Issue No. 76
Spring 2016

BNA Bulletin

THE VOICE OF BRITISH NEUROSCIENCE TODAY

Rhythms of speech

Brain oscillations and the art of conversation

Seeing sounds

The neurobiology of synaesthesia

PLUS:

Boosting the brain's antioxidant defences

Anosognosia and the sense of self

The neuroscience of dance

A cool look at neuromarketing

BNA
British Neuroscience Association

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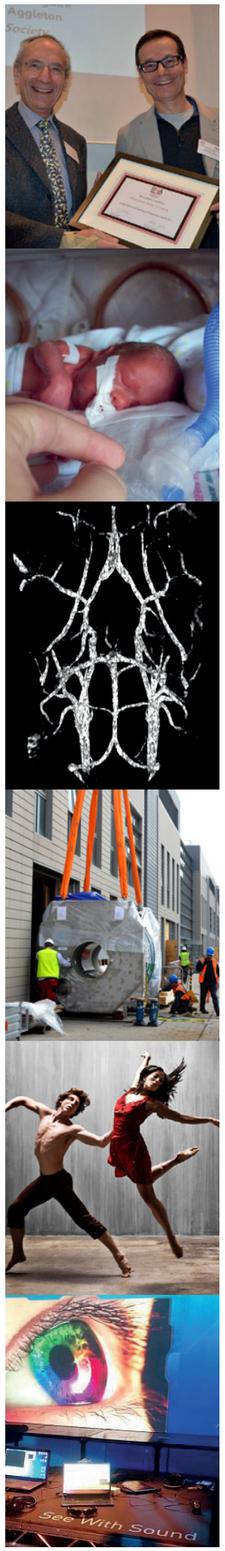

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Cover: 'The Conversation' by Étienne Pirot (2012), a public artwork in Havana, Cuba (Gareth Williams/Flickr). During conversation, rhythmic features of speech entrain oscillations in the listeners' brain (see page 24).

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Message from the President

Dear BNA Members

As you read the paragraph below you will almost certainly conclude that I am a hypocrite.

The Local Groups are the lifeblood of the BNA. They provide an essential route by which the President, Council and Committee can interact and work with members in order to promote neuroscience and meet the aims of the BNA. In short, the Local Groups and the initiatives they undertake are critical to the BNA's long-term success. So why did the BNA Council and I recently decide to suspend temporarily the funding of Local Group activities?

It was a difficult decision, but it had become apparent that the current funding system for Local Groups was not working. Local Group Representatives have highlighted several shortcomings, including the feeling that its goals were too narrow (with respect to the activities that could be supported), it was unfair (funding limits were based on the number of members in a group, disadvantaging smaller groups) and that it was inflexible (only one call each year).

Nevertheless, we remain absolutely committed to supporting Local Groups, and we have launched a new scheme that we believe will be more fit for purpose. One key feature is that we will encourage more imaginative applications, such as novel forms of public engagement or collaboration with clinical groups. We will continue to support more traditional activities, such as seminars, but we will look for greater involvement of BNA members, with stronger justification and better reporting. Money provided by the BNA will reflect the quality and innovation of activities, rather than simply the size of a particular Local Group.

I can but apologise to groups whose applications were turned away last year due to the actions we felt had to be taken. I am, however, confident that the new funding system will prove a far better way of supporting UK neuroscience, neuroscientists and BNA members in the long run.

An overview of the new scheme can be found on page 13. We hope it will encourage members to come up with innovative new ways of supporting neuroscience locally – if you have an idea, do have a chat with your Local Group Representative: we're looking forward to receiving your proposals.

John Aggleton, President

Duncan Banks

Stafford Lightman presents Angela Vincent with her award.

2015 BNA awards

Angela Vincent (Oxford) was the 2015 recipient of the BNA's Outstanding Contribution to Neuroscience Award. Professor Vincent was recognised for the significant advances she has made in understanding the science of autoimmune disorders affecting the nervous system, such as myasthenia gravis.

The 2015 Public Understanding of Neuroscience Award went to **Mark Lythgoe** (UCL). As well as running an internationally recognised biomedical imaging facility at UCL, Professor Lythgoe has also been involved in multiple outreach projects, including a highly successful spell as Director of the Cheltenham Science Festival. Student prizes went to **Kathryn Mills** (Postgraduate Award; see page 29) and to **Veselina Petrova** (Undergraduate Award; see page 32). Winners received their awards from President-Elect **Stafford Lightman** (Bristol) at the 2015 BNA Christmas Symposium.

Christmas Symposium

The 2015 BNA Christmas Symposium was even more special, marking the 50th anniversary of the founding of the Black Horse Group, which played a key role in establishing what later became the BNA. A sell-out crowd gathered at King's College London to hear a stimulating range of presentations across the full range of UK neuroscience – with some art and literature thrown in for good measure. See page 11 for a brief overview of the day.

BNA legacy

The BNA is extremely grateful to Edward Walsh who has bequeathed more than £9000 to the organisation.

Glyn Humphreys

The BNA was shocked and saddened to hear of the sudden death of **Glyn Humphreys** (Oxford) in January 2016. As well as his scientific achievements, he was a hugely popular figure in UK neuroscience. We hope to include an appreciation in a future issue of the *BNA Bulletin*.

Secretary's Report

Dear Colleagues

This is my first letter of the year, after a very full 2015. The highlights were undoubtedly the successful Festival of Neuroscience, held in Edinburgh, and the Christmas Symposium, celebrating the 50th anniversary of the first meetings that laid the ground for our association.

The 2015 BNA Award for Public Understanding of Science was conferred on Mark Lythgoe (UCL), while the work of Angela Vincent (Oxford) was recognised by the award of the Outstanding Contribution to Neuroscience prize. Kate Mills (UCL) and Veselina Petrova (Edinburgh) received the postgraduate and undergraduate awards, respectively.

In November, the BNA and the Royal Society of Biology sponsored a public lecture by former BNA President David Nutt, addressing the always delicate issue of the clash between science and dogma around drug and alcohol policies.

These events helped to swell the ranks of the BNA membership. One of the most rapidly growing membership groups is the undergraduate and postgraduate community, a varied and dynamic community. The election of Jo Bailey (Southampton) as the Students and Early Careers representative will help to develop and integrate their activities, while the new Membership Secretary, John Jefferys (Oxford), is continuing to develop the BNA membership, identifying new interested groups and enhancing the range and quality of membership benefits. In 2015, Deborah Castle was elected as Equal Opportunities and Diversity Representative, bringing our National Committee to full force. The strength of the team running our association has been significantly enhanced by the appointment of Anne Cooke as Chief Executive, working alongside Executive Officer Louise Tratt.

