is a powerful learning tool in childhood. Those who do not develop joint attention, such as autistic children, also appear to be delayed in developing understanding of the goals and intentions of others. Adults, too, are involuntarily drawn to follow gaze and implicitly learn to value higher objects that others gaze at over objects the others do not gaze at.

As this training method is new, it has not been fully tested. For instance, the effectiveness of training has only been tested in the short term. Therefore, this research will test whether any benefits last for a week or a month. Further, testing it on face matching provides a strong test of whether the training generalises, as it is the first task to which this training is applied for which both the stimulus and the task is familiar to the trainee. Although the average person is not particularly good at face matching, everybody has experience of it.
The outcome of this study will be reported in an international journal read by both researchers and practitioners, will be shared with people responsible for training face comparison in forensic contexts, and will inform our further research that will more directly test why this method is effective for some perceptual tasks.

**Funding amount:** £49,256.16
Citizen Led Forensics: DNA & data-banking as technologies of disruption-a novel way to learn and intervene in the search for the disappeared in Mexico

Funder: ESRC
Project Reference: ES/M00063X/1
Start: 8/1/2014   End: 1/31/2016

Abstract
Governmental institutions in Mexico have officially recognised 121,683 violent deaths in the period between 2006-2013. During the same period around 27,000 disappearances occurred, and approximately 15,000 bodies remain unidentified, as there are no national databases in the country. In Mexico, distrust in governmental authorities is the norm, since the practice of forensic science has been opaque, and has sometimes been used to cover the tracks of the perpetrators of grave crimes. The inimical response of the government to this humanitarian crisis, has repeatedly shown that the problem is not one that can simply be solved by the construction or strengthening of forensic technical capacities, but rather the absence of due investigation and diligence that is related to the existing ties between public institutions and organised crime, as well as other normalised practices of corruption.

Our project will explore new forms of citizenship related to the use of forensic science in the search for the missing in Mexico, and will also provide invaluable insights into the disruptive dimensions of Forensic Science and DNA profiling. Through Participatory Action Research (PAR), we wish to explore what would happen if forensic techniques (including DNA) were to be placed in the hands of the relatives of the disappeared, or in non-governmental forensic experts, and/or in interested citizens in Mexico. The project aims to create the first citizen-led Forensic DNA database as a way of positively intervening in the humanitarian crisis currently lived in Mexico. The citizen-led Forensic database will be designed as a mobile and PAR device, articulated through civil society organisations of relatives of the disappeared, already partnered with the project. The project will make DNA swab kits available for 1,500 people (approx. 500 Mexican families), accompanied by a clear set of instructions on how to collect DNA from cheek swabbing, as well as from the personal belongings of the missing person. In the same DNA Kit we would ask the participating families to include written accounts of their case, their experience with forensic investigations (if any), and personal narratives of what they have gone through since their relative(s) disappeared.

Academic literature, mostly centred in EU and the US, solely links the use of forensic databases with state surveillance and issues of privacy. In this project we aim to move the debate beyond these common tropes to explore how citizen-led forensic databases can become a tool for reparation and truth finding. Our project breaks with traditional (state-centric) ways of researching about violence and disappearance, since it surpasses the boundaries between victims' claims for justice and the experts in charge of providing 'truth' about the missing. It is also innovative as it brings together biogenetic and social research; thus providing a tool to open novel avenues of academic inquiry, as well as grounded insights for humanitarian and political intervention. Regardless if our citizen-led forensic project succeeds or fails, our research has the potential to have a truly transformative and global impact, considering the fact that we can help to provide new pathways for forensic research and intervention, in the mass atrocities of today and of the future.
**Funding amount**: £198,143.45
Assuming Identities Online: description, development and ethical implications.

Funder: ESRC

Project Reference: ES/L003279/1

Start: 8/1/2014   End: 7/31/2016

Abstract

Preventive policing of serious crime sometimes involves deception and disguise. A case in point is the prevention of abuse arising from paedophile grooming and peer to peer networks where abuse images of children are discussed and exchanged. The preventive techniques by police investigators include assuming identities of existing community members, and of children, so that interventions and arrests can be made. Often, there are tight time constraints associated with this process - investigators have only a small window in which to learn and assume the identity in question before arousing suspicion in their target(s). The training that undercover online investigators currently receive, although broadly informed by linguistic theory, is in need of development. Furthermore, the time constraints mean that a semi-automated system to assist in identity assumption would represent a crucial contribution to the investigative toolkit.

Research taking a computational approach to the analysis of online communications has thus far focussed overwhelmingly on the structural elements of Computer Mediated Discourse (CMD), such as typography, orthography and other low level features, with little to no attention being paid to the socially situated discourses in which these features are embedded. The Centre for Forensic Linguistics (CFL) - a research centre within Aston University combining leading-edge research and investigative forensic practice - and Lexegesys - a consultancy and technology company specialising in developing and implementing data analysis solutions, recently collaborated on a project that was successful in automating the process of identification and extraction of low-level features for the purposes of attributing authorship of unknown texts within the context of Twitter. Yet CMD has widely been recognized to operate on a number of linguistic levels, such as those of meaning, of interaction, and of social practice. Outside of the computational linguistic field, the characteristic features of CMD are understood as resources that users draw on in the construction of identities in particular contexts, and CMD constitutes social practice in and of itself rather than simply being shaped by social variables.

Taking an inductive approach, which is to say that the phenomena of interest, rather than a specific theoretical paradigm, are primary, this research aims to bridge the gap between complex theories of the discursive construction of online identities on the one hand, and computational approaches to analysing online communications on the other. A small scale study CFL and Lexegesys are currently engaged in is addressing the challenges of automation at the pragmatic and interactional levels, working towards the semi-automated identification of phenomena such as indirect speech acts and topic management.

The work is extremely practical and is informed by real-world police investigations. A partner in the project, the West Midlands Police, Technical Intelligence Development Unit is crucially committed to providing data and operational insights. In addition to empirical applied linguistics, the project conducts proof-of-concept work for software that will assist in an ethical use of assumed identities in policing. Furthermore, it will involve an assessment of the
ethical and policy implications for policing and security of complexity in online identity performance.

This proposal was previously submitted to the AHRC, and is resubmitted here on their advice.

**Funding amount**: £418,885.58
Examining emotion specific memories: An investigation into the persistence of true and false memories

Funder: ESRC

Project Reference: ES/L00853X/1

Start: 1/5/2015   End: 5/31/2018

Abstract
False memories occur when people recollect events that did not happen or incorrectly recollect events that did happen. In legal contexts, the inaccurate recollection of events can lead to errors in convictions. It is therefore important to establish the conditions under which false remembering can occur. When people are exposed to a crime, either as a witness or a victim, they tend to experience a negative event that has the potential to induce a negative emotion. Furthermore, there can then be a considerable delay between experiencing this negative event and recalling it during legal proceedings.

These important factors from the forensic context have only recently been examined in the false memory research. One of the most popular methods for studying false remembering in the laboratory is the Deese/Roediger-McDermott (DRM) paradigm. In this paradigm, participants study a list of words that all semantically associated (e.g., cigar, cigarette, chimney) to one nonpresented word (e.g., smoke). We refer to this word as the critical lure. On subsequent memory tests, participants often falsely recall and recognise these critical lures more frequently than the studied items. We refer to this as a false memory. Moreover, when participants are asked to make remember-know judgments to the critical lures (where a remember response indicates participants can mentally re-experience the presentation of a studied item and a know response indicates participants believe an item is familiar but cannot recollect its presentation) they typically make a remember response. The DRM paradigm can therefore produce vivid false memories.

A few experiments have studied the effect of negative emotions on false memory formation using this paradigm. Participants may be asked to study information while in a particular mood using a temporary mood induction technique. Participants may also be asked to study information that is emotionally negative or positive in content. Of particular relevance to forensic situations, research has also manipulated the delay from when the participants studies the information and then completes the memory test. However, research has yet to examine how specific emotions relevant to such forensic situations may impact on recall of specific information relevant to that emotion. We believe this could be of particular interest given that recent research shows we produce more true (and false) memories for information that matches the emotion/mood that we were experiencing at the time of study.

Furthermore, although research has shown that negative false memories increase over time, recent evidence suggests that this selective consolidation for emotional false memories may occur preferentially during sleep rather than over time per se. The explanation comes from neurochemical changes that occur during REM sleep that result in activity in brain regions that are thought to play a role in the selective consolidation of emotional stimuli. The role of sleep consolidation on the formation of negative emotional false memories has yet to be examined.
The series of experiments outlined in this proposal will further examine these factors (specific emotions elicited during these events and the time and type of delay between encoding and retrieval of the event) that have the potential to mediate the degree to which people falsely remember emotion relevant information.

**Funding amount:** £285,856.58
The Effect of Emotional Salience and Alcohol on Women's Memories for Sexual Assault

Funder: ESRC
Project Reference: ES/J005169/1
Start: 8/11/2012  End: 1/19/2015

Abstract
Sexual offenses often involve alcohol use by the victim and perpetrator. Victims who were under the influence at the time of the crime are less likely to have their cases prosecuted compared to victims who were sober. A major concern the legal system has is that victims who were under influence of alcohol will not remember forensically information about the assault. To date, however, no research has systematically examined the influence of alcohol on remembering sexual offenses.

The overarching objective of the research is to predict when victims who were under the influence of alcohol will accurately remember details about a sexual offense. The results will provide essential knowledge for establishing best practice guidelines for interviewing witnesses who were intoxicated.

Currently, no such guidelines exist anywhere in the world.

Previous research suggests that alcohol intoxication narrows attention, thereby making people more responsive to the most central and emotionally salient elements of a situation. In the context of rape, the culprit's physical appearance and actions are the most emotionally salient aspects of the situation. Other aspects of the situation—such as the presence of bystanders and the physical environment—are considered peripheral because they capture less of the victim's attention.

Pilot research carried out at the University of Leicester has found the first support that salient and peripheral information about a sexual assault is remembered differently when people are under the influence of alcohol. As previous research—quite surprisingly—has not examined this phenomenon, research is needed to better understand the relationship between alcohol intoxication, information salience, and memory for sexual assault. As such, a set of 3 interrelated experiments are planned.

In all 3 experiments, female participants will read a sexual assault scenario. Participant alcohol intoxication level whilst reading the scenario will be experimentally controlled. 24 hours later participants will have their recognition memory for the scenario tested.

In the first experiment, the memories of participants who were given different doses of alcohol will be examined to see if they differ in terms of their accuracy. We will test whether there is a difference in remembering the scenario perpetrator as a consequence of alcohol dose. Additionally, the qualitative characteristics of memories for the hypothetical sexual assault, such as the vividness of the memory, how much participants feel they are reliving the memory as they recall it, and so on, will be examined in relation to alcohol dose.

The second experiment will build upon the results of the first experiment by examining whether intoxicated participants provide less accurate information when they are administered the Cognitive Interview. It is important to examine...
the accuracy of sexual assault memories using the Cognitive Interview because it is a forensic interview technique that is used by criminal investigators.

The third experiment examines whether participants who were under the influence of alcohol whilst reading the scenario are more susceptible to memory distortion. Victims frequently delay reporting sexual assault to the police. Delayed reporting is potentially problematic because previous research has found that delayed reports increases one's susceptibility to memory distortion. Therefore, it is important to assess whether alcohol intoxication leads to memory distortion more often than when the victim is not intoxicated.

In sum, the proposed research aims to describe and predict when victims of sexual assault who are under the influence of alcohol will accurately remember forensically relevant information. This project may have far reaching implications for sexual assault victims, public safety, and public policy.

**Funding amount:** £68,237.07
The use and utility of localised speech forms in determining identity: forensic and sociophonetic perspectives

Funder: ESRC

Project Reference: ES/M010783/1

Start: 1/4/2016   End: 7/2/2019

Abstract

The project aims to investigate variation in accents of English across Northeast England. We focus on the speech of working-class people from Newcastle, Sunderland and Middlesbrough. It is well established that these accents differ significantly from one another, but it is less clear what particular pronunciations lead listeners to group the varieties as one accent (typically, 'Geordie'). The project seeks to identify specific features that cause the accents to be classed together, such that they are heard to be distinct from other accents of northern Britain. Simultaneously, we will ascertain what sounds listeners use to classify speakers into subgroups, e.g. from Newcastle versus Sunderland. The role of socio-economic class is of key importance here. The localised patterns that allow listeners to assign speakers to one group or another are, according to the literature, traditionally associated with speakers from lower socio-economic groups, i.e. the 'working class'. However, in this project we ask whether clear differences exist between the speech of working-class speakers who routinely travel for work or leisure and that of economically marginal individuals we might label 'never worked/long-term unemployed'. Plentiful sociological research on this social divide exists, but how it impacts on people's speech has not yet been investigated systematically. We will also take gender and age differences into account, and assess the data for signs of sound change. It has been shown that greater mobility promotes linguistic uniformity through convergence of speech habits, while limited mobility has the opposite effect. We therefore predict that more mobile members of our sample would converge linguistically over time and across the three localities, while the economically marginal groups in each place would become more divergent.

The project's second strand concerns speech variation at the level of the individual rather than the group or community. This is particularly relevant in the forensic domain, wherein individual identity is crucial. In criminal investigations, forensic speech analysts perform two main tasks. The first, speaker profiling, involves attempting to specify the geographical and social origins of an unknown speaker from a recorded sample of his/her speech, so as to assist the police in identifying potential suspects. The task requires detailed, up-to-date information about the speech of the community/ies to which the unknown speaker may belong. Given its focus on the identification of highly localised speech forms, the corpus produced by the proposed project will satisfy those requirements. The second forensic task is speaker comparison. Here, the expert compares two speech samples, and assesses the likelihood that they were produced by the same or different speakers. Increasingly, this is done in an automated way, using software that extracts information about the acoustic properties of the recordings. The level of similarity between the two samples is evaluated in the context of a relevant 'background population' of recordings of speakers with the same or similar accents. This yields a measure of the samples' typicality. The problem with this approach is that ideally one ought to collect a new corpus for every case, which is likely to be prohibitively expensive. It would be advantageous, therefore, if acoustic parameters in the speech signal which are
relatively insensitive to accent variation could be identified. The proposed project tests whether this is possible by combining the Northeast recordings with those from an existing corpus of a markedly different accent (Standard Southern British English). If the approach proves legitimate, its practical value to the forensic speech analysis community would be considerable.

Findings emerging from this two-stranded project will therefore benefit the relevant academic communities as well as having significant applied utility in the field of forensic speech science.

**Funding amount:** £673,328.34
Constructing Facial Composites: Increasing the Forensic Relevance of Laboratory Research

**Funder:** ESRC

**Project Reference:** ES/I002022/1

**Start:** 9/19/2011   **End:** 3/18/2013

**Abstract**
Abstracts are not currently available in GtR for all funded research. This is normally because the abstract was not required at the time of proposal submission, but may be because it included sensitive information such as personal details.

**Funding amount:** £78,131.28
The Role and Work of Forensic Nurses in Sexual Assault Cases: An International Comparative Approach

**Funder:** ESRC

**Project Reference:** ES/H044698/1

**Start:** 6/1/2010  **End:** 5/31/2011

**Abstract**
Abstracts are not currently available in GtR for all funded research. This is normally because the abstract was not required at the time of proposal submission, but may be because it included sensitive information such as personal details.

**Funding amount:** £77,206.13
'Urgent Invite': Securing a data set on allegations of sexual abuse made against the former disc jockey, Jimmy Savile

Funder: ESRC

Project Reference: ES/L011778/1

Start: 12/1/2013   End: 11/30/2014

Abstract

In 2012, a year after his death, allegations of historical sex abuse by the former disc jockey, Jimmy Savile, began to emerge following an ITV 'Exposure' programme. The case generated massive public interest; initial allegations led to hundreds of others. It caused public outrage; Savile's grave was desecrated, his holiday cottage vandalised. The reverberations of the case have engulfed major institutions in controversy leading, for example, to the resignation of the BBC's Director General and to two reports (Pollard, 2012 and Smith, ongoing) into the organisation's handling of the affair. It has also led to investigations of sex crimes by other celebrity figures from the 1960s and 70s and more currently. Previous allegations of abuse in North Wales children's homes re-surfaced, implicating (wrongly) the Tory peer Lord McAlpine in child abuse.