We were able to offer a significant number of travel grants for the Festival of Neuroscience. In the same vein of striving to enhance membership benefits, we have now revised the scheme that supports the activities of Local Groups (see page 13).

During 2016, we hope to continue strengthening and developing the BNA as the voice of the British neuroscience community, and a number of exciting initiatives are in the pipeline. The BNA AGM will take place in April in Cardiff, and if there are particular issues that you want to raise, please do not hesitate to send them to me at e.c.toescu@bham.ac.uk.

Emil Toescu, Secretary

BNA Council and National Committee

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Stafford Lightman (Bristol): President-Elect
Russell Foster (Oxford): Immediate Past President
Emil Toescu (Birmingham): Secretary
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Peter J Brophy (Edinburgh): Professional Society Liaison
Deborah Castle: Equal Opportunities and Diversity Representative
Gary Gilmour (Eli Lilly & Co): Corporate Representative
Mark Ungless (Imperial): Education and Engagement Secretary
Anne Cooke (BNA): Chief Executive
Louise Tratt (BNA): Executive Officer

John Hardy (UCL).

Breakthrough Prize

John Hardy (UCL) has been awarded the US$3m Breakthrough Prize in Life Sciences for his pioneering research into the genetic causes of Alzheimer's disease and other neurodegenerative disorders. The Breakthrough Prize, established in 2013 by US entrepreneurs Sergey Brin and Anne Wojcicki, Mark Zuckerberg and Priscilla Chan, Yuri and Julia Milner, and Jack Ma and Cathy Zhang, honours 'transformative advances toward understanding living systems and extending human life'.

One of the world's most highly cited researchers, Professor Hardy identified mutations in the amyloid precursor protein gene (APP), the source of beta-amyloid, in familial Alzheimer's disease. He has contributed to the discovery of multiple other genetic influences on Alzheimer's disease and other neurodegenerative disorders, shedding important light on mechanisms of disease.

In typically irreverent acceptance remarks (**bit.ly/1Udg1xv**), Professor Hardy thanked Tony Turner for "persuading me to go into research when I had taken a job as a long distance lorry driver": Eddie Stobart's loss was thus UK neuroscience's gain.

Neuronal plasticity prize

David Attwell (UCL) is one of the winners of the 2016 La Fondation IPSEN Neuronal Plasticity Prize. Professor Attwell shares the award with Pierre Magistretti (École Polytechnique Fédérale de Lausanne, Switzerland) and Marcus Raichle (Washington University School of Medicine, USA).

New Year's Honours

Congratulations to **Til Wykes** (King's College London), who was awarded a damehood for services to clinical psychology in the 2016 New Year Honours List. Professor Wykes is internationally recognised for her work on the rehabilitation and recovery for people with severe mental illness.

Congratulations also to **Joanna Wardlaw** (Edinburgh), who was awarded a CBE for her services to neuroimaging and clinical science. Professor Wardlaw is internationally recognised for her work on stroke and brain ageing, and particularly the use of brain imaging. She was also a founding member of the Edinburgh Neuroscience Board.

Also recognised was **Alastair Compston** (Cambridge), who was appointed a CBE for services to multiple sclerosis treatment. Professor Compston's research on the mechanisms and treatment of multiple sclerosis included development of alemtuzumab (Lemtrada) as a highly effective treatment for early relapsing-remitting multiple sclerosis.

Joanna Wardlaw (Edinburgh).

Psychiatry award

Sukhwinder Shergill (King's College London) was named the Royal College of Psychiatrists' Academic Researcher of the Year for 2015. Professor Shergill's research explores the brain mechanisms underlying psychosis and the testing of novel treatments.

Klaus J Jacobs Research Prize

Sarah-Jayne Blakemore (UCL) has been awarded the 2015 Klaus J Jacobs Research Prize for her research on understanding emotional and social brain development during adolescence. The Prize, worth one million Swiss francs, is awarded by the Jacobs Foundation, a Swiss-based organisation that promotes child and youth development, to recognise exceptional achievements in research and practice in the field of child and youth development. See **bit.ly/1j2pBqn** for further details.

Leverhulme Prizes

The 2015 Philip Leverhulme Prizes in psychology were awarded to **Caroline Catmur** (King's College London), **Bhismadev Chakrabarti** (Reading), **Steve Loughnan** (Edinburgh), **Liz Pellicano** (Institute of Education) and **Jonathan Roiser** (UCL). The Prizes, worth £100,000, go to early-career researchers who have already achieved outstanding success in research. See **bit.ly/1PD1eHX** for details of the prize-winners' work.

Epilepsy research

A working group established by the National Centre for the Replacement, Refinement, and Reduction of Animals in Research (NC3Rs) has published its review of the current use of rodent models of epilepsy and opportunities to improve animal welfare. The review, published in the *Journal of Neuroscience Methods*, provides practical guidance and advice for researchers working with *in vivo* models. The working group also highlighted priority areas where increased knowledge and technological development would facilitate refinement and promote best practice. The paper can be found at **bit.ly/20uW5ts**.

Events

LSNeuroN 2016

The largest ever neuroscience conference organised by students for students, LSNeuroN 2016, took place on 6–7 February 2016. Organised by the London Students' Neuroscience Network (LSNeuroN), the conference featured keynote lectures from Nobel laureate **John O'Keefe** (UCL), **John Donoghue** (Brown University, USA), **Colin Blakemore** (Oxford) and **Maria Grazia Spillantini** (Cambridge), as well as topical symposia and poster sessions. LSNeuroN brings together the neuroscience societies of Imperial College, King's College London, Queen Mary and Barts and The London, St George's, and UCL.


Duncan Banks

Cambridge Seminar

The 28th Cambridge Neuroscience Seminar took place on 17 March 2016. The plenary lecture was given by **Sarah Tabrizi** (UCL), while **Giovanna Mallucci** (Cambridge, above) delivered a public lecture in association with the Cambridge Science Festival.

New MPhil

Cambridge Neuroscience has launched a new MPhil in Basic and Translational Neuroscience. The programme is a one-year master's course with both taught and research components. See **bit.ly/1QGt0Iz** for more information.

Brighton Science Festival

Sussex Neuroscience brought a little of the magic of the brain to attendees of the Brighton Science Festival in February 2016. **Paul Graham** discussed the wonders of animal navigation, **Miguel Maravall** focused on the neuroscience of illusions, and **Ildiko Kemenes** took a trip down memory lane, discussing memory formation and retrieval.

Midlothian Science Festival

Edinburgh Neuroscience had a major presence at the 2015 Midlothian Science Festival. Activities included the getCONNECTED and getREMEMBERING school workshops and the 'Age – What's your number?' comedy event. As well as two science gala stands, **Stephen Lawrie** spoke to the Midlothian ladies book group about Maggie O'Farrell's *The Vanishing Act of Esme Lennox*, while **Lewis Hou** took the Science Ceilidh Band to eight different schools, entertaining and informing more than 600 primary school children.


ceeayoz/WikiMedia Commons

Theirworld funding

James Boardman (Edinburgh) is leading a new study tracking babies from birth to adulthood in order to find new ways of preventing and treating brain injuries in newborns. The project has been supported by the children's charity Theirworld, founded by Sarah Brown, wife of former prime minister Gordon Brown. The project will follow some 400 premature new borns, who are at risk of suffering brain injury, with data collection covering biological samples, brain scans and educational attainment.

Bristol Brain Centre

The new Bristol Brain Centre, which brings together expertise from North Bristol NHS Trust and the University of Bristol, opened at Southmead Hospital in November 2015. The centre houses clinicians and researchers working in areas such as multiple sclerosis, dementia and movement disorders, including Parkinson's disease.

SMA funding

Tom Gillingwater (Edinburgh) and **Kevin Talbot** (Oxford) are leading a new £1.3m UK Spinal Muscular Atrophy (SMA) Research Consortium. The Consortium, which also includes researchers and clinicians from London and Sheffield, aims to promote collaborative research relevant to SMA and related conditions such as muscular dystrophy and motor neuron disease, with a view to developing existing drug targets and identifying new neuroprotective therapies as well as developing better ways to deliver treatments throughout the body.

Online dementia course

UCL has launched a free four-week online course, 'The Many Faces of Dementia', which provides insights into four less common conditions – familial Alzheimer's disease, behavioural variant frontotemporal dementia, dementia with Lewy bodies and posterior cortical atrophy. The course features interviews with world-leading experts, people with dementia and their families as well as articles and discussion. It is aimed at anyone keen to learn more about dementia, particularly family members, carers and health professionals. The course has been created and directed by **Tim Shakespeare** from the UCL Dementia Research Centre. See **bit.ly/1SkWQIL** for more details.

Oxford drug discovery

John Davis has been appointed Chief Scientific Officer at Alzheimer's Research's UK Drug Discovery Institute at the University of Oxford. The Institute, part of a £30m Drug Discovery Alliance that also includes Institutes at Cambridge and UCL, is aiming to discover new treatments for Alzheimer's disease and other dementias. Dr Davis will work closely with Lead Academic Scientists **Simon Lovestone** and **Chas Bountra** in Oxford, as well as Chief Scientific Officers at the other two Institutes (**John Skidmore** in Cambridge and **Paul Whiting** at UCL).

Dementias Platform UK
Medical Research Council

Dementia Research Institute

The Medical Research Council (MRC) has been tasked with establishing the UK's first national Dementia Research Institute (DRI). Scheduled to be operational by 2020, the DRI will bring together world-leading expertise in discovery science, and is due to receive up to £150m in funding. The MRC will launch a competitive process in 2016 to identify universities able to host the DRI. The MRC will also lead the search for a director.

JPND funding

Nine UK research teams are part of 21 collaborative projects receiving £25.7m funding through the EU Joint Programme – Neurodegenerative Disease Research (JPND).

The JPND was established by European funding agencies, including the MRC, to address the growing challenge of age-related neurodegeneration. The initiative aims to increase coordination of European research efforts and promote collaborative discipline-spanning research.

UK-based researchers receiving funding are **Kevin Mills** (UCL), **Richard Wade-Martins** (Oxford), **Ian Deary** (Edinburgh), **Rebecca Sims** (Cardiff), **Katie Lunnon** (Exeter), **Paola Giunti** (UCL), **Tony Schapira** (UCL), **Thierry Voet** (Cambridge) and **Michel Goedert** (Cambridge).

MRI–PET

Five new MRI–PET scanners are being installed in the UK, thanks to substantial new funding from the MRC Dementias Platform UK. The new sites are Cambridge, Edinburgh, Imperial College, Manchester and Newcastle. All seven sites will be contributing to a national MRI–PET imaging network.

Pathfinder funding

UK neuroscientists are contributing to 11 international 'Pathfinder' projects funded through the Centres of Excellence in Neurodegenerative disease (CoEN) initiative, which supports collaborative research in neurodegenerative disease. Under the third CoEN funding call, 11 teams have been awarded £3.6m for innovative and creative proof-of-principle studies that could have a transformative impact on neurodegeneration research.

The projects are aiming to identify and validate new potential drugs and develop innovative therapeutic approaches. UK-based researchers in the successful international teams include **Dario Alessi** (Dundee), **Miratul Muqit** (Dundee), **Richard Wade-Martins** (Oxford), **Sarah Tabrizi** (UCL), **Rebecca Sims** (Cardiff), **Kevin Talbot** (Oxford), **Rebecca Taylor** (Cambridge) and **Massimo Zeviani** (Cambridge).

CoEN is a partnership between research funders in nine countries, including the MRC. See **bit.ly/1UoNBjU** for more details of the awards.

Imaging collaboration

Molecular imaging consortium Imanova has announced two major collaborations with UK institutions.

In collaboration with Imperial College, Imanova is joining the national imaging network established by the Dementias Platform UK (see left) and will house one of the network's new MRI–PET scanners. It is also collaborating with Teva Pharmaceuticals and UCL to investigate the role of microglia and inflammation in neurodegenerative disease.

Established in 2011, Imanova is a joint venture between the MRC, Imperial College London, King's College London and UCL.

imanova
Centre for Imaging Sciences

News in Brief

Natural intelligence

Anil Seth (Sussex) joined Robin Ince and Brian Cox on *The Infinite Monkey Cage* in January 2016, to discuss artificial intelligence. Go to **bbc.in/1ROUGfx** for a chance to listen again.

Royal recognition

Cardiff University's MRC Centre for Neuropsychiatric Genetics and Genomics has been awarded a 2015 Queen's Anniversary Prize for Higher and Further Education. Established in 1993, Prizes are awarded every two years. The Cardiff centre has been recognised for its outstanding work on the causes, diagnosis and treatment of mental illness.

Genomics meeting

The Wellcome Genome Campus has launched a new meeting, 'The Genomics of Brain Disorders'. With a scientific programme committee including **John Hardy** (UCL) and **Mike Owen** (Cardiff), the meeting will take place on 25–27 April 2016. See **bit.ly/1hDUX4Y** for further details.

Master Class

Trevor Robbins (Cambridge), winner of the 2015 Brain Prize, will lead a Master Class for some of the most promising early-career neuroscientists in Europe in April 2016. The Master Class, to be held in Copenhagen, Denmark, is being organised by the European College of Neuropsychopharmacology and the Grete Lundbeck European Brain Research Foundation. Some 20 junior neuroscientists will have the opportunity to present and discuss their work with Professor Robbins and other senior scientists.