The scale of the allegations against Savile led the Metropolitan Police in the Yewtree Report (2013) (in conjunction with the Crown Prosecution Service and the National Society for the Prevention of Cruelty to children) to identify those making allegations against Savile as victims and, by implication, Savile as a perpetrator of abuse, a 'predatory paedophile'. Alison Levitt QC, Principal Advisor to the Director of Public Prosecution, in her report regarding Savile, notes that the term 'complainant' is inappropriate and substitutes the term 'victim' throughout the report. This is a new and arguably troubling development inasmuch as Savile was never tried or convicted through due process of law.

There is a wider concern that the sexual mores of a particular time period are being examined and judged, perhaps, against standards of a different age. While the general mood against Savile is one of revulsion, voices are beginning to be raised questioning the veracity of some of the allegations against him. Initial allegations emanate from former residents of Duncroft School, a residential school for 'wayward but intelligent girls', which operated in the South of England over the course of the 1960s and 70s and into the 80s. One former resident of Duncroft went on to become a lawyer, now lives in France and blogs under the name of Anna Raccoon. She disputes the picture of Duncroft painted by other former residents and the extent and nature of Jimmy Savile's alleged abuse there. Dozens of other former residents have contacted her to question aspects of the story that has found its way into the public domain. Members of Jimmy Savile's family have similarly disputed claims made against him by a relative.

Picking up on Mark Smith's interest in moral panics, Anna Raccoon contacted him to reveal that she was suffering from terminal cancer and would like to ensure that the information she holds on the Savile case is not lost but is subjected to proper academic scrutiny. This research proposal is to collate the 'urgent' electronic data she holds but also to interview key informants on the Savile case who are known to 'Anna'. The subject of our proposed research takes us onto contested ground: proponents of the approach that has been taken to investigate the 'Savile affair' argue that victims are at long last being afforded justice and the possibility of 'closure' and that to raise questions of the process might put off
others from coming forward; critics see it as a witch-hunt or as Furedi (2013) claims, the latest episode in a wider 'moral crusade' against child abuse. Our proposal raises, among others, questions of human rights and civil liberties, the rule of law, memory, identity and perceptions of trust in social relationships. As such it will be of interest to a range of academic disciplines and publics. It should be of particular relevance to the workings of the criminal justice system in the UK. It is also of international significance as jurisdictions across the world struggle with how best to address vexed questions of historical child abuse.

**Funding amount:** £44,512.88
Human Rights and Information Technology in the Era of Big Data

**Funder:** ESRC

**Project Reference:** ES/M010236/1

**Start:** 10/1/2015   **End:** 9/30/2020

**Abstract**

Edward Snowden's leaks about the extent of US and UK intelligence services' electronic surveillance dramatically demonstrated how in an increasingly digitised world, technological developments and the collection, storage and use of 'big data' pose unprecedented challenges for the protection of human rights. The aim of this programme of research is to ensure that the use of technological developments and big data are compatible with the ideals of human rights protection and can even have a positive impact.

Snowden's revelations are part of a much bigger picture in which electronic monitoring and data is collected and shared by companies and states on a routine, daily basis through social media, consumer activity and smartphones. The same technologies that threaten our privacy also provide opportunities for enhanced protection of human rights through better documentation of human rights violations and by demonstrating the effectiveness of rights-shaped policies in order to influence resource allocation and budgets.

Existing work either fails to consider the rights-implications of the use of Information and Communication Technology (ICT) and big data or focuses on a particular right. What is missing is a wider investigation into the diverse and complex rights-implications (positive and negative) of the use of ICT and big data including, but not limited to, privacy and the many social, ethical and legal issues lurking beneath the surface of human-machine interaction and use of big data. Moreover, regulation of the use of ICT and big data is currently fragmented between states, the United Nations and internet governance sector. This project will provide added value by offering a fuller picture of the totality of human rights issues raised by ICT and big data to advance new thinking and regulatory solutions.

The research questions focus on issues that cut across the threats and opportunities: 1) How is the use of ICT and big data shaping the content and scope of rights? (2) How does the use of ICT and big data shape operational practices across state and non-state activities? What new theoretical questions and implications for human rights are generated? (3) What methodologies are needed to identify and document the misuse of modern technologies and the failure to comply with rights-based obligations? (4) How can the use of ICT and big data best support evidence-based approaches to human rights protection and advocacy? (5) What possibilities and limitations exist for regulating the collection, storage and use of ICT and big data by states and non-state actors?

The project will be organised into 4 work streams. The first (WS1) will focus on the overarching and synthesising themes. This will be complemented and informed by three in-depth studies: state and non-state surveillance (WS2); health as an example of using new technologies and big data for accountability purposes and evidence-based approaches to rights (WS3); and human rights advocacy and humanitarian work (WS4). The project will use multiple methods (desk research, interviews, econometrics, comparative case studies and computational techniques).
Communication and impact streams will be developed across the different stakeholder communities to establish agreement and a shared vocabulary by forming an expert working group of practitioners (human rights and technology), international internet governance, UN actors and academics that will meet twice a year to develop international standards on information technology, big data and human rights.

Dissemination and engagement with academics, practitioners and the public will be achieved via an interactive website; social media channels; conferences; public events; academic publications; shorter practice-orientated articles, policy briefings and blogs; media pieces; and time sensitive interventions targeting key policymakers and influencers and international, regional and national courts.

**Funding amount:** £4,743,734.26
Transnational Organised Crime and Translation (TOCAT): Improving police communication across languages

Funder: ESRC

Project Reference: ES/P001351/1

Start: 11/21/2016 End: 12/20/2018

Abstract

Our societies are more diverse than ever - more than 300 languages are spoken in the UK today. This increased diversity has had a major impact for the police. Officers now have to investigate and combat organised crime 'networks' whose members communicate across multiple languages. Police therefore increasingly need translators to be able to investigate serious crimes such as people trafficking and child sexual exploitation. This involves significant challenges, including cost, number of languages, quality and the limited supply of qualified linguists.

In the Transnational Organised Crime and Translation (TOCAT) project, researchers, the police and translation providers will work together to understand and face up to these challenges. Our starting point is the need for practical guidance to help police officers and translators work together as effectively as possible. A working group has drafted official new UK guidelines for police to use when they work with translators. The TOCAT project team will conduct a trial of these new guidelines, using a 'Test, Learn, Adapt' approach. Selected police officers in the UK and Belgium will be trained to use the guidelines, then researchers will interview and 'shadow' police officers as they work to measure their effectiveness in practice, as well as any other potential needs identified by the users. This will allow us to revise the approach to make it better suited to actual needs. The Belgian trial will also allow us to test how far the approach can be 'translated' to other countries facing similar challenges, since transnational crime operates across national borders.

The main questions we will be asking are:

1. How can police work more effectively to understand and fight transnational organised crime such as people trafficking when it is conducted across different languages? In particular, how should police work with translators when victims, witnesses or suspects don't speak the same language as investigators?

2. Is the planned police approach effective in practice, and, where it is not, what can be done to enhance it?

3. What are the experiences of frontline workers (police officers, support workers, translators) when they face these new challenges, and can they help us develop a better overall understanding of transnational organised crime?

To answer these questions, two researchers at the University of East Anglia in the UK, Dr Joanna Drugan and Dr Alexandria Innes, will work with two researchers at the University of Leuven in Belgium, Prof. Heidi Salaets and Dr Katalin Balogh. We will draw on our established partnerships with the police and all the professional associations representing translators to design and carry out the research. The research team has decades of experience in researching translation practice in 'real-world' settings, migration, and police working with linguists, suspects and victims of crime, including children and other vulnerable groups. Dr Drugan, an expert in translation quality, will oversee the project. Dr Drugan and Dr Innes, who is an expert in migration, will conduct the UK
research, working with three Constabularies and the College of Policing. Prof. Salaets and Dr Balogh, who both have expertise in interpreting in police settings, will conduct the Belgian research, working with local and federal Police.

We will focus particularly on the crimes of human trafficking and smuggling in this project. We will also focus on the impact of language challenges on frontline workers, notably police officers and translators. We will share our research findings and the tried-and-tested approach as widely as possible among police, translation providers and researchers, including making our (anonymised) data available for free. This will result in a valuable contribution to evidence-based policing of increasingly significant transnational crimes, and support further research on this important topic.

**Funding amount:** £85,705.06
Forensic Citizens: The Politics of Searching for Disappeared Persons

**Funder:** ESRC

**Project Reference:** ES/S011307/1

**Start:** 10/1/2018  **End:** 9/30/2019

**Abstract**

The aim of the fellowship is to build upon my track record of publications and further consolidate my contributions to academic and stakeholder understandings of the citizen-led practice of forensics amidst atrocities. I will build a research agenda that revalues the actions of non-state agencies, communities, and families in creating new search technologies. After a very productive doctoral fieldwork, this fellowship will give me the necessary time to analyse data that was collected during my ethnographic work in Mexico, Colombia and Bosnia. Due to the time and format constraints of a PhD thesis there is data which couldn't be included in the final document. The fellowship will give me the time I need to analyse, write and further develop my contribution to human geography, science and technology studies and cognate disciplines.

During the Fellowship I will participate in career development activities: organise an international knowledge exchange workshop at Durham University to collaboratively write a 'Guiding Principles' document on citizen-led practice of forensics. The workshop participants will be families of missing persons and forensic practitioners coming from Mexico, Ireland and the UK. I will write three journal articles to be published in top tier journals (Social Studies of Science, Political Geography and Society and Space); and consolidate and expand my research networks in the UK.

The world-leading research carried out at the Durham Geography makes it the ideal host department to make these interdisciplinary conversations happen. This project will benefit from Louise Amoore's research on Data, Security and Ethics of new technologies; Gordon McLeod's work on Grenfell Tower; Lauren Martin's work on Border and Migration Policy; Jonathan Darling's research on the politics and ethics of forced migration, as well as Cheryl McEwan's research on Postcolonial Studies and Development.

**Funding amount:** £94,841.28
Abstract
Autism spectrum disorder (ASD) is diagnosed in around 1% of the population and presents a number of challenges to the day-to-day lives of these individuals as well as their families and support services. This project will provide an evidence base and guide improvements to existing methods used by professional groups to support those with ASD. This will take place in three important information-gathering contexts in which they are currently at a disadvantage. First, only around half of young adults with ASD have worked for pay outside the home - the lowest rate among disability groups. Performance in occupational interviews is a crucial determinant of employment prospects, yet the social, cognitive and communication difficulties of ASD mean they are often unable to perform to the best of their abilities in interviews. Second, people with ASD are more likely to have certain social and health-related issues and co-occurring conditions, and may therefore be more likely to visit health and social care professionals. However, difficulties with introspection and social communication are likely to make relaying relevant information difficult, unless their specific difficulties are appropriately supported. Finally, although individuals with ASD are over-represented in the Criminal Justice System (CJS) as both witnesses (victims) and suspects, current police interviewing models are ineffective in supporting them to provide 'best evidence'.

For people with ASD and their families, research on societal issues and improving the lives of ASD individuals is vital. Yet research of this nature is currently lacking. Most services including health and social care, employment and the justice system are developed to cater for ‘neurotypical’ people, or adapted for those with broad intellectual disability. However little consideration or support is in place for the social and cognitive difficulties that are specific to ASD. If individuals with ASD are to receive appropriate and fair access to services and justice, their difficulties must be better understood and accommodated. This begins with their reporting of relevant information to authorities and services. People with ASD show impairments in socio-cognitive domains, including a lack of insight into their own and others' intentions, as well as 'executive functions' (a set of capacities involving cognitive control, regulation, planning and flexibility). As a result, they experience problems in open-ended social situations where the desired response or type of information required from them needs to be inferred. The proposed project will compare how individuals with and without ASD perform on varying social and open-ended tasks. It builds on my existing work to test 1) how the shifting social contexts and increased task complexity inherent in information-gathering interactions in employment, healthcare and CJS contexts might heighten ASD impairments, and 2) how these can be ameliorated with appropriate support. Furthermore, people with ASD can also have areas of strength, and the research aims to determine how these strengths can be utilised to develop interviewing formats that support their difficulties whilst capitalising on their strengths.

This research will directly inform best practice in HR, health and social care and the CJS, improving access to services and justice for people with ASD. It will also
advance theory by providing new insight into how the social and cognitive
difficulties (and strengths) of ASD impact upon real life social interactions.
Findings will have implications for national organisations, including the
Department of Health, Department for Business Innovation and Skills, Home
Office, as well as more local groups, for example, potential employers, police
interviewers and health and social care professionals. An extensive program of
dissemination to both academic and non-academic stakeholders is planned to
maximise the research impact with a broad range of key users.

Funding amount: £223,644.27
Data Capture of Syria Chemical Weapons Allegations

**Funder:** ESRC  
**Project Reference:** ES/L014505/1  
**Start:** 5/1/2014  
**End:** 3/31/2016

**Abstract**

This project seeks to collect information related to the recent United Nations investigation into allegations of chemical weapons use in the suburbs of Damascus, Syria on August 21st 2013. Confirmed by that investigation team in its interim report on September 16th 2013 the UN investigation team found that the nerve agent Sarin had been used. The UN Secretary-General described this attack as constituting "the most significant confirmed use of chemical weapons against civilians since Saddam Hussein used them in Halabja in 1988".

Data collected during this project will include government policy documents; media reports; non governmental comment and analysis. Key to the project will be the collection of material from social media platforms. These will span media sharing platforms (e.g. Youtube, Vimeo, Flickr etc.), Networking (e.g Facebook, Linkedin etc.) Blogs (e.g. Wordpress, tumblr) Microblogs (Twitter), Discussion platforms (Reddit) the more innovative sources such as crowdsourcing sites (ushahidi, irevolution, etc.) and live streaming services such as Bambuser. These materials constitute citizen reporting on the events related to the UN report and on the conduct of the investigation itself. The richness of the media means that useful data is collected both intentionally and unintentionally within meta data and background information. To increase the utility of these data a series of initial analysis papers and/or detailed thematic chronologies will be generated as well as a searchable database.

The collection of information relating to the United Nations confirmation of nerve agent use in Syria is an important task for a number of reasons including:

1. The confirmation of use has set in motion a series of unexpected events which have potentially profound consequences, not just for how in the future allegations of chemical weapons use are dealt with, but also for scholars in areas such as international relations, regional studies, toxicology and international law.

2. International responses to the allegation of use have given unusual weight to data produced by non governmental sources. This includes for example, intelligence agencies publicly referencing Internet and social media evidence as indicative of a chemical attack occurring with such force that a potential kinetic response was considered. The value of such material, as intelligence or court admissible evidence, is yet to be decided including how such material should be gathered and presented to be admissible.

3. Already we are witnessing data relating to the investigation 'disappearing' from public view as narratives concerning, for example, who authorised the use of the nerve agent are debated. Near contemporary collection of data therefore generates a more accurate repository and acts as a witness to such events, and in particular gives victims a voice in future academic and policy shaping analysis.

4. Past experience concerning allegations of chemical and biological weapons use suggests that data will continue to 'disappear' from public (and therefore academic) view as a narrative becomes dominant. Failure to collect information
now that attests to multiple narratives may result in future research being based on incomplete or potentially flawed or otherwise contaminated dataset.

**Funding amount:** £135,561.72
Ethics and Security: Terrorism and Transnational Organized Crime

Funder: ESRC

Project Reference: ES/K000098/1


Abstract

This project introduces ethics research into the Global Uncertainties programme and adds value to on-going security research in the programme. The ethics research juxtaposes terrorism and transnational organized crime. On some understandings, terrorism is just a special kind of transnational organized crime, to be dealt with by established policing techniques within and between jurisdictions. Policing operations, at least in the West, are subject to stringent ethical and legal constraints, especially when directed at citizens of the jurisdiction being policed, and especially where the operations seek to prevent crime rather than to detain and try offenders guilty of an offence already committed. On other understandings, terrorism is a military threat, terrorists are combatants, and countering terrorism is literally a war. In a war, lethal force can legally and morally be used against combatants, and the penetration of military secrets by secret or underhand means is not typically considered immoral, because its target is an enemy rather than people who have the status of citizens. So it makes a great difference whether terrorism is seen as transnational organized crime that requires a policing response, or as a military threat. Even if it is seen as a policing matter, and especially as a preventive policing matter, there is considerable controversy over the means that can be used against it. Counter-terrorism involves mass searches at airports, secret wire-tapping, bugging, camera-surveillance and internet monitoring, questionable kinds of data-sharing, questionable kinds of detention even of people there is evidence against, and, at the extreme end, torture and extra-legal killing. Because of the way counter-terrorism affects a wide cross section of the public, some of the associated preventive policing techniques are more controversial than they would be if employed in a more targetted way against paedophiles, people traffickers; drug dealers; and weapons smugglers. Perhaps there is less scope, in policing non-terrorist, serious crime, for the use with bad consequences of ethnic and other stereotypes; and it may make a difference that some kinds of transnational serious crime are much more prevalent, and harm many more people more frequently, than terrorism. Some activities associated in UK legislation with terrorism, such as glorifying it, are arguably protected by human rights to free speech and association; propaganda activities by the other side during a war, on the other hand, are routinely subverted by the other side, with no moral overtones. In short, the ethical differences between counter-terrorism and measures against (other kinds of) transnational organized crime are themselves of research interest. Identifying and explaining these differences, and suggesting how they should be reflected in public policy are important research tasks of this project. But the project also has a role in adding value to projects elsewhere in Global Uncertainties. These other projects sometimes aim at detecting patterns of behaviour that indicate possible criminal conspiracy, or even a tendency to violence. They also speed up identification of suspects. All of these kinds of research carry ethical risks, some of which may not be obvious to scientific researchers. The Leadership function of the project will involve interaction with other GU-funded projects for the purpose of identifying such risks and helping researchers to accommodate them, and even to write about them. Another function of the research will be to organize
interactions between GU-supported researchers, companies in the UK and European security sector, and ethicists. Such interactions have been pioneered by the PI in previous European research.

**Funding amount:** £348,319.19
Science and Security: Research Impact and Co-Production of Knowledge

Funder: ESRC

Project Reference: ES/K011367/1

Start: 3/1/2013  End: 9/30/2015

Abstract

Enhanced knowledge transfer and exchange (KTE) between academia, governments and industry is now key to successful research impact and in providing partnerships that support intellectual insight and technological innovation.

In this research integrator role we will function as a facilitator - a critical friend - of the successful research teams and DSTL in order to allow them, through their own impact plans and co-ordination with other research teams, to produce high quality and user-friendly research outputs and knowledge. The research integrator team will work with successful applicants throughout all the stages of their research to:

1. Ensure that the research projects maximise impact and uptake well beyond their funding period by building durable networks between the project researchers, policy communities and other project relevant stakeholders.

2. Help foster and develop research impact communities between social (including arts and humanities) and natural/physical scientists within academia, business and industry, and policy; laying the foundations for future collaborations and continued synergies beyond the funded life of the projects.

3. Ensure that the research projects are exposed to the policy community at the earliest stages to ensure that they have sufficient input to produce significant impact whilst developing world class research findings and insights.

4. Identify opportunities through horizon-scanning to ensure that the projects keep stock of developments and opportunities within the defence and security sectors.

5. Facilitate the cross-fertilisation and integration of research findings, to provide added intellectual value, through a range of innovative strategies and techniques.

6. Ensure that our communication and engagement activities highlight the world class nature and importance of these projects and the role of ESRC, AHRC and DSTL.

Using a 'critical friendship' approach we will use 'Case Study Integrity Fora' (CSIF) to facilitate connections between academic research and the users of research, supplemented with the use of specialist online software and series of supplementary stakeholder engagement meetings to form a new approach - the Research Impact Co-Production of Knowledge (RICK) Strategy. To ensure the co-production of outstanding research our integrator activities will include: regular communications with, and site visits to, the research teams; programme meetings to understand and exploit synergies across the project teams; a bi-monthly programme newsletter and project webpage (with embedded new media technologies); direct engagements with user communities - to include workshops and meetings with government departments; and, the production of policy briefs and reports.
Our work will be undertaken in three project phases, which will follow our RICK methodology. Stage One (months 1-7) will identify emergent research challenges and the development of 'exploitation plans' to give greater visibility to the GU programme and DSTL. Stage Two (months 8-12) will develop, greater opportunities for impact, engagement and integration and explore opportunities for uptake and allow research results to inform policy-making and professional practice. Stage Three (months 13-24) will be focused on promoting the research project's findings, producing insights and policy recommendation and establishing a lasting legacy for the projects.

We expect a range of outputs to be generated during these three stages ranging from the establishment of new contacts and networks facilitated by communication and engagement activities, to user-friendly outputs that can be published widely and utilized in horizon scanning activities. We also plan to produce one academic paper/commentary, which highlights the projects and engages with the on-going debate in that journal regarding the importance of integrating the arts, social science and the natural sciences.

**Funding amount:** £120,831.8
Understanding and improving risk assessment on domestic abuse cases

Funder: ESRC

Project Reference: ES/M01178X/1

Start: 6/1/2016  End: 9/30/2019

Abstract
Domestic violence is one of the most common forms of crime coming to the attention of the police. It can have severe and long-standing consequences. Yet our understanding of how to respond to domestic violence, despite various decades of research is limited. It is, thus, important to develop evidence that helps to improve our responses.

A particular response that became popular during the 1990s was to develop tools trying to identify those cases coming to the attention of the police that could result in more severe incidents in the future. As much as a third of domestic abuse cases may result in new calls to the police, but only a smaller percentage will result in more severe injuries. Given the volume of cases and the increasingly limited resources available, police and victim services organisations have used these predictive tools to focus their attention in those cases that have a higher probability of future harm. These predictions have very real consequences for they shape the level of responses.

In the UK the tool that most organisations and police forces use is called DASH. DASH was developed only by means of (1) reviewing the literature on intimate partner violence (IPV) characteristics and (2) by examining the features of a small non-random sample of homicides and near misses. There are more appropriate methods for developing and testing predictive models. These methods have been developed by statisticians and computer scientists and they are increasingly been used to improve the quality of decisions made in criminal justice. Our project aims to use these methods to evaluate the quality of the predictions made with DASH. We suspect DASH may work better in cases of IPV than in other cases in which it is applied, because of the way it was originally developed. We also suspect (based on existing research) that simply counting the presence of particular risk factors is not optimal -some factors may be more important or may particularly elevate risk when appearing in conjunction with others. Finally, we suspect there may be other characteristics of these cases that would lead to better predictions - given all we have learnt about domestic abuse since DASH was created. Our project will use data from the police and other organisations to explore if we can develop better predictive models that could result in tools to subsequently be piloted. We will also investigate the challenges the police would face to implement these new models. We know that it is possible to develop national risk assessment systems like the one we envisage (as in Spain), but we also know that implementing these changes would benefit from understanding the challenges associated with it.

Our second objective is to investigate if we can identify types of IPV. Various scholars have argued that IPV can be grouped in various types associated with different causes, evolution, and treatment needs. Although various researchers have been making this point for over 20 years now, we have little understanding of whether we can actually identify these types using police data. If we could identify particular profiles when they first come to the attention of the police, then potentially we could start experimenting with more tailored responses to the needs of each of these profiles.
Finally, our project is also trying to explore whether current responses to domestic abuse work. Those victims classified as high risk with DASH are referred to a MARAC: a group of professionals aiming to produce a set of responses that can help victims to cope with their situation and improve their safety. Our data will allow us to study whether these referrals reduce the probability of future victim harm. The official evaluation of the MARAC's concluded that we do not know whether they are having a measurable impact. We will use a method called regression discontinuity design that is particularly well suited in situations in which you cannot do a classic experiment.

**Funding amount:** £437,727.69
Accent Bias and Fair Access in Britain

Funder: ESRC

Project Reference: ES/P007767/1

Start: 9/1/2017   End: 2/29/2020

Abstract

RATIONALE

Fair access to employment is the cornerstone of a just, equal and socially mobile society. Despite efforts in recent years by government and industry to implement fair access policies, a 2015 report by the government's Social Mobility Commission revealed persistent bias in recruitment and selection processes in elite sectors of the UK economy in favour of applicants from middle-class backgrounds. This bias, which Commission Chair Alan Milburn describes as keeping working-class candidates "locked out of top jobs," results in part from the reliance on subjective and non-educationally-based "talent" criteria, such as a candidate's appearance and communication style, when making hiring decisions. Characterised by the report as "poshness tests," talent criteria such as these privilege middle-class norms and behaviours, such as accent, at the expense of an objective assessment of a candidate's aptitude, and can ultimately impede social mobility.

This project examines the role of accent bias in hiring situations in the legal profession, a sector identified by the Commission report as particularly prone to the use of subjective criteria. Specifically, we investigate whether bias against certain regional and class-linked accents in the UK interferes with employers' objective assessment of a candidate's job suitability. We also investigate sources of bias and test whether different anti-bias interventions are effective. For scholars in linguistics, social psychology and related fields, the project offers an updated quantitative examination of attitudes to accent variation in Britain, and a novel understanding of the real-world effects of accent bias. For legal, HR, and policy stakeholders, the project responds to a key recommendation of the Commission's report about the need to "interrogate current definitions of talent ... to ensure that applicants are not ruled out for reasons of background rather than aptitude and skill"; and provides concrete evidence on the efficacy of different types of interventions.

RESEARCH PLAN

The project makes use of survey and experimental methods to examine the effect of accent bias on hiring decisions in law firms. Five accents that differ in terms of region and class will be examined: two Northern (Leeds, General Northern), two Southern (Estuary, Multicultural London), and the nationwide standard (Received Pronunciation).

The project is composed of two phases. In Phase 1, we collect large-scale quantitative data on how the UK public evaluate these five accents in a hiring context. This provides an up-to-date picture, currently lacking, of attitudes to accents in the UK today and how those attitudes vary across the UK population. In Phase 2, we focus specifically on attitudes among lawyers in hiring contexts, given concerns about lack of diversity in this sector. We examine whether a candidate's aptitude and skill may be obscured by their accent. 120 expert evaluators (lawyers) are divided into three groups: one completes the judgement task with no prior information, and the other two first receive different anti-bias
interventions. This design allows us to investigate whether accent interferes with the fair assessment of a candidate's suitability for employment, and whether such bias can be mitigated by different possible interventions. We draw on theories of discrimination from social psychology and labour market economics to analyse the origins of any bias effects observed (e.g., personal exposure to accents vs. received attitudes to social groups) and to inform data-driven policy recommendations.

Findings will be disseminated to academic colleagues via conferences, seminars and articles; to stakeholders and policymakers via policy papers, workshops and training materials; and to the general public via the media and an interactive project website.

**Funding amount:** £471,042.55
'Good' police custody? Theorizing the 'is' and the 'ought'

Funder: ESRC

Project Reference: ES/J023434/1

Start: 9/1/2013   End: 8/31/2018

Abstract

Police custody is where an arrested person is taken whilst a decision is reached about what should be done with the case, for example whether to charge or bail them. It is therefore an important gateway to the criminal justice process, where much is at stake for suspects and staff. In recent years, there have been changes to the way that police custody areas are staffed and managed, in particular, civilianization of roles formerly done by police officers has given way to privatization through the use of public-finance initiatives (i.e. when a private security company owns and/or manages a police custody suite and the police let it from them).

Though there have been a few recent studies of police custody, including the Principal Investigator's book, 'Police Custody' (Willan, 2011), there have been few attempts to rigorously examine 'good' police custody or to map out changes to police custody arrangements on a national basis. Information about how police custody is currently delivered can be used to theorize about 'good' police custody practices and 'good' policing, and explore how police custody should be delivered in the future. Therefore the aims of the research are to:

1. Describe and appraise variations in police custody arrangements across the UK.

2. Identify the key dimensions of police custody areas in operation. They might include occupational culture(s), power, fairness, justice, emotions and relationships, cost, governance and accountability.

3. Explore how police custody arrangements such as civilianisation and privatisation impact on these key dimensions of police custody.

4. Conceptualise and theorise the dimensions of 'good' police custody and the links between them, and examine the implications for 'good' policing.

5. Develop benchmarks and a survey tool to monitor and improve police custody facilities, complementing the inspections conducted by HMIP/HMIC.

The research will be undertaken by a team of researchers over three years:

Phase 1 (months 1-6): There will be a survey of all 52 police services in the UK, asking them about the composition of their main police custody facilities in terms of police/civilian input, throughput, and management. This information will be used to describe and appraise types of police custody suites and to select four sites for Phase 2.

Phase 2 (months 7-16): In each of these four police custody suites, one month of participant observation will be followed by 52 interviews with staff and the collection of data from official records about suspect experiences and outcomes. In each site, a random sample of 20 suspects will be interviewed about their experiences of police custody. With their consent, they will also be followed up in Phase 3. In Phase 2, these data will be used to identify the key dimensions of police custody areas. They might include occupational culture(s), power, fairness, justice, emotions and relationships, cost, governance and accountability.
Phase 3 (months 17-30): Based on the data collected in Phase 2, a survey tool will be designed to test developing theories about the key dimensions of police custody and the impact of police custody arrangements on them. This will be administered to staff and suspects in 1-2 of the busiest police stations in 20 police services in the UK. Suspects identified in Phase 2 will be followed up through a combination of face-to-face interviews and an examination of police records.

Phase 4 (months 31-36): The purpose of Phase 3 is to examine the implications of all the data for conceptualising 'good' police custody. This will lead to a set of benchmarks and survey tool for police organisations to measure their performance. Information about this and other key findings will be disseminated to key police stakeholders through an end-of-project conference and workshop. A key impact of the study will be ongoing assessment and reform of police custody to complement HMIP/HMIC inspections.

**Funding amount:** £421,224.73
Understanding the Use of Digital Forensics in Policing in England and Wales: An Ethnographic Analysis of Current Practices and Professional Dynamics

Funder: ESRC

Project Reference: ES/R00742X/1

Start: 9/1/2018   End: 8/31/2021

Abstract

Digital evidence can reveal a suspect's intent to commit an offence and help establish when events occurred, where victims and suspects were and with whom they communicated. It has been increasingly used in examinations of homicides, sex crimes, missing persons, child sexual abuse, drug dealing, fraud and theft of personal information, as well as in civil disputes. As the volume of cases requiring digital forensic analysis and the amount of information to be processed in each case have risen rapidly in recent years, law enforcement agencies are struggling to address this demand. In this context, social science research is needed to illuminate how current practices can be improved and the ways in which the usefulness of digital evidence in crime detection can be maximized while preserving ethical acceptability, civil liberties and protecting both the victims and the wrongly accused. To date however, these critical issues remain under-explored and little is known about the deployment of digital forensic evidence in police inquiries and the organisational, professional and societal issues it raises.

This project aims to offer a theoretically grounded and empirically based ethnographic analysis of the digital forensic resources, practices and expertise mobilised to provide intelligence for on-going investigations and aid the prosecution of suspects. Focusing on areas of improvement prioritised with the input of digital forensics (DF) practitioners working across four police forces as part of a regional forensic collaboration, its main objectives are to examine current provision in the constabularies covered by this organizational arrangement and explore how DF capabilities are used in the production of digital evidence. The project will employ qualitative methodologies to analyse the interactions and exchanges between different occupational groups and render visible this rarely explored socially and politically sensitive domain. A focus on the transformation of digital data into evidence and its trajectory to the final stage before prosecution, will enable the observation of DF knowledge and routines (1) as they unfold and (2) at different points in the investigative process. It will bring into relief operational procedures and dependencies, professional tensions, regulatory dynamics and distinct understandings of DF capabilities. The potential benefits of this project are multi-layered:

Conceptually, the project will contribute to sociological and criminological studies on the seldom explored application of forensic technologies in policing. The analysis will also inform and update wider socio-legal, crime and police studies approaches to assessing the contribution of forensic science to criminal justice outcomes, and social science literature on how various stakeholders understand the role of DF in police investigations.

Methodologically, the project will facilitate practitioners’ engagement with and through its design, and provide novel insights on the role of social science research in documenting, establishing and sustaining dialogue between different communities of practice.
At a practical level, the project will provide an in-depth understanding of current DF arrangements. The study will augment initiatives by police forces to improve performance by educating stakeholders about the ways in which DF can contribute to criminal investigations. It will do so in an organizationally reflexive way, with a view to foster cross-sector co-operation and exchange and improvements. The findings will help identify the gaps in DF resources and tensions in its delivery and impact directly on current practices. They will promote dialogue between providers and users, and inform the future training of investigative staff.

At a policy level, the findings will contribute to better informed decision making. With a focus on 'What Works' in DF they will help promote best practices and lead to a more efficient delivery of DF provision.