STOP PRESS

Brain Prize 2016

Congratulations to Tim Bliss (Crick Institute), Graham Collingridge (formerly Bristol, now at the University of Toronto) and Richard Morris (Edinburgh) who have been awarded the 2016 Brain Prize by the Grete Lundbeck European Brain Research Foundation for their work on long-term potentiation. See **www.thebrainprize.org/** for full details.

The striking new home for CUBRIC on Cardiff's Maindy Park site.

Cardiff goes large in brain imaging

A spectacular array of imaging technologies have been installed in Cardiff University's Brain Research Imaging Centre (CUBRIC). Early in 2016, researchers began moving into CUBRIC's striking new building, which houses an exceptional range of imaging equipment currently unique in Europe.

CUBRIC's reincarnation dates back to 2012, when CUBRIC Director Derek Jones and colleagues recognised not only that space was becoming a severely limiting factor in their existing building but also that substantial new investment in equipment was needed to ensure that the Centre remained internationally competitive.

Keen to build on the Centre's international reputation, Cardiff University were highly receptive to CUBRIC's ideas, and were willing to make available a large space on its Maindy Park site, undergoing a multimillion pound redevelopment. This provided a rare opportunity to design an ambitious new facility from scratch.

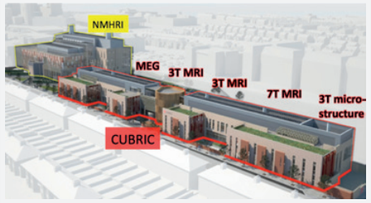
The University was prepared to make its largest ever single investment in the new centre, committing £44m to underwrite the move. The CUBRIC team has so far secured £27m of external funding from multiple sources to support construction and fitting out of the building, purchase of equipment, and associated research, including generous funding from the Welsh Government.

Scanning technology

At the heart of CUBRIC are five state-of-the-art scanners: a magnetoencephalography (MEG) machine, two 3T MRI scanners (including one tailored to clinical research, as part of an integrated Clinical Research Facility), a 7T MRI scanner and Europe's first 3T CONNECTOM microstructural imaging device. The 7T scanner is the third to be installed in the UK, as part of the Medical Research Council's (MRC's) major investment in high-power MRI facilities across the UK.

The microstructural imaging device, funded by the Engineering and Physical Sciences Research Council (EPSRC) and the Wolfson Foundation, is a real coup for Cardiff neuroscience. It has long been on the wish list of UK brain imagers, providing opportunities to probe neural architecture at resolutions far higher than conventional MRI methods. With a limited marketplace, however, manufacturers have been reluctant to invest in development of the necessary technology, until the huge US investment in the human connectome project persuaded Siemens to develop a new instrument, now installed at Massachusetts General Hospital in Boston. CUBRIC has acted as a focal point of a UK consortium – involving nine principal investigators at seven institutions – which successfully bid for funding to ensure a second machine could be installed in the UK and act as a hub for neuroimaging in Europe.

Alongside these major new instruments, space has also been allocated to research using complementary technologies, such as EEG and various forms of transcranial stimulation. Furthermore, emphasises Professor Jones,



CUBRIC is home to a unique array of imaging facilities.

innovation in imaging technology will be matched by equally innovative approaches to cognitive testing and data analysis.

The Welsh Government and the European Regional Development Fund both made substantial awards to fund the new building. In addition, CUBRIC secured a major strategic award from the Wellcome Trust, to support research exploiting the new equipment and to enable the Centre to recruit new staff. Finally, the MRC-funded Dementias Platform UK provided funding towards a 3T MRI system.

Empowering research

Cross-disciplinary research will be fundamental to CUBRIC, suggests Professor Jones. Of the 150 or so researchers occupying the new facilities, around half are from the life sciences and half have a background in the physical sciences – engineering, physics, mathematics and computing.

About half of CUBRIC's research will focus on normal brain function and half on brain-related diseases – particularly epilepsy, psychosis and bipolar disorder, as well as neurodegenerative conditions such as Huntington's disease, multiple sclerosis, Alzheimer's disease and Parkinson's disease. A key aim is to take advantage of the multiplicity of technologies under one roof, by using a combination of technologies to explore topics from multiple perspectives. Furthermore, says Professor Jones, the new technologies will further shift brain imaging away from descriptive studies and towards mechanistic understanding – *in vivo* brain physiology.

A formal opening for the new CUBRIC is planned for June 2016. While it provides an unmatched combination of facilities for local researchers, Professor Jones is keen to stress CUBRIC's 'open door' policy and its desire to establish national and international collaborations so that the full potential of its resources can be realised.

A Christmas treat

The 2015 BNA Christmas Symposium, celebrating 50 years of the BNA, provided an enticing view of neuroscience past, present and future, thanks to a stellar line up of speakers.

Compere John Aggleton with Stafford Lightman; speakers Giovanna Mallucci, Seth Grant and John Hardy.

Hosted for the first time by King's College London, the 2015 BNA Christmas Symposium featured art and literature as well as cutting-edge science, with historical perspectives complementing scientific presentations. BNA President **John Aggleton** achieved the remarkable feat of identifying Charles Dickens quotations to introduce each speaker, in recognition of the theme of the meeting – the past, present and future of neuroscience, an allusion to Dickens's suitably topical *A Christmas Carol*.

With Steven Rose unfortunately indisposed, **John Lagnado** stepped in to describe the early days of British neuroscience and the pioneering activities of the Black Horse Group (see *BNA Bulletin* 70, Spring 2014). Then it was on to the scientific presentations, starting with a thought-provoking contribution from **Seth Grant** (Edinburgh) on the synapse. After recounting the early history of the synapse (a term coined by Charles Sherrington), he went on to suggest that 1989 was a turning point, with the cloning of the first gene encoding a synaptic protein. Genetic and proteomic approaches have since identified remarkable complexity in protein diversity and organisation at the synapse. He concluded with the provocative idea that the synapse was not just a simple connector but a structure capable of complex computations.

Focusing on brain rhythms, **Miles Whittington** (York) pointed out that, although they have been known about for nearly 150 years, their exact role has been obscure. Although rhythms are associated with a range of conscious states, their functional contribution to such states is unclear. Nevertheless, they are a potentially powerful mechanism for synchronising activity across brain regions, and advances in technologies such as MEG and fMRI may provide more insight into the functional significance of human brain rhythms (but a better theoretical conceptualisation might be at least as important).

By complete contrast, **Paul Matthews** (Oxford) presented a fascinating insight into the life and times of William Shakespeare. He argued not only that Shakespeare was remarkably accurate in his depiction of medical conditions, but also that he was a keen observer of human behaviour. The psyche of his characters was often instrumental to the development of his stories.

Returning to science, **Alasdair Coles** (Cambridge) discussed the long history of multiple sclerosis, first described by Charcot. Demyelination was identified as far back as the 1910s and the importance of the immune system was recognised in the 1960s. The greater understanding of disease has led to the development of effective therapies, not least Campath-1h (alemtuzumab), developed in Cambridge.

Continuing the neurological theme, **John Hardy** (UCL) discussed the genetics of neurodegenerative diseases, from his and Martin Rossor's discovery of the first gene responsible for an inherited form of Alzheimer's disease, through genome-wide association studies to identify risk factors, and recent exome-sequencing work revealing disease genes in affected families. A key question, he suggested, is why certain types of cell are particularly vulnerable in different neurodegenerative conditions – their intrinsic biology may position them on the edge of a 'catastrophic cliff'.

Concluding a session on neurodegenerative diseases, **Giovanna Mallucci** (Cambridge) described her pioneering studies on prions. Curiously, misfolded prion proteins are not toxic – the problem seems to lie in the conversion of cellular prion protein into the misfolded form. Her work has identified the importance of the cell's 'unfolded protein response' and subsequent disruption of protein synthesis, opening up exciting new avenues for therapeutic development.

Nick Wade (Dundee) next took us on a fascinating historical digression, introducing key figures in neurology, psychiatry, neuroscience and related disciplines. For each, he showed a composite artwork combining a portrait with a visual reference to their work.

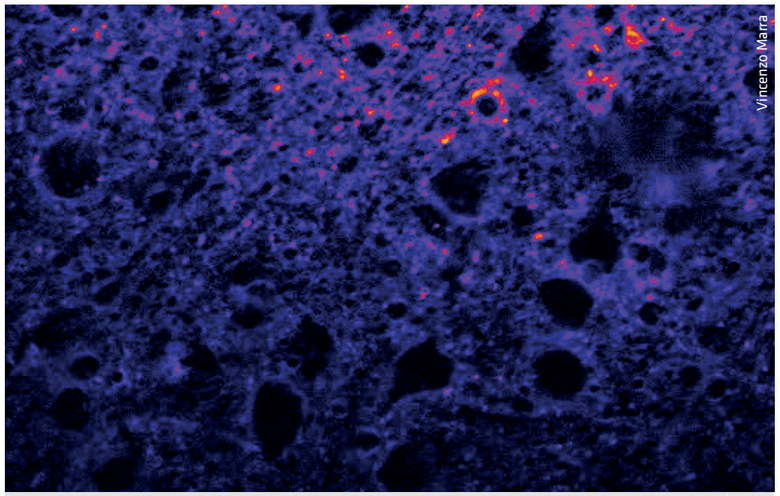
Back in the modern-day realm, **Irene Tracey** (Oxford) reviewed latest thinking on the neurobiology of pain, and how brain imaging is providing new insight into a phenomenon with a strong subjective element. Finally, in a tour de force finale, **Eleanor Maguire** (UCL) argued that the focus on 'HM' (Henry Molaison) in memory research, while providing much important insight, had placed too much emphasis on the hippocampus as the seat of memory. Several other structures were also critical to memory encoding and retrieval, she suggested, and the hippocampus's function extends beyond memory.

With an award-giving ceremony (see page 5) and a wine reception to enjoy after, the audience could enter the festive season in good cheer and with much to think about.

A sell-out crowd enjoyed the festive presentations.

Leicester Neuroscience

A new department – Neuroscience, Psychology and Behaviour – is providing a focal point for the development of neuroscience at Leicester.



Multiphoton image of labelled pre-synaptic terminals in mouse cortex.

Much like Leicester itself, the University of Leicester boasts a diverse range of backgrounds and cultures – both socially and academically. Also notable for the invention of DNA fingerprinting and the discovery of King Richard III's remains, the University has a strong neuroscience research community. Within its campus are internationally renowned specialists working on areas ranging from clinical ophthalmology and neurodegenerative diseases to computational modelling and locust neurobiology (see *BNA Bulletin* 76, Autumn 2015). This vibrant blend of disciplines serves as a compelling attraction for upcoming neuroscientists hoping to increase the scope of their research.

Neuroscience, psychology and behaviour

Until recently, Leicester's neuroscience community was organised into 'themes', with researchers scattered across multiple departments. However, in 2015 a growing desire for official recognition of Leicester's neuroscientific contributions encouraged the University to combine the bulk of its neuroscience groups with psychologists and animal behaviourists into one overarching department – Neuroscience, Psychology and Behaviour (NPB).

Under this NPB 'umbrella' are approximately 50 principal investigators focusing on topics including zebrafish models of disease, clinical psychology and neuronal calcium imaging. Head of the new NPB department, Claire Gibson, is excited about the new structure and its prospects for developing and strengthening research collaborations and training upcoming researchers. "It is the first time we have given a department identity to neuroscience," she enthuses. "This has important benefits not only for our research programmes but also for us to achieve synergies in PhD supervision and teaching future neuroscientists."

Hopes are high for the University's new NPB department. By assembling the new department, long-serving researchers at the University such as the prolific psychologist Andrew Colman hope to boost the University's international reputation for excellence in research. This was reiterated by the department's Head of Research, Ian Forsythe, who led the Research Excellence Framework (REF) UoA4 submission: "The NPB Department allows us to consolidate our broad approach to neuroscience and develop a strategy which focuses on mechanisms of brain function and behaviour. It would also be great for us to all to come under one roof, build on our impressive REF result and boost our research funding."

One example of an exciting research pursuit is work carried out by Nick Hartell, whose group develops state-of-the-art technology to visualise synaptic plasticity. Having recently pioneered a novel method for rapidly imaging cellular processes, Professor Hartell is currently building one of the first microscopes in the world to capture fast super-resolution multiphoton images in living systems. His future plans for NPB are grander still. "I believe that imaging in behaving animals will be of great importance for the near future, making it a vital method to develop in our institution," he remarks. "This department is a nice step in that direction."

Appetite for communication

With the formation of a new department comes the potential for more inter-group interactions. The increased size of journal clubs and seminars improves cohesion and provides greater scope for collaborations. Furthermore, neuroscience-based groups in other colleges of the University, which are not part of the new department, will benefit from a defined neuroscience community. Researchers such as Rodrigo Quian Quiroga (first author of the famed 'Jennifer Aniston cell' paper in 2005), in the University's Centre for Systems Neuroscience, and Matias Ison, in the Department of Engineering, are anticipating more opportunities to work alongside their colleagues. Dr Ison explains: "I expect the new department is going to bring together its own research groups, but I also hope that it will foster more interdepartmental collaborations too."