**Funding amount:** £356,035.74
About distraction: Cognitive control processes in the service of distraction resistance

**Funder:** ESRC

**Project Reference:** ES/L00710X/1

**Start:** 5/1/2014  **End:** 4/30/2017

**Abstract**

Whether in the form of music, environmental sounds or human speech, auditory distraction accompanies substantial parts of our everyday activities, including learning and remembering. Laboratory and field studies have shown that this makes a material difference to performance. We also know that this occurs even when the sound is not loud - effects just above the threshold of audibility may be just as disruptive as loud sound. In particular, a broad spectrum of memory processes is disrupted by the presence of irrelevant sound. However, nearly all previous research has worked on the assumption that the individual is a passive agent in these circumstances and has no control over how or if the sound impacts upon performance. Only recently has the issue of whether people can and do spontaneously counteract the negative effects of auditory distraction arisen. Do people modify their behaviour under conditions of auditory distraction to attain memory performance equivalent to performance in the absence of distraction, or does the presence of distraction also interfere with such strategies? The present project aims at answering this question.

Decades of research in the area of metamemory has revealed a wealth of strategies people can deploy to control their memory performance. Most obviously, people can decide for how long they wish to study to-be-remembered material, with longer study times leading to better memory performance. Other widely investigated learning strategies pertain to spacing (vs. massing) of study episodes and deep semantic elaboration of the study material. Strategies to enhance the quality of memory output can also be employed at retrieval, for example withholding information that may be inaccurate, and controlling the length of a memory search.

All of these strategies could, in principle, be deployed in the presence of auditory distraction to mitigate its disruptive effects. However, whenever people are free to control their encoding and retrieval operations, they could also use this freedom maladaptively. For example, when auditory distraction is present people could extend their study times to compensate for the disruptive effect of distraction or they could shorten their study times, reducing memory performance even further. It remains to be established whether the effective deployment of strategies used to study and retrieve information from memory serves to compensate for the negative effects of auditory distraction or whether it is itself impaired by auditory distraction, leading to an even more pronounced memory impairment.

The results of the research are important for our understanding of people's functioning in the presence of auditory distraction and, as such, have important consequences for our understanding of the processes contributing to performance in settings as diverse as classrooms, offices, call centres, or, more generally, any working environment, including safety-critical environments. Importantly, the results of this project will also contribute to our general understanding of the governance of mental operations. The project will provide us with information on the extent to which people are capable and willing to
modify learning and retrieval strategies when performance is under threat from sources of potential distraction.

**Funding amount**: £361,257.25
Legal advice-giving communication in intercultural and multilingual contexts: challenges, complexities and strategies for success

Funder: ESRC

Project Reference: ES/S010912/1

Start: 10/1/2018   End: 9/30/2019

Abstract
Effective communication between lawyer and client is fundamental to the delivery of legal advice. However, communication can be a great challenge in many key areas of legal practice, including in asylum and refugee law where individuals' fundamental human rights are at stake. The doctoral research project on which the Fellowship is based investigated intercultural and multilingual communication in asylum and refugee family reunion legal advice meetings. Drawing on audio recordings and observations of advice meetings which took place in England between an experienced immigration lawyer and a range of asylum seeker and refugee clients, the research examined the ways in which lawyers and clients who come from different linguistic or cultural backgrounds communicate with each other in order to give and receive crucial legal advice. From this project, an understanding of the range of strategies that lawyers and clients can use in legal advice communication across languages and cultures, and the role that interpreters can play in this, has emerged. The goal of this Fellowship is to share the results of the research project, the insights gained from it, and the practical implications, with a diverse range of relevant groups and individuals.

Firstly, the Fellowship will support engagement with legal advice practitioners, particularly those working in fields where clients are likely to come from diverse cultural and linguistic backgrounds, in order to share the findings of the research and identify practical applications in legal advice practice. Engagement will also be sought with legal educators and interpreter trainers, so that contributions of the research to legal advice communication education and training on the one hand, and legal interpreting training on the other, can be explored.

Secondly, the Fellowship will support awareness-raising activities with asylum seeker and refugee communities in the UK, and civil society organisations which support them to access legal advice services. Through workshops and the publication and dissemination of practical advice, such activities will raise awareness about what to expect from legal advice sessions, how clients can prepare for them, and what they can do to facilitate communication with legal advisors.

Thirdly, the Fellowship will enable dissemination of the research findings to a range of relevant academic audiences through publications, presentations and academic exchange and networking activities. Activities will be focused on harnessing the future potential for practice-based impact of the research. Key audiences include scholars and researcher-practitioners in the fields of applied linguistics, intercultural communication, public service interpreting, vocational and clinical legal education, asylum and migration studies, and the sociology of institutions, for whom the research and its findings have a range of implications for enhancing practice.

Funding amount: £88,699.88
Recogntion of the Ageing Face

Funder: ESRC

Project Reference: ES/R005788/1


Abstract
We can recognise the faces of our friends and family across a huge range of conditions. However, despite decades of research, we still do not know how this is achieved. One clue - so far unstudied - arises from our perception of faces as they age. For those around us, we typically only notice face changes when shown an old picture. For famous people, some have spent a lifetime in the public eye (The Queen, Paul McCartney); whereas others are famous for more limited times periods (Angela Merkel, Meghan Markle). How do we represent these people in order to recognise them? In this project, I will study the psychological mechanisms that allow us to recognise the same face across substantial changes. For example, do we need multiple representations of The Queen or Paul McCartney, or have we somehow developed representations of them that are sufficiently general to work across the huge range of their photos? For people known over a more limited time, how well do our representations generalise? Could we recognise Mrs Merkel at 20? In these ways I will study the fundamental processes of face recognition - how do we recognise one another? However, I will be taking advantage of natural changes that occur around us throughout life - changes that are typically ignored in face recognition research, but which I believe could provide critical evidence.

Changes over time are also a problem for unfamiliar face processing. For example, our passports can be up to ten years old, and yet a viewer checking our identity must nevertheless make the match. It has been known for many years that unfamiliar face matching is difficult, and it becomes more difficult with larger time intervals between photos. In this project, I will study this problem, and establish the circumstances under which unfamiliar face recognition is prone to age changes, and how this is mitigated by the method of presentation (for example, should a younger image be presented before an older image?). We know that some people are particularly good at unfamiliar face matching - people known as super-recognisers are employed in some police and security settings. However, we do not know whether these people are especially good at generalising photos across age ranges. I will test this, and use the results to establish recommendations for selection and training of personnel in these key roles.

In summary, the project examines face recognition across changes in age, using this natural process as an opportunity to gain understanding of a fundamental human ability - our ability to recognise one another.

Funding amount: £235,344.83
Investigating New Ways to Improve Eyewitness Identifications Using Receiver Operating Characteristic Analysis

Funder: ESRC

Project Reference: ES/L012642/1

Start: 1/12/2015   End: 7/11/2018

Abstract

There is a two-pronged, very real societal problem concerning identifications made by eyewitnesses: innocent suspects are mistakenly identified and charged with a crime they did not commit, or guilty suspects are not identified and free to commit more crimes. Decreasing the chances that innocent suspects are misidentified, unfortunately also decreases the chances that guilty suspects are identified; and likewise, increasing the chances that guilty suspects are identified also increases the chances that innocent suspects are identified. In other words, an eyewitness's accuracy is not just about choosing the right suspect; it is also about not misidentifying the wrong suspect. This teeter tottering is what eyewitness memory researchers have been grappling with for decades, and we aim to combat it.

That may seem like a bold claim, but it is now possible because of the new method of analysis we recently introduced to the field of eyewitness memory. The method disentangles the concept of response bias (i.e., the inclination of an eyewitness to choose someone or not choose someone from an identification parade) from discriminability (i.e., the ability to discriminate an innocent suspect from a guilty suspect). While the method is new to eyewitness memory researchers, the method is tried-and-true for medical diagnosticians who routinely use it to test whether one diagnostic procedure is better able to discriminate a disease state from a non-disease state, for example. Eyewitness memory researchers are faced with the same conceptual issue as medical diagnosticians in which they need to determine whether one procedure is better able to discriminate guilty from innocent suspects. Our new method allows us to answer important questions in eyewitness memory that could not be previously answered because there were no satisfactory ways to measure discriminability.

We will use our new technique in a series of experiments designed to investigate ways to increase discriminability. We will do this by comparing commonly used identification parade procedures and manipulating components of each procedure to investigate the factors that increase discriminability. The results of the experiments will shed light on why certain identification parade procedures (e.g., sequentially presented videos vs. simultaneously presented videos) and components of those procedures (e.g., identifications made quickly, number of individuals presented in an identification parade) increase discriminability. The results of this research could ultimately lead to more guilty people and fewer innocent people being identified and later prosecuted. Thus, the proposed research has the potential to make significant societal impact.

Funding amount: £252,578.18
Cross Disciplinary Thinking about 'Antisocial Personality Disorder'.

**Funder:** ESRC  
**Project Reference:** ES/L000911/1  
**Start:** 1/13/2014  
**End:** 2/28/2017

**Abstract**

This seminar series is designed to promote thought and provide new perspectives on the difficulties posed by people who have major problems in their lives and their relationships - who are sometimes given the diagnosis of 'personality disorder'. At their most extreme these difficulties involve high levels of criminal offending and violence. For over 200 hundred years efforts have been made to diagnose these individuals as though they suffer from a mental disorder. Various labels have been used to describe this disorder - for example 'moral insanity', 'sociopathy', 'psychopathy' and personality disorder; with most concern in recent years being addressed to those said to suffer from 'Antisocial Personality Disorder' (ASPD).

This issue began to receive a great deal of Government attention in the late 1990s, when the then Labour Government became very concerned by the case of Michael Stone who was convicted of the murder of Lin and Megan Russell in 1997. Stone's psychiatrists had recommended his discharge from a psychiatric hospital some 18 months before the murders because, although they viewed him as disturbed and dangerous, they felt that he suffered from 'ASPD' which they believed could not be treated in hospital. The Government proposed a series of initiatives that were aimed at encouraging the NHS to engage with and treat problems that were attracting the label of 'personality disorder'. They also initiated a well funded programme called the 'Dangerous and Severe Personality Disorder Programme' that aimed to treat serious offenders who were seen as suffering from this disorder. Research has suggested that these programmes have not been very successful. Nevertheless further initiatives have been planned.

We believe that although there is benefit in understanding the psychology of such individuals there is a danger of too narrow a focus on the individual nature of these difficulties and of too little attention being paid to the social and cultural contexts that produce and sustain these problems. This seminar series will bring together perspectives from a range of academic disciplines along with professionals representing different aspects of the health and welfare services, and with service users who had direct experience of living with these difficulties.

The first year will start with an event that focuses on historical perspectives. This is important as although the diagnosis has a substantial history going back at least 200 hundred years; that history is not always well understood and there is a danger that the lessons of that history are not utilized. We will also hold a seminar that looks at what can be learned from people's own experiences of having the diagnosis themselves and from those who work directly with people who have had that diagnosis. Another seminar will examine philosophical perspectives on the nature of these difficulties. Such diagnoses have consistently been subject to legal controversy as they raise questions as to the nature of individual responsibility.

The central event of the second year will be one that examines the impact and implications of the way that these kind of problems have been represented in different kinds of media (from film, art, fiction to the news media). We suggest
that media representations have been an important factor in constructing our understanding of these problems. We will also look at how useful concepts of 'personality disorder' are within the highly charged public debates about, on the one hand, the world of those who are dependent upon long term on benefits and on the other in the world of corporate greed.

Cross disciplinary ideas from the first two years will flow into the events of the final year that will be used to understand and point towards solutions to specific difficulties such as the rather different relationships that men and women have towards violence and the specific issues of 'hate crimes and terror' and 'school shootings'.

**Funding amount: £27,549.52**
Abstract
The UK government is considering a 'rehabilitation revolution'. It is investigating how to reduce the prison population and reoffending. Both of these will reduce monetary and emotional costs to the government and wider society. New policies will require all prisoners to learn a new skill or vocation for a job in prison, which will help them lead law abiding lives after release. At the same time as vocational, educational and psychological initiatives are being run, prison and probation workshops are allowing offenders to paint and draw, embroider and stitch, make pottery and music, write and perform stories, poems and plays. They are being creative. Most of this activity is not strictly about changing an offender’s behaviour or teaching them new vocational skills (although writing a story or a song might help with literacy). It is about ensuring that prisons fulfil their duty to punish and rehabilitate prisoners with decency and humanity.

When people take part in a creative, or spiritual, activity they feel 'affect'. Affect is a sense of belonging to a community, or a pride in something which they have made themselves. Australian researchers found that graffiti artists reported having the same sort of response when spray painting - committing the act of vandalism. If affect plays a role in offending behaviour, could it also play a part in reducing reoffending?

There is work to suggest that artistic interventions have a positive impact on broken communities and people's general health and well-being, but there is little academic literature to support the ideas that taking part in something creative while in prison will reduce an offender's likelihood of breaking the law in the future. This seminar series will help to change that.

This innovative seminar series is not just about increasing academic knowledge; it is important for artists, playwrights, actors, musicians, prison governors and staff, charitable funding agencies, researchers and civil servants and government policy makers. People from all of these groups will be invited to speak at, and take part in, the seminars so that they can share experience and ideas.

The participants will consider what works well when artists, writers, and actors deliver creative activities in prisons and probation settings. It will help social scientists, psychologists, medics, lawyers and fine artists compare their different understanding of how people experience taking part in creative activities. They will then be able to apply this knowledge to their understanding of what might change offenders' future behaviour and attitudes. Prison governors and staff will be able to talk about the impact that holding plays or exhibitions has on prisoners, which may then result in less violence and unacceptable behaviour in the prison. The seminar series will then draw all of these elements together in helping all participants to improve future research and evaluation. Improvements in recording best-practice will ensure that funds are allocated to only the most effective initiatives. An effective initiative is one that has a positive outcome: an improvement in a prisoner's mental health, might mean that they have to be seen by a doctor less often; prisoners learn to react less aggressively towards each other or staff because of the communication skills they learn staging a play,
which means a calmer prison environment; a released prisoner setting up a business as a textile designer meaning that they are much less likely to reoffend. All of these positive outcomes are good for wider society.

While there has been a good deal of positive, creative activity being carried out in prisons for a number of years, it is only very recently that the research to show the impact of this work has begun to be published. This seminar series will ultimately improve the research and evidence that demonstrates effectiveness and value for money when rehabilitating offenders.

**Funding amount:** £17,455.24
Communicating Assisted Voluntary Return (AVR): Examining tensions in discursive practice

Funder: ESRC

Project Reference: ES/S01151X/1

Start: 10/1/2018   End: 12/31/2019

Abstract
Assisted Voluntary Return (AVR) programmes are resettlement packages offered to asylum seekers and undocumented migrants (people in the UK without legal papers) to aid return to their countries of origin. These programmes are funded by the UK government and the EU; they are organised by the UK Home Office. AVR programmes, particularly those in the UK, have attracted significant criticism: academics, practitioners and stakeholders have questioned whether return can be labelled as 'voluntary' when many people applying for AVR have had a negative asylum decision or are undocumented. As such, they have little choice but to return.

My research sought to understand how inequality occurred and was challenged within AVR programmes by focusing on two central elements of AVR: 1) the voluntary aspect of the return and 2) clients' opportunities to make informed decisions about their return. I analyse institutional AVR publications and interviews with AVR staff from the International Organization for Migration (IOM) and Refugee Action, the two former providers of AVR in the UK.

By analysing the institutional leaflets and brochures about AVR from both organisations, I show how people applying for AVR are represented differently by each institution. Detailed analysis of language reveals how sometimes people are represented as having a choice about going home; other times people are represented as having few other legitimate options. I discuss how this is significant when labelling the programmes as 'voluntary' and consider the implications. I conclude that representing people as having a choice about return when many feel they do not, might contribute to the problem of widespread distrust around AVR.

By interviewing staff, I show how many staff members challenged the use of the term 'voluntary', demonstrating that within the workforce there are wide-ranging views over what AVR is, and what service they are or should be providing. I show how staff legitimised their work in this controversial area by focusing on 'voluntary' as meaning giving impartial (non-coercive) advice and foregrounding their work in advocating for AVR applicants.