Research using EEG (top) and eye-tracking technology.

More diverse collaborations also mean greater funding and teaching opportunities. The department is becoming more involved with Research Council-funded doctoral training partnerships and PhD project funding from international governments. In addition, opportunities for undergraduates in neuroscience are plentiful. The university has been offering a BSc in Psychology with Cognitive Neuroscience for several years, and in 2014 a Neuroscience BSc option was added to the Biological Sciences stream. Thus, undergraduates form an important part of the community, particularly during their final year lab-based dissertations.

In the brave new world of managing a department as extensive and diverse as NPB, Dr Gibson is confident that the University of Leicester's neuroscience research environment, newly combined with psychology and animal behaviour, will thrive for years to come. "We have formed a large department, one of the largest in the University in terms of academic staff," she concludes. "This will bring challenges but also exciting opportunities in the coming future."

Aman Asif-Malik and Jonathan Smith

Local Group Funding Scheme

BNA British Neuroscience Association

The BNA is delighted to announce a new funding scheme for Local Groups.

The aims of the funding scheme are to enable Local Groups to organise activities that benefit current members of the BNA and recruit new members of the Association. Creative ideas for activities that fulfil the objects of the BNA and engage with as many people as possible will be looked on favourably. Such activities can include but are not restricted to:

- training or career opportunities in the field of neuroscience for BNA members
- opportunities to foster translational neuroscience
- public engagement projects
- an individual or a series of seminars
- initiatives that support neuroscientists relating to wider issues of neuroscience (e.g. use of animals in research, neuroethics, working with the media)
- initiatives to recruit new members to the BNA (e.g. at the start of the academic year).

Any application for support of seminars should describe how the activity will directly benefit BNA members and have impact beyond those attending (e.g. via live-streaming or an associated public engagement event). There should be strong justification for requests that fund purely a stand-alone seminar or seminar series.

Application procedure

- Two calls per year: spring deadline 31 May and autumn deadline 31 October
- Funding decisions will be made within one month of submission deadline
- Applications must be submitted through a Local Group Representative
- Collaborative proposals submitted by two or more Local Groups are welcomed
- There is a limit of one individual or collaborative application per Local Group each academic year
- Maximum of £500 awarded per Local Group per year, whether via an individual or collaborative application (e.g. a collaborative application involving three Local Groups may apply for a maximum of £1500).

For full details and an application form, see **www.bna.org.uk/localgroups**.

Inspiring school students in Southampton

Degree subject choice and university location are important decisions for sixth-form students. In November 2015, on behalf of the Southampton Neuroscience Group (SoNG), we organised a sixth-form outreach event to demonstrate the wonders of studying the brain. The aim was to educate school students about the brain, and why it is a fantastic organ to study, and to convey a sense of what it is like to study neuroscience at university. More than 100 students and teachers from 12 schools attended the event, from as far afield as Bristol and London.

The day started with a seminar on the trebling of the size of the human brain during evolution. During lunch, undergraduates and master's students talked to the sixth formers about university life, studying for a degree, and why they chose to study at Southampton. The school students also had a chance to look around laboratories and seminar rooms.

A workshop on imaging the brain exposed the students to live imaging and the power of 3D imaging using the confocal microscope. Further workshops focused on electrophysiology, *C. elegans*, biochemistry and the fruit fly *Drosophila*.

The laboratory workshops provided the school students with a first look at what it is like to enter a working research facility. They also had a chance to experience other innovative projects run by SoNG, such as the 'Changing Minds' project, a collaboration between neuroscientists, students from the Winchester School of Art and Peter Symonds Sixth Form College, which used fashion to explore mental health.

The last two workshops aimed to enlighten the students and enthuse them to study neuroscience. As well as a fun interactive quiz, the students enjoyed an exhilarating tour through the brain and its remarkable functional and structural complexity.

Joanne Bailey and Shmma Quraishe

A longer version of this article can be found on the BNA Facebook site.

Bright Brains
Newsletter

Issue No. 2
Spring 2016

Welcome to the spring edition of our 'Bright Brains' Newsletter! We are pleased to present you with an impressive variety of thought-provoking articles that have been composed and edited by BNA students, postdocs and early-career researchers from a diverse array of neuroscientific disciplines throughout the UK.

We have made every effort to make the second edition of 'Bright Brains' bigger and better! Thanks to the alacrity of the BNA to support and strengthen the voice of young BNA members within the BNA community, these positive changes can be visibly and clearly seen throughout this edition. One significant change, for example, is the extension of the newsletter by two additional pages. This change allowed us to include novel and interactive facets to the bulletin such as the first 'BNA crossword', and exciting features such as 'Numquid sciebat...?' ('Did you know...?') and 'Quid novi?' ('What's new?') that will provide you with a special and more stimulating BNA experience.

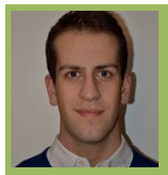
As scientists, we know only too well how critical science communication is regardless of whether it is aimed at other scientists via journal articles and conferences, or at everyone else via magazines, television or radio programmes. Blogs present a special channel for science communication because they can be directed at both the general public and scientists. By enhancing your skills as a writer, and by challenging you to be more creative to bring science to life outside of your lab in an engaging and energetic way, blogs can truly help you with both your personal and professional development. For that purpose, 'Bright Brains' has provided you with a list of animating blogs from both young neuroscientists and established neuroscience bloggers that can either inspire you to create your very own science blog, or help experienced bloggers propel their blogs into the next level of the blogosphere.

In addition, 'Bright Brains' has many more intriguing and energising features in store for you in this edition. Our 'Nuntia' section features our review of the first conference by the London Students' Neuroscience Network (LSNeuroN), and a fascinating article on the utility of cognitive training interventions in Huntington's disease. Our 'Socialia' section highlights the significance of grassroots initiatives to students and postdocs, and presents to you our first 'Bright Brains' interview.

Our 'Varietas' section introduces you to the exciting 'method of loci', and offers you a first glimpse into the state of research in India, with further insights to follow in future editions. The new feature 'Numquid sciebat...?' reveals what makes us human, while 'Quid novi?' explores a novel method to study brain circuits. Last but not least, we are challenging you to test your brain on how well it knows itself! Are you up for the challenge? Then have a go at our first 'BNA crossword', which has neuroanatomy as its theme.

Finally, we sincerely hope that you have as much joy in reading our second 'Bright Brains' newsletter as we had in producing it. On that note, we encourage you to get involved in science communication by joining our newsletter team. Please direct enquiries to jayanthinykangatharan@gmail.com.