AVR applicants come from all over the world and speak, read and write many different languages - and to different degrees of competence. AVR staff members are responsible for ensuring that applicants have made 'an informed decision' about their return. This is particularly important because the very act of applying for AVR can negatively affect someone's asylum application (whether they decide to actually go through with AVR or not). In my research I focus on how staff members describe achieving this with the linguistic resources provided by IOM and Refugee Action. In considering how AVR applicants have the opportunity to make an informed decision, I show how staff deal with institutional approaches to diversity. I demonstrate how there is a wide spectrum of responses to this situation and how staff members are resourceful in challenging linguistic inequality and building ad hoc communicative strategies into the administrative
process in order to enhance applicants' opportunities to access information about - and prepare for - return.

In applying for this fellowship, I aim to share, publish and expand upon my research findings. In doing so, I hope to develop my research, professional and networking skills and establish myself as an independent researcher in the field of institutional communication, focusing on multilingualism and diversity. The objectives of this fellowship are: to disseminate information by attending conferences in the fields of linguistics and migration; to publish papers in peer-reviewed journals and edited volumes; to develop my academic and professional networks; to work with AVR practitioners and stakeholders, and feedback findings to AVR staff.

**Funding amount:** £86,292.58
Access to justice for children with autism spectrum disorders

Funder: ESRC

Project Reference: ES/J020893/1

Start: 1/14/2013   End: 9/15/2013

Abstract

Evidence collected from eyewitnesses is crucial for the success of a criminal investigation. Information from witnesses governs the initial direction of an investigation (providing lines of enquiry and identifying possible suspects), and the strength of evidence has been associated with guilty suspects confessing to their crimes. However, little is known about the capabilities of individuals with autism spectrum disorders (ASD) when providing witness information. Given their vulnerabilities in terms of cognitive, social and emotional difficulties, these children are at high risk of victimisation, violence and abuse. Therefore, fair and appropriate access to justice for children with ASD is an issue of paramount importance.

The population of children and adults with ASD is very large, with prevalence rates of approximately one in 100 (Baird et al., 2006). We already know that individuals with ASD display a characteristic pattern of memory difficulties (e.g., having trouble recalling personally experienced events and recognising faces) and social communication impairments (e.g., lack of eye contact and problems with holding conversations) that call into question their abilities as criminal witnesses. Yet the few studies that have been conducted on this topic have shown that, although individuals with ASD recall less information about a witnessed event than typical groups, the information that they do provide can be just as accurate.

Even less is known about the strengths and weaknesses of individuals with ASD across all the different stages of a criminal investigation. During the proposed research, several novel questions will be addressed: How does this group fare throughout the investigative process (e.g., during initial questioning, in an investigative interview, when identifying perpetrators, and during cross-examination)? What can be done to improve the amount of information that children with ASD recall, without a subsequent decrease in the accuracy of this information? How do the general public (who may be evaluating the evidence of individuals with ASD within a jury) perceive witnesses with ASD? And what factors (e.g., mood state, anxiety, suggestibility, basic memory abilities) are associated with the performance of children with ASD in a witness context?

This research will represent the first in depth investigation of witness characteristics in children with ASD and will fill an important gap in our knowledge of this disorder. The work will address the need for basic theoretical research to increase our understanding of the cognitive strengths and weaknesses of children with ASD, but it will also provide answers to an important and pressing real-world issue - how do we ensure that children with ASD obtain fair and appropriate access to justice? The project has been designed to impact directly on policy by providing a basis for the development of guidelines and interventions to improve the performance of children with ASD in the Criminal Justice System (in collaboration with the National Autistic Society, UK).

Funding amount: £376,525.18
The Financial Aspects of the Trade in Counterfeit Products: An Exploratory Study

Funder: ESRC

Project Reference: ES/P001327/1

Start: 10/1/2016   End: 9/30/2017

Abstract
The trade in counterfeit goods is growing and has been linked to the operations of transnational organised crime (TOC). Much work and popular scrutiny has examined these flows of illicit goods. Less scrutinised are the financial mechanisms that enable them. To enter this criminal market at the wholesale level, 'organised criminals' may need significant financial resources, from credit facilities to processing international transactions. Their need for financing can concern every 'stage' of illicit supply, from production, shipping, to retail, be that small or large scale. However, while large sums of investment may be needed to enter a specific counterfeit market at the wholesale level, participation at the retail stage requires only modest resources; a process that has been simplified for criminal entrepreneurs as late-modern information and communication technologies (ICTs) and electronic commerce have developed over time and space. The appropriation of e-commerce could have a scaling effect allowing 'petty' traders to act globally. The development of the counterfeit trade in cyberspace is significant. Yet little is known about how the financing of counterfeit goods is facilitated by digital technologies. There is also a general lack of information on the blurring of TOC into legitimate actors, which is particularly apparent in the context of the grey market in counterfeit goods.

This project will address these issues. Drawing upon cross-disciplinary research expertise in social sciences (criminology and sociology) the humanities (law and geography), and working in collaboration with practitioners from the National Trading Standards e-Crime Team (NSeCT), the research seeks to investigate the financing of the trade in counterfeit goods. The study focuses specifically on financing and financing-related aspects of illicit markets in material counterfeit goods. Furthermore, while focusing on the UK context, it will contribute to our understanding of TOC by examining financial and physical flows in the counterfeit trade over borders. In this context, China, the dominant manufacturing force in the global economy with an advanced export infrastructure (see Intellectual Property Office and Foreign & Commonwealth Office, 2015), is part of the focus of this project.

Lasting for twelve months, this exploratory project's key objectives are to:

1. Identify the various forms and sources of financing that are being used to trade in counterfeit goods.

2. Map the transnational physical and financial flows relating to the trade in counterfeit products, focusing in particular on UK-China.

3. Examine how the Internet and electronic commerce presents financial opportunities for counterfeiters and to explore how these online processes interact with the material trade in counterfeit products.

4. Consider the role of licit financial and business structures in relation to the illicit trade in counterfeit products.
5. Develop the team's network and expertise in a way that will enrich future research and enhance their contribution to enforcement and regulatory policy and practice on a larger scale beyond the scope of this exploratory project.

The project will begin to develop an important knowledge base for law enforcement, regulatory agencies and policy makers. This will support informed decision making about resource allocation and measures to tackle counterfeiting, criminal financing and transnational organised crime. In addition, the project will establish a cross-disciplinary and cross-sector counterfeiting research network, an innovative methodology to research counterfeiting, and more generally provide an important contribution to the TOC knowledge base.

**Funding amount:** £80,223.76
Precarious Trajectories: Understanding the Human Cost of the Migrant Crisis in the Central Mediterranean.

Funder: ESRC

Project Reference: ES/N013697/1

Start: 9/17/2015   End: 9/16/2016

Abstract

Context

In the first six months of 2015 a series of tragic vessel sinkings in the Mediterranean resulting in hundreds of migrant deaths forced the European Union to reconsider its refusal to support the Italian Navy's search and rescue operation Mare Nostrum, which had been suspended due to a funding dispute in October 2014. In April 2015 the European Council convened an emergency summit at which it was agreed to resume official search and rescue operations. The budget for the Operation Triton border surveillance and search and rescue operation was tripled and Germany, Ireland and the UK agreed to commit naval vessels to support the operation. By June 2015 some 137,000 migrants had made the sea crossing to Southern Europe with Greece (68,000) and Italy (67,500) taking the vast majority of new arrivals according to the UNHCR.

While the focus of European policy makers and the western media has centred on the Mediterranean because its dangerous international waters are now the last resort for those desperately fleeing conflict, forced conscription and destitution from the Middle East and North Africa (MENA) region and beyond—the precarious trajectories and the hidden harms experienced by the irregular migrants and refugees are often overlooked and ignored.

Aims and Objectives of the Proposal

In order to develop a rigorous, evidence based account of the human cost of the current Mediterranean emergency we therefore propose a research agenda that seeks to understand and demonstrate

(i) how the Mediterranean crossing is only a segment of more extensive and complex migration trajectories, linking distant countries in Africa, the Middle East and Asia on the one side, and splintering across European space on the other

(ii) how different state and non-state actors can add or reduce friction to the mobility of migrants, thus shaping the directionality of migrants' trajectories as well as the risks to life and liberty faced by migrants and their families, and

(iii) how conventional governmental and media representations can be qualified or challenged by giving voice to migrants as knowledge bearing subjects.

In adopting a research perspective that allows us to identify and trace the precarious trajectories of a constantly changing population in search of protection we will also seek to document and explore

- the hidden harms that are experienced by and carried with 'illegalised' migrant populations

- the complicity of state and non-state actors in both failing to protect those in need because of their nationality status/statelessness and in actively contributing to the physical and psychological risks they face in escaping destitution and danger
- the role of official organisations and NGOs in promoting a humanitarian response to the migrant crisis and in generally mitigating harm
- the official and media representation of migrant subjects as bearers of 'collective harm' and radical 'otherness' with respect to western populations, economies and cultural and religious values
- facilitating alternative representations through auto-ethnography and other migrant subject based counter-narratives
Potential Applications and Benefits
Our multidisciplinary approach will lead to outputs of different formats including
- a documentary film
- videos of migrants testimonies and of field visits
- maps of migrants' trajectories and of the spatial practices of the actors they encounter
- written analyses, articles and reports to be published in academic, policy and news contexts
These outputs will not only allow us to engage a broad public, our insights will be crucial for policy makers in terms of enabling them to better understand how policies translate at the ground level, and what - at times unexpected - consequences they may have, in particular in terms of making migrants trajectories more or less dangerous or addressing the challenges of integration under the current EU asylum and refugee protocols.

**Funding amount:** £137,564.83
University of Bradford and Acume Forensics Limited

Funder: Innovate UK

Project Reference: 509752

Start: 8/1/2015   End: 8/31/2017

Abstract
To develop an innovative Biometric identification and Tracking System and supporting database that provides accurate and immediate identification of subjects from custody suites or CCTV footage, in line with Home Office requirements

Funding amount: £73,059.0
CameraForensics for Law Enforcement and beyond - Market Study - Matt Burns Ltd.

**Funder:** Innovate UK

**Project Reference:** 700480

**Start:** 12/1/2014  **End:** 7/31/2015

**Abstract**

We aim to introduce a new web-based forensic tool to the law enforcement sector that is capable of providing new evidence in solving crimes involving digital cameras (robberies / burglaries etc.). By uploading a single photograph that was taken by a camera, the user is instantly able to see a list of other photographs that have been posted online that were taken with the same camera. By inspecting the images that were taken after the date of the crime, and the websites where they were posted, the user has a starting point for locating the camera.

For example, the results may point to social network images on sites such as Twitter or Google+. The user can also monitor particular cameras so as to be notified when new images taken with the camera are posted online.

CameraForensics is made possible by the fact that many digital cameras stamp the camera’s serial number into every jpeg image they produce (known as EXIF metadata). A proof-of-concept has already been prototyped that proves that the solution is technically possible. It has successfully identified stolen cameras including one which lead to the retrieval of a camera that was stolen during an armed assault.

Underpinning this tool is a cloud-hosted database of photograph locations, along with information about their ‘digital fingerprints’. This database currently contains millions of cameras and is continually updated and growing, built through the use of web-crawling technology running in the cloud. The purpose of this project is to determine if there is market that would justify the significant technical effort required to turn this technical prototype into a commercial product.

**Funding amount:** £22,391.0
Sheffield Hallam University and Consolite Technology Limited

**Funder:** Innovate UK

**Project Reference:** 509990

**Start:** 5/1/2017    **End:** 4/30/2019

**Abstract**
To develop design procedures, a design tool and prototype of an innovative fingerprint recovery system to prevent cross contamination of DNA at crime scenes for use in forensic investigation.

**Funding amount:** £98,064.0
D-Figo and D-safe - Digital Evidence Management Solution

**Funder:** Innovate UK

**Project Reference:** 700015

**Start:** 9/1/2011    **End:** 11/30/2011

**Abstract**

Computer Science Labs Ltd (CSL) is a spin-off from Data Clinic Ltd (DC), a specialist computer support service company delivering data recovery products, technology, solutions and services to its clients. The B2B brand CSL was created as a ring fenced trading vehicle for R&amp;D, specialist products, data recovery solutions, forensic and network services. Forensic tools are essential to avoid an investigation failing at the initial hurdle of evidence gathering and analysis but existing tools are not keeping pace with the increasing complexity and data volumes of modern digital forensic investigations. D-Figo (DF) and D-safe (DS) are a novel concept that CSL intend to develop to meet with the evolving Digital Network Forensic Analysis (DNFA) requirements. DF will capture evidential data from all forms of digital devices and then DS will be used to transfer the data for safe sharing and to allow the forensic team to work on the data securely. Currently, the ability to quickly process data evidence is limited with delays of hours or even days when processing average volumes of evidential data. Often DNFA is conducted under urgency as part of a serious crime investigation and results are needed quickly. There is an obvious need to improve the speed with which these investigations can be completed and evidence obtained. The novelty of DF and DS is about developing novel methodologies and technologies to quickly process evidential data and display the evidence in one DF format regardless of the particular data format in which they were found. In recent years, researchers have expressed the need for more capable DNFA tools with greater processing capabilities, auditability, accuracy and reliability. DF &amp; DS will considerably shorten the time needed for network forensic data to be processed and analysed. The aim of the Proof of market is to enable CSL to test the commercial potential of innovative data recovery solutions in DF &amp; DS through in-depth market research.

**Funding amount:** £24,437.0
Low-Cost, High Accuracy 3D Scanning

Funder: Innovate UK

Project Reference: 700529

Start: 3/1/2015   End: 9/30/2015

Abstract
3D scanning quickly measures, digitises and surveys physical objects with benefits including process cost reduction and the creation of high-value personalised services. Applications include medicine, construction, real estate, forensics, insurance, design, architecture, entertainment and cultural preservation. Advances in 3D printing mean that personalised hardware can be manufactured quickly and cheaply on-site using low-cost machinery. This is creating demand for scanning systems at the same performance and price level. The 3D scanning market is estimated to grow from $2.06b in 2013 to $4.08b by 2018. Manufacturing, aerospace and defence will have the largest market share, with automotive, transportation, and retail also showing significant growth.

Cadscan's 3D scanners will transform sections of the market, reducing prices while increasing volumes. This is likely to have the biggest impact in the medical, forensics, design, architecture, and cultural preservation sectors. These scanners will create new markets as well as changing existing ones. Because market segments will require product customisation to meet diverse application requirements, Cadscan will only be able to realistically address a subset of the total market opportunities over the next five years. In order to effectively exploit its disruptive capabilities Cadscan needs market intelligence on these emerging markets; their product & application requirements; a ranking in order of attractiveness & ease of entry; and a clear understanding of the compelling ‘value proposition’ that the company brings. This knowledge will help to guide product development and develop innovative marketing programmes to exploit these rapidly emerging market opportunities.

Funding amount: £24,999.0
Teesside University and Acume Forensics Limited

Funder: Innovate UK

Project Reference: 509531

Start: 4/1/2015      End: 9/30/2017

Abstract
To develop a cross platform Evidence Exploration System that automatically ingests, stores and searches civil and criminal law evidence bundles for review and disclosure securely and accurately using artificial intelligence and character recognition.

Funding amount: £98,727.0
Novel DNA fingerprinting apparatus: Portable, Ultra-Rapid and single base pair resolution

**Funder:** Innovate UK

**Project Reference:** 710470

**Start:** 5/1/2014   **End:** 1/31/2016

**Abstract**
This project will produce and evaluate prototype consumables suitable for the diagnostic separation and detection of DNA targets differing by only a single base pair in length. A large number of genetic tests rely on polymorphisms between DNA molecules, including DNA fingerprinting. The standard kits available on the marketplace involve the use of expert operators and expensive laboratory equipment. BioGene has previously demonstrated and applied for patent protection in the field of massive multiplexed detection, via novel chemistries and apparatus. The proposed research will investigate means of improving the resolution of this approach to the point where a lower cost, simplified consumable could be used in both the laboratory but also the field in markets such as forensics, human genomics and bacterial pathogen typing.