List of neuroscience blogs	
http://threepoundsofgrey.blogspot.co.uk/	http://www.talkingbrains.org/
http://neuroconscience.com/	http://neurocritic.blogspot.co.uk/
http://www.bangscience.org/category/blogs/bangblog/	http://www.spring.org.uk/
https://neurekaseminars.wordpress.com/	http://neurocomplimenter.blogspot.co.uk/
http://www.sciencenutshell.com/	https://www.psychologytoday.com/blog/neuronarrative
http://neurobabble.co.uk/	http://blogs.discovermagazine.com/neuroskeptic/#.Vp5mJyhnHwy
http://ego-audio.blogspot.co.uk/	https://futureofscipub.wordpress.com/
https://neurophilosophy.wordpress.com/	http://mindhacks.com/
http://theneurosphere.com/	http://researchblogging.org/post-search/list/tag_id/14
http://neurowhoa.blogspot.com/	http://blogs.plos.org/neuroanthropology/



Steven Jerjian
PhD student in
Clinical Neuroscience, UCL

London Students' Neuroscience Conference 2016

On 6-7 February 2016, Imperial's South Kensington campus hosted LSNeuroN2016, the inaugural London Students' Neuroscience Conference. Organised by the London Students' Neuroscience Network, a collaboration between the student-led neuroscience societies (NeuroSocs) at UCL, King's, Imperial, Queen Mary's, St George's Medical School, and now Goldsmiths, the sell-out event saw more than 450 students gather to attend a series of talks, seminars and workshops by world-leading academics and clinicians from across the field.

Keynote talks were delivered by esteemed neuroscientists John Donoghue, Sir Colin Blakemore, Maria Grazia Spillantini and 2014 Nobel Laureate John O'Keefe. Symposium sessions, organised by NeuroSocs members, allowed a more in-depth exploration of a wide variety of topics, including a neuropathology workshop featuring a live human brain dissection, a panel discussion on neuroscience-inspired artificial intelligence, an exploration of the interactions between art and neuroscience, from aesthetics to creativity, and many more.

More than 50 students at both undergraduate and postgraduate level also presented posters on their own research, with prizes awarded to the best presentations. Several exhibitor stands also gave students the opportunity to speak with companies and organisations involved in neuroscience, and we would like to thank the sponsors of the event for their generous support.

Despite being the very first conference organised on this scale for students, the great success of LSNeuroN2016 means that it certainly will not be the last! We would also like to run smaller, more frequent events, including journal clubs, museum visits, and socials. If you would like to get involved, please write to us at info@lsneuron.com as we are always looking for keen and enthusiastic young people to join us.

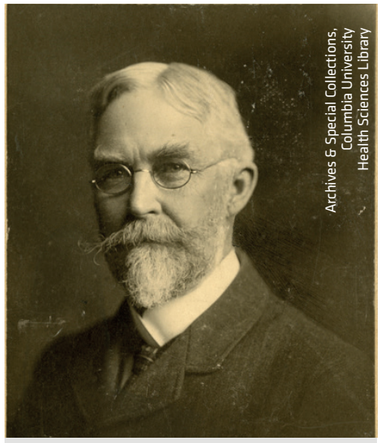
Emma Yhnell
Postdoctoral researcher,
Cardiff University

Can cognitive training be used as a therapeutic intervention in Huntington's disease?

Huntington's disease is a rare neurodegenerative disease, which was first described by George Huntington in 1872. Despite this, the genetic cause of the disease – an expansion of the CAG trinucleotide repeat within the first exon of the huntingtin gene – was not discovered until 1993 (1). Although we know the genetic cause of the disease, there is currently no cure.

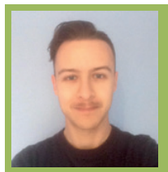
Huntington's disease causes a triad of cognitive, psychiatric and motor symptoms. Cognitive disruptions are a particular early feature of the disease, which can significantly affect daily activities, independence and quality of life (2). But cognitive training via repeatedly conducting tasks (often on a computer), which focus on improving executive function, offers a potentially exciting therapeutic intervention, which has not yet been used in Huntington's disease.

We know that certain cognitive skills, such as memory and attention, decline as the disease progresses, so if these particular skills can be trained early within disease progression, before cognitive decline occurs, or even prior to onset, then we may be able to prevent or delay these symptoms. Cognitive training studies have been shown to improve disease symptoms in other neurodegenerative diseases, including Parkinson's disease (3) and Alzheimer's disease (4). Therefore, cognitive training interventions present a potentially exciting non-pharmacological treatment option for Huntington's disease, which requires further investigation.



George Huntington.

1. **MacDonald ME**, *et al*. (1993) A novel gene containing a trinucleotide repeat that is expanded and unstable on Huntington's disease chromosomes. *Cell*. 72(6):971-983.
2. **Helder DI**, *et al*. (2001) Impact of Huntington's disease on quality of life. *Mov Disord*. 16(2):325-330.
3. **Milman U**, *et al*. (2014) Can Cognitive Remediation Improve Mobility in Patients with Parkinson's Disease? Findings from a 12 week Pilot Study. *J Parkinson's D*. 4(1):37-44.
4. **Davis RN**, *et al*. (2001) Cognitive intervention in Alzheimer disease: a randomized placebo-controlled study. *Alzheimer Dis Assoc Disord*. 15(1):1-9.



André Marques-Smith
Postdoctoral researcher,
King's College London

'Grassroots' initiatives in neuroscience

I have contributed to the creation and development of two neuroscience student societies. The Cortex Club was founded in Oxford in 2009 by former PhD students Abhishek Banerjee and Dennis Kaetzel, with the aim to run neuroscience seminars that focus on inclusivity and open discussion. I was involved with the Cortex Club for two years and upon joining King's College as a postdoc, I approached some colleagues and we founded Neureka on similar principles.

'Grassroots' initiatives such as the Cortex Club and Neureka are more than just seminar series run by students. They are flexible organisations with determined committees whose imagination is the only limitation to the type of event that can be organised. Since neuroscientists are often scattered throughout distinct departments due to the multidisciplinary nature of brain research, Cortex Club events offer a rallying point to the neuroscientific community.

The Cortex Club often hosts social networking events, as well as 'Leavers Lectures', where soon-to-be graduates of PhD programmes in neuroscience expand on their vision and future plans. At Neureka, we are presently building a career advice bank based on interviews with our speakers. Furthermore, we are creating a neuroscience blog where we explain challenging concepts from our talks to lay audiences.