BioGene(BG), BG Research(BGR)

**Funding amount:** £99,999.0
INHERIt: INtelligent HypERspectral Imaging

Funder: Innovate UK

Project Reference: 131746

Start: 10/1/2014   End: 9/30/2015

Abstract
Imaging of artwork is an important aspect of art conservation, technical art history, and art authentication. Many forms of near-infrared (NIR) imaging are currently used by conservators, archeologists, forensic scientists and technical art historians to examine the under-drawings of paintings, to detect damage and restorations, to enhance faded or over-painted inscriptions, to study artists’ techniques, to examine questioned documents, and as a non-destructive analytical tool for identifying certain pigments. We propose using an infrared optical parametric oscillator (a very broadly tunable source of mid-infrared light with exceptional spectral purity) to explore oil, acrylic and water colour paintings, specifically to realise an automated system than can scan in an artwork and determine its authenticity. Once proven in this challenging application, the technology we will develop will find utility in a range of diverse, impactful and timely end use applications in the wider fields of imaging for security, chemical sensing and environmental monitoring.

Funding amount: £131,247.0
**Abstract**
More challenging environmental standards (Code 5+) add considerable complexity to housing design, procurement and build processes causing performance in use to often fall short of design intent. This 44 month research project at Bicester eco-town, Oxfordshire will shrink this gap and assure the delivery of high-performance, low impact homes cost effectively and at scale.

The consortium, led by housing provider A2Dominion and drawing on the expertise of key supply chain actors and academics, will employ a forensic mapping method to highlight process failures in technologically innovative build systems. Insights will inform the creation of a best practice toolkit for use on later phases and across the UK. Bicester is the perfect test-bed for this work as the UK’s largest Code 5+ development (5,000 homes by 2026), targeting true zero carbon (unregulated emissions, no allowable solutions) and homes designed for full climate change adaptation including overheating to 2050.

**Funding amount**: £666,719.0
**LOQUITUR: bringing the field of ballistic forensics to DNA-type standards.**

**Funder:** Innovate UK  
**Project Reference:** 103844  
**Start:** 9/1/2017  
**End:** 8/31/2020

**Abstract**  
The increased use of firearms in criminal and terrorist acts drives the need for development of technology in the area of ballistic analysis which enables efficient and successful prosecution of criminals by providing high quality bullet, cartridge and thus firearm matching evidence. Current ballistic analysis technologies perform poorly compared to DNA evidence and the leading technology providers only offer a highly restrictive system. Current technologies do not make use of the latest scientific and technological developments, and their approach severely hinders evidence sharing between LEA’s, using what should be compatible systems. This is specifically a problem for countries sharing a border, where sometimes bullets/cartridge cases have to be physically transported between countries to enable comparison. Ultimately this delays, and in some cases, prevents, the successful prosecution of criminals. This project will exploit the most recent scientific and technological advances to produce a cutting-edge technology which provides LEA with highly efficient, reliable, totally compatible and more cost-effective methods of generating/sharing ballistic evidence.

**Funding amount:** £440,047.0
DNA sampling tool

**Funder:** Innovate UK

**Project Reference:** 700420

**Start:** 8/1/2014   **End:** 12/31/2014

**Abstract**
Forensic DNA analysis has become increasingly important in many criminal trials. The collection of DNA at crime scenes is a key stage in a process that can establish a connection between the crime scene and the suspect. Swabs are typically used to sample and recover DNA both at the crime scene and from items within the laboratory. Forensic Access has identified a gap in the market for a novel sampling tool to recover DNA from a crime scene.

**Funding amount:** £23,594.0
Pointclouds and measurement from mobile video

Funder: Innovate UK  
Project Reference: 103004  
Start: 4/1/2017  End: 12/31/2017

Abstract
The proposed project is to assess the feasibility of using mobile phone video to create colourised 3d Point clouds for any given environment for the purpose of accurate infield distance measurement and assessment. This application is unique because we will use low cost mobile phone video instead of single images to create 3D point clouds. This will make it easier for the non-specialist user because they don’t have to understand 3D data processing requirements and have to think less about the capturing configuration (image overlap and distances between images). It also does not rely on expensive (e.g. laser scanning) equipment and it will be easy to train people using familiar technology, i.e. mobile phones. There will be a very high degree of automation throughout the workflow. The proposed tool will enable accurate measurement of vegetation and subsequent auditing, and will allow office staff to make accurate measurements at the office base. The new application will enable Bluesky to diversify into adjacent markets by applying their experience of airborne photogrammetry to land based applications. The application will also have use in insurance industries (claims assessment/forensics) or any industry requiring onsite 3D measurement, including from drone video footage.

Funding amount: £68,733.0
A Low-Cost Medium-Range 3D Scanner

**Funder:** Innovate UK

**Project Reference:** 720614

**Start:** 2/1/2015   **End:** 1/31/2016

**Abstract**

3D scanning is a fast way to measure and digitise physical objects with many benefits including process cost reduction (virtual prototyping, quality control, digital transmission) and the creation of high-value personalised services. Scanners that can capture larger structures, such as people, vehicles and buildings, operate over a range of 1-5 metres and are known as mid-range 3D scanners. These are used in fields such as medicine, construction, real estate, forensics, insurance, design, architecture, entertainment, cultural preservation and gaming to measure, digitise and create 3D surveys and assets. However, most applications need high accuracy (50-100 microns) which is expensive, ranging from £15,000 for static tripod mounted and handheld systems (Geomagic Capture) to over £100,000 for automatic systems mounted on robotic arms (Faro). This makes them prohibitively expensive for smaller organisations who otherwise benefit greatly.

The barrier to low-cost scanning is the technology involved. High resolution mid-range scanners typically use structured-light and triangulation, which requires expensive digital projectors cameras. Lower cost systems are available from but are based on laser triangulation technology designed for computer games rather than 3D scanning. Their low accuracy is insufficient for medical, design and engineering applications.

We will develop a low-cost mid-range scanner that is suitable for these applications. Our novel technique is fast and accurate, giving depth measurements for every pixel on the camera and can be configured for high resolution imaging despite using very low-cost components.

**Funding amount:** £88,917.0
De Mont University and AirbusGroup Limited

Funder: Innovate UK

Project Reference: 509449

Start: 12/1/2015  End: 2/29/2020

Abstract
To develop digital security and forensic capabilities for Critical Infrastructure Supervisory Control and Data Acquisition and Smart Grid Systems.

Funding amount: £106,504.0
Rapid point of care DNA extraction system

Funder: Innovate UK

Project Reference: 710055

Start: 10/1/2011   End: 2/28/2013

Abstract

The end goal of the project is the proof of concept demonstrator for rapid extraction of high quality DNA that could be performed in the field. Existing techniques either require significant expertise and manpower, large automation systems or are simply too time consuming to be performed in a 'while you wait' situation. The ability to perform low cost and rapid DNA extractions out of the laboratory environment would be of great benefit in markets such as forensics, human medicine and pen side animal testing. The core technology could also be incorporated into larger laboratory based systems to further broaden the market for the technology.

The core technology being explored in the proposal would be suitable for incorporation into a wide range of other instrumentation as well as being able to be marketed as either a stand alone laboratory system or field based and handheld unit.

Currently there is only a single system available in the marketplace that incorporates this step and it is considerably more time consuming and expensive than the approach being considered in this proposal. It is also not portable so would miss a key niche: the Point of Care (POC) one.

The key benefit in the marketplace would be the time taken for extraction and the minimal number of steps required. Traditional approaches requiring multiple steps and additional reagents or equipment such as magnetic beads and centrifuges. The proposed proof of concept is to rapidly lyse the cells containing the DNA by optimised 'Ultra-rapid' freeze thawing cycles in a suitable buffer medium. This would reduce the time taken to extract the DNA to less than 5 minutes.

This could then be incorporated into downstream processes provided by many other companies, hence bringing in licensing revenue, but also combined with BioGene's rapid PCR technology and therefore making a UK built portable DNA testing system that is low cost, 'world's fastest' and portable. All unique user benefits.

Whilst the POC market is a key one, the low cost of ownership and compact size would allow penetration of the lab market.

BioGene manufacture their own instrumentation and have a dedicated team of scientists and engineers and as a result are well placed to realise the aims of the project within the proscribed timescales.

Funding amount: £57,900.0
Cloud Based Digital Forensics Gateway - DFG

Funder: Innovate UK  
Project Reference: 101066  
Start: 3/1/2012   End: 2/28/2014

Abstract  
PROJECT NUMBER: 101066  
PROJECT TITLE: Cloud Based Digital Forensics Gateway - DFG  
PROJECT DESCRIPTION
Investigating new methods and techniques for delivery of Forensic Cloud Computing and the merging of Forensic Techniques

PROJECT PARTICIPANTS
Forensic Pathways Ltd  
D2 Network Associates Ltd  
Staffordshire University  

Funding amount: £320,623.0
**CameraForensics - An Online Service for Law Enforcement, Insurance and Security Services**

**Funder:** Innovate UK

**Project Reference:** 710712

**Start:** 7/1/2015  **End:** 10/31/2016

**Abstract**

We will introduce a new web-based forensic tool for the law enforcement, security and insurance sectors - one that is capable of providing new evidence and intelligence by crossreferencing digital imagery online.

By uploading a photo taken by a particular camera, the user is able to see a list of other photos taken with the same camera that have been posted online. For example, the results may point to images on social network sites such as Twitter or Google+. The user can monitor particular cameras and be notified when new images taken with that camera are posted online. This provides a powerful online investigative tool in a number of scenarios: a user is able to build up lifestyle information about a person of interest, make linkages that are otherwise not apparent, or find a camera that has been stolen and is being used to post photos to the web.

A limited proof-of-concept has already been prototyped, utilising the fact that many digital cameras stamp the camera’s serial number into every jpeg image they produce (known as Exif metadata). It has successfully identified stolen cameras, in one instance leading to the retrieval of a camera stolen during an armed assault.

Underpinning this tool is a cloud-hosted database of photograph locations (URLs), along with information about their ‘digital fingerprints’. This database contains references to millions of cameras and is continually updated and growing, built through the use of web-crawling technology running in the cloud.

To be truly useful in the identified markets, the system needs to take a step-change in search penetration, timeliness, relevance and capability to perform comparisons. This requires novel research and development activities to be carried out, which this project is designed to address. Building on our previous work and a strong understanding of the potential market, the purpose of this project is to prove the concepts involved, a significant step towards taking the service to market.

**Funding amount:** £98,689.0
A novel integrating probe for whole tablet Raman Spectrometry

Funder: Innovate UK

Project Reference: 131344

Start: 8/1/2013  End: 11/30/2013

Abstract
The Pharmaceutical industry is the UK’s highest added-value industry. Two key problems in the production of pharmaceutical tablets are counterfeit products and the lack of whole tablet measurements. This feasibility study will investigate a possible solution whereby a standard COTS spectrometer can be made into a whole tablet sampling device by using a new and innovative sampling probe. Raman spectrometry is used as a QC technique but currently only very expensive systems can sample more than very small target areas. The proposed probe will uniformly mix then capture the light emitted from an entire 6mm tablet, enabling bulk measurement of a whole tablet using a relatively cheap COTS spectrometer and providing a complete solution for under £40k. It could potentially be made rugged enough for field deployment in many areas, such as forensic and law enforcement for illegal drug identification.

Funding amount: £24,750.0
Innovation Voucher Application

Funder: Innovate UK

Project Reference: 750176

Start: 11/1/2012   End: 3/31/2013

Abstract
Development of Forensic Testing kits for eliminating theft of precious materials such as lead and copper from buildings and building sites. These kits would result in a better build environment whilst aiding police and forensics in the fight against this crime which is believed to cost the economy £700m a year.

Funding amount: £5,000.0
Abstract
Ipsotek Ltd (Ipsotek) is an established market innovator with unique video content analysis techniques and IPR based on enriched video metadata. The key objectives/aims of the project are to be able to accurately, automatically and retrospectively ‘Tag and Track’ (TnT) specific moving objects through an area covered by multiple cameras.

The TnT project aims to extend these concepts by developing new solutions for;
1) Scene understanding;
2) Crowded scene analysis;
3) Algorithms and models to enhance metadata and analysis performance;
plus undertake
4) Site based operational demonstrators for validation of performance.

The majority of present day intelligent ‘detect & alarm’ systems provide only rudimentary automated triggers. In other areas video used for retrospective event analysis and forensics requires close scrutiny of footage which can currently only be achieved manually. This is also limited to single channel (camera) content and is therefore time-consuming, costly and errorprone.

The innovation and novel aspects of TnT will include:
1) Solving the problem of tracking objects in a single crowded scene. This is a limitation in all video analytics systems that significantly hampers deployment in real world environments.

This alone merits consideration for advancing Video Analytics generally but when applied to the project it will significantly lift the commercial opportunity;
2) Unique and innovative metadata enrichment;
3) Increasing intra-camera recognition for effective enhancement of appearance models.

The main benefits will include:
1) Provision of true capability for real time and retrospective automated moving object tracking with enhanced object identity data across multi-camera scenes with complex backgrounds;
2) Considerably more effective forensic video tracking capabilities saving time and increasing search success rates;
3) A robust framework on which to develop and productise practical applications having solved key technology roadblocks

Funding amount: £229,711.0
Innovative Cloud-Based Application for Evidence and Data Presentation in Court Cases

**Funder:** Innovate UK

**Project Reference:** 700666

**Start:** 6/1/2016    **End:** 9/30/2016

**Abstract**
The visual communication achieved when using modern Electronic Evidence Presentation (EEP) systems can increase a jury’s retention rate from 20% to 80%. Despite this, the UK criminal justice system still relies on a combination of long-standing manual processes and ageing computer systems. A major challenge in complex litigation is organising, crossreferencing and accessing mountains of evidence. In 2013, Justice Minister Green announced the use of £160m to transform the UK court system into a digital and modern public service. If implemented, ~4.5m police officer hours will be saved, freeing up time for the frontline. UK courts require better, quicker and cheaper ways of creating, filing and distributing documents, as well as more flexible communication. SRi Forensics propose a complex EEP system that can be used during national and international tribunals, Crown Court cases and complex civil trials.

**Funding amount:** £24,507.0
**SmartWater- Forensic Protection for Historical and Cultural Artefacts**

**Funder:** Innovate UK  
**Project Reference:** 103829  
**Start:** 7/1/2017  **End:** 6/30/2019

**Abstract**
There is a compelling need emanating from within the World’s cultural heritage sector for new technology that will assist with the establishment of ownership but, importantly, in a way that does not damage the potentially priceless historic object. SmartWater is an award-winning technology company working at the forefront of forensic science, responsible for the development of a method of establishing provenance, called ‘traceable liquids’ Each water-based, non-hazardous solution contains a unique forensic formula, with millions available, which can be applied to valuable assets, either by spraying or brushing on. SmartWater solutions have been accepted as a viable technique for proving ownership of recovered stolen property in both the UK and US Courts. However, having worked closely with the archaeological and conservator sectors in the UK and USA, the Board of Antiquities of the Iraq Government has recently approved the use of special SmartWater solutions on stone, glass, ceramic tile and potentially ivory. But there remains a large number of substrates, such as vellum, papyrus, canvas and paper, that need substantial work, in terms of testing, both technical and industry acceptance. Working closely with academic institutions both in the UK and USA, SmartWater seeks funding to conduct research in order to create a range of products suitable for use on these remaining substrates that will act as a deterrent to 1st World buyers of stolen artefacts, thereby reducing the ready market for thieves.

**Funding amount:** £366,556.0
Loughborough University And Visimetrics (UK) Limited

**Funder:** Innovate UK

**Project Reference:** 508431

**Start:** 8/1/2011  **End:** 8/31/2013

**Abstract**
To optimise the design, implementation and deployment of an intelligent CCTV video forensic tool using multi-core processors, multi-threaded programming and multi-objective optimisation.

**Funding amount:** £40,589.0
certaj networks limited

**Funder:** Innovate UK

**Project Reference:** 752482

**Start:** 5/1/2015  **End:** 10/31/2015

**Abstract**

High speed database architecture and POC for 100% Network Packet Capture, Index, Analysis and ultra fast search response for Network Forensics usage.

**Funding amount:** £5,000.0
Enhancing Sensor Pattern Noise for Digital Forensic Applications

**Funder:** Innovate UK

**Project Reference:** 130590

**Start:** 5/1/2011  **End:** 7/31/2011

**Abstract**  
Abstracts are not currently available in GtR for all funded research. This is normally because the abstract was not required at the time of proposal submission, but may be because it included sensitive information such as personal details.

**Funding amount:** £24,750.0
Integrated sample Processing Systems

Funder: Innovate UK

Project Reference: 730073


Abstract

The Integrated Processing System (IPS) project aims to develop a portable, disposable modular sample processing system to pre-production level. The system is intended to be deployed in locations where the laboratory facilities required to process biological samples for analysis do not exist, such as at crime scenes, factories and in environmental monitoring activities. The concept allows rapid diagnosis to be delivered at point of care without the need for highly qualified operators, saving both time and valuable human resources. The project shall deliver a functional pre-production prototype of the IPS along with supporting documentation concerning the design process, the procurement and assembly of the prototype and the testing performed on the prototype. The pre-production prototype shall be designed for mass manufacture and marketing to the intended sector and shall be used to prove the manufacturability of the system, to develop the process modules and as a firmware development platform for the production models. This technology will allow organisations that currently use out-sourced laboratory analysis to streamline the analysis process, and to reduce the risk of human error. The risk of sample contamination shall also be greatly reduced due to the sterile nature of the device, and the risk of the operator being exposed to potentially hazardous material is reduced as the entire process is contained and automated. The adoption of this technology by forensics teams and environmental monitoring organisations would enable greater confidence to be placed in the integrity of a given sample, as full process traceability is integral to the operation of the device. The small format also allows the device to produce results at the point of care or at the arrest scene, allowing swifter action to be taken. The project is budgeted to cost £406,000 (APPENDIX C) over a period of eighteen months. The project work shall be completed at Magna Parva premises in Leicestershire, with The University of Leicester included as technology partners in this proposal as their experience and expertise will be called upon during the development of the processing and analysis mechanisms. The IP associated with the LMC project (from which the IPS technology is derived) is shared equally between Magna Parva and the University of Leicester. Comac Engineering are experienced subcontract machinists based in the East Midlands. This company shall perform general manufacturing tasks as required by Magna Parva Ltd. Work requiring a high degree of precision shall be handled by CECA (Centre of Excellence in Customised Assembly) at the University of Nottingham. Magna Parva maintains links with this organisation through various projects, and through the steering committee; of which our Commercial Director is a member. CECA shall also be consulted in connection with the manufacturing design of the pre-production prototype. In the absence of a suitable grant, this work would not proceed. The company books reflect a stable business with sufficient cash reserves to pay outright for the project, however this is a by product of being a high-risk project orientated company that requires a large cash buffer to absorb peaks and troughs in the project cycles and cannot be used extensively for product development. Additional funding was
sought through traditional lending; this however in the current climate is not possible.

**Funding amount**: £157,211.0
University of Wolverhampton And Forensics Limited

Funder: Innovate UK

Project Reference: 507846

Start: 2/1/2011    End: 4/30/2013

Abstract
To develop and validate new laboratory methods within an internationally recognised laboratory accreditation system (ISO 17025).

Funding amount: £36,300.0
King's College London and Illumina Cambridge Limited

Funder: Innovate UK

Project Reference: 509242

Start: 10/1/2014   End: 9/30/2016

Abstract
To drive the development, validation, accreditation and adoption of Next generation Sequencing solutions for forensic genomics.

Funding amount: £65,861.0
Exploratory Data Analysis Tools for Chemical Microscopy

Funder: Innovate UK

Project Reference: 101945

Start: 10/1/2014   End: 9/30/2016

Abstract
Spectral microscopy is a rapidly growing field critical with applications in pharmaceutical development, biomedical diagnostics and forensics. This project aims to develop reliable, validated, high speed data analysis tools for exploration and analysis of multi-mode spectral microscopy data. Spectral microscopy is used for label-free detection of molecular compounds within the micro and nano-scale structures of cells, tissues and materials. It encompasses a wide range of techniques such as Raman Microscopy and Mass Spectrometry Imaging and is of increasing importance in biomedical research. Applications are found in pharmaceutical development, disease detection, biomaterials design, forensic analysis, and characterization of nano-structured materials. Analysis of the very large hyperspectral image stacks acquired by these instruments is computationally challenging. Accurate interpretation often depends on combining multiple complementary imaging modes. The tools developed in the project will allow non-ICT experts to combine multiple types of imaging data and efficiently explore these data sets to create novel insights.

Funding amount: £230,237.0
Development of a highly multiplexed optical detection system for analysis of complex, PCR-based DNA tests.

**Funder:** Innovate UK

**Project Reference:** 710092

**Start:** 12/1/2011  **End:** 3/31/2013

**Abstract**

Recent increases in genomic information has led to an exponential increase in the numbers of genetic diseases characterised. This and a greater understanding of the infection process, generates the need to detect larger numbers of targets such as pathogens and disease causing genetic variants as rapidly as possible and in a single test.

One such approach commonly in use is real-time PCR and yet the application of this for multiplex testing has been limited by inherent flaws in existing detection systems, cost of the technology, and the time taken to generate results.

The design and manufacture of a rapid and low cost optical system capable of concurrently analysing a large number of targets is the goal of this study. Such an approach would reduce the cost of such testing, by allowing more targets to be screened in a single test and would reduce the cost for uptake of the technology, as well as reducing the time to result to the point it could be performed "while you wait;", for example at a doctors surgery.

Similarly this would allow novel PCR based techniques, previously impossible by conventional real-time PCR. Examples could include forensics, by virtue of being able to analyse more targets in a single run. This could also be applied to complex medical diagnostics such as mixed infections.

The system would inherently also be many times faster than existing approaches, since it could detect and deconvolute all visible wavelengths of light in a single reading as opposed to having to switch between a series of filters which greatly increases the analysis time on current instrumentation as well as reducing the number of analytes that can concurrently be tested for.

In essence this proof of concept will use expertise in the field of satellite imaging and mathematical modelling in conjunction with our Ultra-Rapid thermal cycling IP to solve the problem of multiplex detection of labelled PCR targets and hence allow unique targeting of a growing market niche.

**Funding amount:** £98,797.0
3DCloud [3d Dataset in the Cloud]

**Funder:** Innovate UK

**Project Reference:** 101419

**Start:** 4/1/2013  **End:** 9/30/2015

**Abstract**
The 3DCloud project develops secure cloud storage and distribution services for Terabyte 3D image datasets with novel image processing applications including precision alignment of datasets and pattern recognition. Building on innovative research at UCL on ultra-high resolution 2D image recording, alignment and mosaicing, we aim to develop tools that solve specific problems encountered in 3D and 4D datasets in a wide variety of applications including oil & gas exploration and architectural surveying. To prove robustness in dealing with significantly different types of data, we will work with reference customers to solve existing business problems: BG Group for pattern recognition in 3D and 4D seismic datasets, Jones Lang Lasalle Surveyors for aligning and merging overlapping 3D scans of indoor public areas. Subsequently the service will be opened to medical, architectural, particle physics, astronomical, satellite, and forensic 3D image datasets.

**Funding amount:** £724,104.0
Early Warning System for Data Exfiltration

Funder: Innovate UK

Project Reference: 132833

Start: 9/1/2017   End: 1/31/2018

Abstract
Network security monitoring needs an early warning system. Attacks are getting slower, stealthier and more sophisticated. The average detection time of a security breach is lengthening, resulting in the wrong balance of reactive and proactive defence, and driving up the total cost of security and remediation. Existing monitoring tools will simply fail to cope with this. Broadly, the signature- or rule-based tools are very retrospective. This is quickly becoming obsolete, in a world where a specific malware is often only used a small handful of times. By contrast, anomalous behaviour monitoring overwhelms the defender with false positives and struggles to deal with pre-infected environments. There is a need to monitor networks for threat probabilities of indicators associated with early phases of attacks. This is a new approach to network security monitoring. It will shift the advantage back to the defender, by allowing them to “nip attacks in the bud”, before the organisation is exposed to significant costs of data loss. This approach also enables warning of unknown attacks and exploits; a fundamentally different approach to post-incident forensic signature-based methods.

Funding amount: £70,000.0
Microspectrophotometer using mid-infrared optical parametric oscillator

**Funder:** Innovate UK

**Project Reference:** 130901

**Start:** 8/1/2012  **End:** 11/30/2012

**Abstract**
Microspectrophotometry is a very useful tool in the forensic analysis of many kinds of trace evidence. It combines a microscope with a spectrophotometer so that the light absorption properties of a very small sample can be recorded. We propose replacing the traditional broadband lamp and optical grating with a tunable optical parametric oscillator (OPO). M Squared Lasers’s tuneable OPO, Firefly, and its associated scanner are designed to produce hyperspectral images at a distance. The aim of the project is to reconfigure the OPO and scanner to produce microscope type images with sub millimeter resolution in the mid-infrared. The resultant system can then image small samples whilst changing wavelength from 1.5um to 3.8um, thus exploring the composition of the subject material.

**Funding amount:** £24,680.0
CASE: Compact Attribute Set of Sensor Fingerprint for Imaging Device Forensics

Funder: Innovate UK

Project Reference: 130881

Start: 8/1/2012   End: 11/30/2012

Abstract
Digital cameras, camcorders and mobile phones rely on semiconductor sensor to capture images. Because the semiconductor wafers are not perfectly made and the imperfection is unique, the imperfection gives rise to the so-called Sensor Pattern Noise (SPN) in the images. Even devices of the same model have unique SPN, which can be used as device “fingerprints”. Functional Technologies Ltd has developed a Forensic Image Analyser (FIA) to exploit SPN for forensic applications. However, the SPN is as big as the original image. The high computational complexity due to the size of the SPN has limited the FIA's applicability. This project aims at studying the feasibility of using a Compact Attribute SEt (CASE) to represent the SPN. If successful, the computational cost can be reduced by hundreds of thousands of times.

Funding amount: £24,975.0
Acume Forensics Limited (Add on KTP9885)

Funder: Innovate UK

Project Reference: 320079

Start: 10/1/2015  End: 12/31/2015

Abstract
Awaiting Public Project Summary

Funding amount: £1,500.0
Tape Lift Trace Searching Tool

Funder: Innovate UK

Project Reference: 700488

Start: 3/1/2015   End: 7/31/2015

Abstract
Terrorism presents a serious and sustained threat to the UK and the rest of the world. The potential of Chemical, Biological, Radiological and Nuclear (CBRN) materials being used by terrorist organisations is ever present and increases as the ability to acquire them becomes easier. However, in the event of a CBRN incident, there is no existing forensic technique that can assist the MoD with full provenance intelligence through the recovery and isolation of valuable trace evidence. Forensic Access has developed an automated trace searcher that can improve the existing tape lift method and be adaptable to the confines of a glovebox.

Funding amount: £23,993.0
Financial Services through a secure Cloud platform for SMEs

Funder: Innovate UK

Project Reference: 752071

Start: 2/1/2015   End: 7/31/2015

Abstract
Hanson & Associates (UK) Ltd have been expanding rapidly as an SME that emerged from a Sole Trader business a few years ago. Our client base is spreading across the UK with the potential expansion to emerging economies which has business links to the UK. We also intend to export our financial and business planning services abroad. As part of these developments, it has become necessary to create a cloud based secured financial management system for our clients across the UK as well as to cater for future growth that might emerge from clients abroad.

We believe that this system will enable our clients to access tailored services and reports designed for their needs through a secured network tunnel such as a VPN. We have been in contact Intellas UK Ltd, experts in document security and forensics management system to help us develop and implement this system.

Funding amount: £5,000.0
Integrating CameraForensics with Law Enforcement Workflow

**Funder:** Innovate UK  
**Project Reference:** 132559  
**Start:** 1/1/2017  
**End:** 3/31/2017

**Abstract**  
CameraForensics have developed tools to assist law enforcement agencies with victim identification investigations in online child sexual exploitation cases. This feasibility aims to identify and work with international collaborators and stakeholders in the industry to find innovative ways in which the technology can be used within existing law enforcement software tools and processes.

**Funding amount:** £20,887.0
Preoperative evaluation of bone quality for dental implant therapy using laser induced breakdown spectroscopy

**Funder:** MRC

**Project Reference:** G0802650

**Start:** 7/15/2009  **End:** 7/14/2010

**Abstract**
The success of a tooth implant depends on the quality and structure of the jaw bone. Current bone evaluation methods are expensive, time consuming, have limited availability and can risk exposing the patient to harmful radiation. A possible, novel, approach to this problem would be the use of a laser-based analytical technology known as LIBS to determine whether implant treatment would be suitable for a particular patient. LIBS is a rapidly emerging technique and is successfully employed in tissue analysis and by forensic laboratories. The technique is relatively inexpensive and offers rapid in-situ measurements and diagnosis.

**Funding amount:** £94,169.0
Crystal forensics: constraining the timescales of magmatic processes leading to volcanic eruptions

Funder: NERC

Project Reference: NE/G01292X/1

Start: 10/1/2009   End: 9/30/2012

Abstract
Volcanoes erupt daily and are an everyday hazard for millions of people worldwide. Today, active volcanoes are continuously monitored looking for signs of imminent eruptions. However, in order for the accurate prediction of future eruptions to be achieved a comprehensive knowledge of the internal workings of volcanoes is required, including the timescales over which molten rock moves through the volcano. Magma is molten rock composed of liquid rock and solid particles called crystals. The migration of magma through the Earth's crust and the eventual eruption is complex, however a record of this is preserved in crystals. Just as your favourite crime drama uses forensic science to solve the crime, we can do the same with the composition of minerals from volcanic eruptions. The life of a crystal is not simple but a complex one involving periods of growth and melting, migration and periods of residence in different magma bodies until eventually the crystal is erupted and the composition frozen in. Each of these experiences are preserved in the crystal as chemical or textural markers, that results in highly zoned crystals. These crystal zones can be treated in just the same way as tree rings which record the growth history of a tree. The chemical composition of individual zones can be used to fingerprint the magmatic process that formed the zone and we can use the difference in the chemical composition between two adjacent zones to determine the timescale over which these magmatic processes occurred. Immediately after formation the compositional difference between two adjacent zones is sharp, but with time diffusion of elements (migration of small particles that the crystal is made from) smoothes this compositional boundary and this can be used to calculate the timescale of magmatic processes. Importantly, different elements migrate through the crystal structure at different rates and therefore a whole range of magmatic processes that occur on the timescales of hours to months prior to eruption can be investigated. However, the zoning in these crystals occur on a sub-micron scale (smaller than the width of a human hair). Therefore, for the first time this study will use the new generation of high resolution Secondary Ion Mass Spectrometers permitting the measurement of fine-scale chemical zonation of plagioclase crystals from Mount St. Helen's in the USA and Mount Taranaki in New Zealand. This will allow the magmatic processes and the timescales over which these processes occurred directly prior to eruption to be assessed. These timescales can then be evaluated against the known timescales for the movement of magma prior to the recent eruptions of Mount St. Helen's allowing better models for the future prediction of volcanic eruptions to be constrained. This will provide valuable insights into the working of volcanos directly prior to eruption and could have immense benefits to the millions of people worldwide who live in the shadow of volcanoes and help mitigate the associated hazards of active volcanoes. This research will be conducted in the Department of Earth Sciences, University of Bristol in conjunction with the Interface Analysis Centre, Bristol, Muenster University, Germany, University of Western Australia, Cascades Volcano Observatory and University of Orogen in the USA and Victoria University of Wellington, New Zealand.
Funding amount: £294,876.38
Integrated software solution for the 3-dimensional capture and analysis of footwear evidence

**Funder:** NERC

**Project Reference:** NE/M021459/1

**Start:** 5/1/2015    **End:** 6/30/2016

**Abstract**

Footwear impressions provide a source of evidence within a range of criminal investigations including gathering of criminal intelligence. A potential suspect will leave foot or footwear impressions en route to, at and while exiting, a crime scene. This not only allows a sequence of events to be determined but may also link a suspect to a scene if their footwear is distinctive, for example as a consequence of damage or wear. Indoors crime scene officers deal mainly with two-dimensional traces; impressions left by a foot tracking mud, blood or other bodily fluids. Three-dimensional tracks, the proverbial footprint in the flower bed, are common at outdoor scenes. Traditional methods for the collection of three-dimensional traces consist of photography and casting, supported by two-dimensional pattern recognition that can type a footwear sole to a particular make or model of shoe. Three-dimensional imaging is now available as an alternative or complementary option, particularly as algorithms for digital photogrammetry have improved dramatically in recent years allowing easy operational deployment. No expensive three-dimensional scanners are required, only that a crime scene photographer take a few moments to collect additional oblique photographs of footwear impression. Consequently, three-dimensional analyses of footwear impressions are now already possible at a routine operational level, but remain the exception rather than the norm.

As part of previous NERC grant NE/H004246/1 into ancient footprints we developed a range of methods and freeware to facilitate the three-dimensional capture and analysis of footprints. Engaging with police as part of the Impact Plan demonstrated the interest and potential of such methods to enhance the analysis of three-dimensional trace evidence especially by allowing statistical analysis of differences between tracks and/or footwear. Currently comparison is done primarily via visual inspection rather than by quantitative and statistical comparison. Working with our Project Partners we propose to employ a software engineer to draw on this research, practice and existing code to create a single integrated software application for the capture, analysis and presentation of three-dimensional footwear evidence which will allow routine operational deployment by police and forensic agencies both in the UK and overseas. This will change the fundamental cost-benefit ratio associated with the collection of this type of evidence, such that three-dimensional imaging can become the norm rather than the exception. Software of this sort needs to be available to all parties involved in forensic jurisprudence - the defence as well as the prosecution - without handicap of cost. As such our proposed software will be made available as freeware rather than commercialised, which will also assist with user adoption. This knowledge translation has the potential to contribute to criminal investigations and in the safeguarding of society.

**Funding amount:** £97,487.0
NANOstructured Beta Detectors for Detection Of Tritium (NANODOT)

Funder: NERC

Project Reference: NE/H025650/1

Start: 1/1/2011   End: 12/31/2014

Abstract
Tritium is a radioactive isotope of hydrogen that is produced from nuclear fission reactions and from the action of corrosion, radiolytic and microbial processes on radioactive wastes. It decays to He-3 by soft beta decay of average kinetic energy 5.7 keV. This low energy makes it difficult to detect even by scintillation counting. Fast, accurate and precise measurement of gaseous tritium is required for, inter alia: environmental monitoring & leak detection around interim storage sites for higher level radioactive wastes; development of the environmental safety case for the geologic repository for those same wastes; environmental and safety monitoring in and around nuclear reactor and nuclear fuel processing plant; and nuclear forensics, including applications in counter-terrorism, homeland security and non-proliferation. Palladium is a metal that shows an almost unique capacity for absorbing H2 into its crystal matrix. There are a number of commercial H2 sensors on the market based on the interaction of H with palladium metal, most of which quantify this uptake by measurement of the metal capacitance or resistance. No one to date has explored the possibility of exploiting the unique Pd-H interaction as a means to selectively preconcentrate tritium from gas phase sample matrices in order to improve its detection using a Pd-modified scintillation detector. We therefore propose to exploit new concepts in nanomaterials synthesis to allow us to couple nanoporous palladium layer-modified transducers / scintillation counters and digitized data capture from ionizing radiation events to develop a novel radiometric sensor-based measurement system for gaseous tritium detection. The use of nanoporous palladium will increase the surface area of metal available for tritium absorption whilst the use of digitised data capture will allow for whole data sets to be captured for posterity and post-processing. Both measures are expected to lead to improved signal to noise ratios assistive to the achieving of lower limits of detection and so greater accuracy and precision in measurement. In developing this sensor for the applications mentioned above, the proposed work addresses the following NERC Theme Action Plans (TAPs): Technologies; Environment, Pollution & Human Health; and natural Hazards. We aim to develop the sensor system through to Technology Readiness Level 5 (Demonstration). This project is a partnership between the Engineering Dept and the Lancaster Environment Centre (LEC) at Lancaster University and Hybrid Instruments, a Lancaster spin-out. The National Nuclear Laboratory (who have served as partners on predecessor projects to this), and the Nuclear Decommissioning Authority Radioactive Waste Management Directorate will be a key end user.

Funding amount: £66,945.02
Diagnostics of Cosmic Discordance

Funder: STFC

Project Reference: ST/G002231/1


Abstract
The last twenty years have seen a revolution in the field of Cosmology which has led to the establishment of a standard model that accounts, at least in a broad-brush sense, for most of the observed properties of our Universe; this model is frequently dubbed 'the concordance' model. This progress has been brought about by an exciting synthesis of theoretical ideas about the early stages of the Big Bang with data from large-scale galaxy surveys and observations of the cosmic microwave background. One of the most important challenges for the future development of cosmology is to discover, diagnose and explain departures from the concordance model because these would offer the prospect of learning more about the origins of our Universe. One particularly important element of the concordance cosmology is that quantum fluctuations on sub-atomic scales were stretched many orders of magnitude during a period of inflation, becoming sound waves in the process. This is what put the 'bang' in the 'big bang'. Moreover these sound waves are detectable both in the pattern of temperature variations on the sky seen in the cosmic microwave background and in the clustering properties of the large-scale distribution of galaxies. In the simplest versions of inflation, these fluctuations are random and have the simplest possible statistical form, a Gaussian (or 'normal') distribution. We do not, however, know how, or even if, inflation actually happened or whether it was simple or not; there are apparently viable models, such as those deriving from string theory, that offer radically different descriptions of the early Universe. One of the most exciting ways of probing the fundamental physics involved in the origin of the Universe is to look for evidence of primordial non-Gaussianity in the observed properties of our Universe. We know from the success of the concordance model that any departures from 'normality' must be relatively small, so this approach requires sophisticated statistical techniques of a different nature to those required for measuring the relatively simple characteristics needed to establish the standard model. The size and complexity of the data sets, the possibility of contamination with noise or systematic errors, and the mathematical subtleties involved in characterizing random fluctuation fields all combine to make this approach a challenging one. Even in current data sets, such as those derived from the Wilkinson Microwave Anisotropy Probe (WMAP), there are already indications that there might be things going on that are inconsistent with the standard cosmology. There is an unexplained 'cold spot' on the sky, there are peculiar alignments in the temperature pattern, and there is a large-scale variation across the sky, to name just a few. Are these caused by experimental systematics or do they suggest that the concordance model may be incomplete? In future, satellites such as Planck will yield more information about these suggested anomalies. It is obviously essential to prepare for the flood of new data by developing analysis techniques capable of exploiting it. The research described in this proposal is designed to develop and test sophisticated new ways of analysing astronomical data for signs of primordial discordance. The approach we take highlights the intriguing nature of cosmology, in that it is closer to forensic science or archaeology than it is to laboratory-based disciplines. We have access to only one Big Bang, so there are no opportunities to re-run the experiment with slightly different initial conditions. We must piece together what
happened from fragmentary and noisy data, sifting through the aftermath of the primordial explosion for clues to what caused it. The more detailed the questions we ask, the more complicated is the processing required to extract relevant information. It is painstakingly precise work, but it is a sign that cosmology has at last become a proper science.

**Funding amount:** £332,626.95
Sample preparation equipment for ultra low background screening with ICP-MS

**Funder:** STFC

**Project Reference:** ST/M006891/1

**Start:** 11/1/2014   **End:** 3/31/2015

**Abstract**

'Dark Matter' - a mysterious substance that holds the galaxies together makes up an incredible 85% of the mass of the Universe. It is believed by many to be made up of Weakly Interacting Massive Particles (WIMPs) - but they have not yet been detected experimentally. This is because they bounce off atoms only very rarely and weakly such that their presence is extremely difficult to detect. Despite this, scientists have been working on constructing sensitive detectors capable of registering WIMP interactions should they occur. The trouble is that there are many other particles interacting in these detectors that may mask the few and faint WIMPs.

Since WIMPs will interact so rarely the experiments must be shielded from all the cosmic-rays bombarding Earth from space, forcing them deep underground. However, this is still not enough to provide the quiet environment required; they are therefore shielded from natural radioactivity found in underground rock - harmless to us but catastrophic to the sensitive devices. A final background remains, coming from the very materials the detectors are made from. Tiny amounts of uranium and thorium produce signals by radioactive decay that are often indistinguishable from those expected from WIMPs. This means that extensive material screening campaigns must be conducted to select only the purest materials in constructing detectors.

Developing ever more sensitive detectors in the hunt for WIMPs has demanded ever-cleaner construction materials. However, we have now reached a technological maturity such that our next detectors could have the sensitivity theoretically predicted to finally detect Dark Matter. The trouble is that capability to screen materials from which to construct them has not kept pace. We have traditionally relied on 'High Purity Germanium' detectors (HPGe) to measure materials before using them to build experiments. However, HPGe requires many weeks to screen a single sample - unacceptable when we need to check hundreds of materials in the coming years. Furthermore, HPGe cannot actually measure U and Th directly. Instead it measures elements that U and Th decay into.

Inductively Coupled Plasma Mass Spectrometry (ICPMS) is capable of measuring U and Th directly. It cannot tell us about the decay products from U and Th as HPGe can, but together they produce the complete picture we need. Moreover, the time taken to screen materials - about a day or less, is just what is called for in building the next generation of experiment. However, ICPMS requires all materials to be 'prepared' - dissolved in acid and introduced as a liquid. ICPMS will only achieve high sensitivity if the materials are digested, prepared and introduced cleanly. With traditional techniques, heating materials in open glassware exposed to the elements, sensitivity can suffer dramatically.

This proposal is to enhance the UK's existing ICPMS with closed microwave ashing and digestion ovens with ultra-pure, high concentration, aggressive acids, to support the UK's Dark Matter R&D programme. Such new capability would give incredible sensitivity, in only hours. This would elevate the UK's
R&D programme to unique world-class status now and well into the future, at a time when internationally HPGe and ICPMS facilities are struggling to cope with demand and do not possess enough sensitivity.

It will also aid other rare event searches that require ultra-low activity, such as those seeking to observe neutrino-less double beta decay. These experiments could tell us about the fundamental properties of neutrinos, and in doing so explain the tiny imbalance between particles and anti-particles shortly after the Big Bang needed for any matter to exist today. ICPMS also has powerful application in food safety, pharmaceutical, environmental, forensic and clinical studies, where elemental analysis of low levels of contaminants is a rich area of research with significant societal and economic impact potential.

**Funding amount:** £99,845.0
Rapid, Parallel Imaging in Surface Chemistry and Biochemistry

**Funder:** STFC

**Project Reference:** ST/J002895/1

**Start:** 7/1/2012  **End:** 10/1/2013

**Abstract**

Spatial imaging mass spectrometry is an analytical technique of growing importance, with a wide range of exciting applications ranging from forensics, tissue sampling, to parallel, high throughput chemical analysis, and is increasingly being applied to the characterization of biological samples. Spatial imaging MS is usually performed in one of two ways, microprobe or microscope mode. In the former, microprobe mode, an ionization source, such as a stream of ions or laser radiation, are focused to a small point on the sample and a mass spectrum is recorded at that precise location. If an ion beam is employed, the technique is usually referred to as secondary ion mass spectrometry, or SIMS. The sample or the ion source is then moved to a new position, and the process repeated until an entire spatially resolved mass spectrum is built up. By contrast, in microscope mode the entire surface is ionized, usually with an intense pulse of laser radiation, and the ions are typically recorded on a two-dimensional detector. Application of fast imaging sensors, with tens of nanosecond timing resolution, to microscope mode mass spectrometric imaging will allow the spatial imaging of all mass peaks in each experimental cycle. As all fragments can be detected simultaneously, far fewer laser shots and acquisition cycles are required for a full set of data to be acquired. A smaller amount of sample is required, samples suffer less degradation, and overall collection times are reduced.

Our proof-of-concept experiments in this area have yielded extremely promising results, and we are currently working to improve our spatial and mass resolution, and sample preparation techniques. SAI, a UK manufacturer of matrix-assisted laser desorption/ionization (MALDI) instruments, is very keen to collaborate on this aspect of the project, providing a specially modified commercial MALDI spectrometer, LaserToF LT2Plus, on which the fast imaging sensors can be tested. In the new instrument, the positions of release of the various molecular ions will be preserved and faithfully mapped onto a position sensitive detector. Their molecular weights can then be calculated from the time of flight of the various molecular ions. The spatial resolution of the instrument will be determined by a combination of the spherical aberration in the image forming electrostatic lens, the pore size of the ion detector, and the pixel size of the imaging sensor, and could in principle achieve 0.25 microns.

A number of established markets would benefit from this improvement in the measurement technology, in particular in the biochip testing industry. Biochips have been developed for high throughput analysis, and, in the case of reverse phase protein micro-arrays, some 500 samples are typically spotted in an area of less than five square millimetres. They are currently read sequentially, employing florescence or colorimetry techniques, which is costly and could be insufficiently sensitive. The proposed development will dramatically improve parallel measurements using biochip technology, yielding much faster analysis times and higher precision, whilst at the same time elimination the need for expensive photo-chemicals.

**Funding amount:** £118,920.43
Detection of drug abuse is essential for safety and fairness in sport. Steroid hormones are the most commonly abused drugs in athletics but confirming steroid abuse can be difficult. One highly accurate method is to look inside the carbon atoms of steroid to measure the ratio of their non-radioactive isotopes (carbon-12 to carbon-13). The carbon isotope ratios of natural human steroids and those used by drug cheats are recognizably different. However, measuring carbon isotope ratios requires good sample preparation steps and steroids can be problematic for the instruments used. Existing preparation techniques lag behind the powerful capabilities of modern mass spectrometer detectors. STFC research has produced a rapid on-line method that can be used to treats steroids with hydrogen to leave only the carbon skeleton intact - the perfect preparation step for carbon isotope ratio analysis. This grant will commercialize the method by demonstrating its advantages relative to existing techniques and by producing a prototype system that will allow the method to be used by technical staff in forensic laboratories world-wide. The commercialization will benefit from partnership with a major UK provider of drug testing services.

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Ultra-low activity material screening with in-house ICP-MS

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Abstract
An incredible 85% of the mass of the Universe is 'Dark Matter' -- a mysterious substance that holds the galaxies together, preventing them from flying apart. It is believed to be made up of Weakly Interacting Massive Particles (WIMPs) - but these particles have not yet been detected experimentally. This is because, although they are predicted to interact with normal matter, bouncing off atoms, they do so only very rarely and weakly such that their presence is extremely difficult to detect. Despite this, scientists have been working on constructing sensitive detectors capable of registering WIMP interactions should they occur. The trouble is that there are many other particles interacting in these detectors that might mask the few and faint WIMPs.

Since WIMPs will interact so rarely the experiments must be shielded from all the cosmic-rays bombarding Earth from space. This forces them deep underground, in mines or under mountains. However, this is still not enough to provide the quiet environment required. The experiments are next shielded from natural trace radioactivity found in underground rock - harmless to us but catastrophic to the sensitive devices. Yet still a final background remains, coming from the very materials the detectors are made from. Tiny amounts of uranium and thorium produce signals by radioactive decay that are often indistinguishable from those expected from WIMPs. This means that extensive material screening campaigns must be conducted to select only the purest materials in constructing the detectors.

Developing ever more sensitive detectors in the hunt for WIMPs has demanded ever cleaner construction materials. However, we have now reached a technological maturity such that our next detectors could have the sensitivity theoretically predicted to finally detect Dark Matter. The trouble is that capability to screen materials from which to construct them has not kept pace. We have traditionally relied on 'High Purity Germanium' detectors (HPGe) to measure materials before using them to build experiments. However, HPGe requires many weeks to screen a single sample - unacceptable when we need to screen several hundreds of materials in the coming years. Furthermore, HPGe cannot actually measure U and Th directly. Instead it measures elements that U and Th decay into.

Inductively-Coupled Plasma Mass Spectrometry (ICPMS) is capable of measuring U and Th directly. Additionally, each sample can be screened in a matter of days, and to levels much better than HPGe. ICPMS cannot tell us about the decay products from U and Th as HPGe can, but together they produce the complete picture we need. The time taken to screen materials in the first place, however, is just what is called for in the building the next generation of Dark Matter experiment.

This proposal is to develop the UK's low-background material screening capability with ICPMS to support the UK's Dark Matter R&D programme. Such new capability would provide the required and unprecedented sensitivity to U and Th screening, and with turnaround times of days. This would enhance the UK's R&D programme to the point that we would have world-class capability, at
a time when internationally HPGe and ICPMS facilities are struggling to cope with demand and do not possess the sensitivity we need.

The ICPMS that we will develop will aid other rare event search experiments that require ultra-low levels of activity, such as those seeking to observe neutrino-less double beta decay. These experiments could tell us about the fundamental properties of neutrinos, and in doing so explain the tiny imbalance between particles and anti-particles shortly after the Big Bang needed for any matter to exist today. The ICPMS also has significant application in food safety, pharmaceutical, environmental, forensic and clinical studies, where elemental analysis of low levels of contaminants is a rich area of research with significant societal and economic impact potential.

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