These activities, however, do not detract from our core mission: to provide exciting and informal neuroscience seminars. Being part of such a student and postdoc organisation is empowering because it trains members in organisational, leadership and fund-seeking skills, and it creates an atmosphere that encourages interactions between 'junior' neuroscientists and renowned speakers. At the Cortex Club, over the years this has distilled into a healthy atmosphere where students and faculty feel equally encouraged to participate. This has spurred collaborations and generated research ideas, but most importantly, inspired and excited our audiences.

My experience with Cortex Club and Neureka has been overwhelmingly positive. The support from university departments, commercial sponsors and the BNA allows these clubs to operate autonomously. Under these conditions, their impact on the wider scientific community and the public can be powerful and transformative.

'BRIGHT BRAINS' INTERVIEW WITH...

Gunes Unal
Postdoctoral researcher,
University of Oxford

Tell us a little bit about yourself.
My name is Gunes Unal. I have been working in the Somogyi Group at the MRC Brain Network Dynamics Unit under the Department of Pharmacology at Oxford since October 2013. Before moving to the UK, I completed a PhD in neuroscience at Rutgers University-Newark (USA), where I have been studying plasticity in cerebral networks, focusing on the perirhinal cortex.

What is your current research about and what has been the highlight so far?
I focus on how hippocampal and cortical theta rhythms are implemented via septal/diagonal band GABAergic input. My colleagues and I have recently published an article analysing the target area and cell type selectivity of septal GABAergic projections. We revealed that septal GABAergic pathway selectively innervates inhibitory interneurons of the mouse hippocampus and extra-hippocampal cortex (1). I am currently building on this finding and investigating how the firing patterns of single identified medial septal cells relate to their postsynaptic cortical target neurons.

What are the practical applications of your research?
My research falls under what we call 'basic science'. This does not mean that what I do has less practical value. Imagine a world where we would have actually resolved many mysteries of the human brain at a level where we could attempt to accurately reproduce certain key aspects of it. This would give rise to numerous practical applications, either good or bad. I am afraid we are quite far from this and my research makes a very small contribution to this ultimate, perhaps impossible, goal.

Who has inspired you during your research journey?
I would say Jules Verne books I have read as a child started it all. Then I became interested in the history of science and started reading about famous scientists. Memoirs and biographies of scientific heroes affected me a lot. But the practical inspiration, that is the motivation to turn my passion for science into a profession, came later when I was an undergraduate at Bogazici University, Istanbul. Resit Canbeyli opened the doors of his Psychobiology Laboratory to me and constituted a living example of what I have read many times as a child.

What are you looking forward to doing in future? What are your plans?
Science. I always feel extremely lucky when I think that I am actually receiving a salary for what I am doing. Being able to continue doing science in an open-minded and collaborative environment is all I can wish for.

1. **Unal G**, ***et al*** (2015). Synaptic Targets of Medial Septal Projections in the Hippocampus and Extrahippocampal Cortices of the Mouse. *J Neurosci*. 35(48):15812-15826.

Tom Hall
MSc student in Blood Science,
Keele University

The 'method of loci'

The infamous Hannibal 'the cannibal' Lecter, in every incarnation, is an utter genius, capable of memorising and recalling information in exquisite sensory detail (though his uses of this knowledge are questionable), but how does he do it? Hannibal makes use of the method of loci (locations), or 'mind palace' (1).

The mind palace is an ancient mnemonic system used to increase one's ability to commit information to long-term memory. This is achieved by forming over-embellished, ludicrous and sometimes obscene images of target information, such as a number, word or diagram. The image is subsequently attached to the visual memory of a physical locus, usually a structure, such as a wardrobe in your room. To recall this, you imagine walking through your 'palace', 'visualising' the information (2). Your palace does not need to be a real structure either, as artificial palaces, or hybrid palaces, such as those used by Hannibal, seem to produce similar results (3).

Of course, Hannibal is not bound by the same limits as you or I; so does this method really have any merit? The answer is: yes, it does! In fact, the method is so efficient that it is the most popular technique amongst 'memory athletes' – some of the best memorisers in the world. Though the mechanisms behind the palace are poorly understood, studies show that using a palace activates areas involved in spatial awareness, memory encoding and recall, such as the parietal cortex, retrosplenial cortex and hippocampus (4).

You might ask how could this benefit you? After all, you probably are not interested in becoming a memory athlete. However, a palace has a plethora of functional uses, which can vastly improve your recall of almost any information. You could learn to memorise names and birthdays and, as you become more efficient, more complex tasks, such as memorising foreign languages, speeches or perhaps your course subjects. The possibilities are endless, so give it a go.

1. **Harris T** (1988) Hannibal Lecter Novels (William Heinemann Ltd, New Hampshire).
2. **Yates FA** (1966) The art of memory (University of Chicago Press, Chicago).
3. **Legge ELG**, ***et al.*** (2012) Building a memory palace in minutes: Equivalent memory performance using virtual versus conventional environments with the Method of Loci. *Acta Psychol*. 141(3): 380–390.
4. **Maguire EA**, ***et al***. (2002) Routes to remembering: The brains behind superior memory. *Nat Neurosci*. 6(1): 90–95.

Joshua Au-Yeung
Final-year medical student,
Newcastle University

A trip to Kolkata: Research heading to the East (part 1 of 3)

We stand in the midst of a revolution, the globalisation of urbanisation - one of the most pivotal social changes of the century (1). Cities and their populations are growing at an exponential rate and services are struggling to keep up, resulting in a host of problems, including overcrowding and struggles to meet basic needs of food, water, shelter, education and health. Eighteen out of the twenty-two most populated cities are now in developing countries and these cities will be impacted the most (1).

Kolkata, the medical, commercial and cultural hub of east India, is a city that encapsulates the challenges of urbanisation and inequality. Boasting a population of 15 million (2), roughly four times the area of London and five times as dense, Kolkata is a city that is packed to its brim.

A market in Kolkata.

Just 90 registered neurologists in Kolkata cater for the whole of east India and surrounding regions. It is not unusual for a neurologist to work seven days a week, averaging 150–200 patients a day (3). This means that all their time is dedicated to clinical duty and none is left for quality scientific research.

Indeed, research papers published in India have little to no impact and 70% of papers are never cited. Research funding has stifled at a meagre 0.9% GDP for more than 10 years (4, 5). However, doing research in India offers benefits that should not be overlooked: the large number of patients, rare untreated diseases, and the pathophysiological impact of poverty and malnutrition. As researchers abroad realise this, both funding and international collaborative projects are increasing (6). Expect to see a surge in joint research ventures from the western world, perhaps one that will match and benefit the growth of urban India.

1. **Gupta K**, ***et al***. (2006) Health and Living Conditions in Eight Indian Cities. Ministry of Health and Family Welfare document.
2. **Office of the Registrar General & Census Commissioner, India** (2011) Census of India: West Bengal.
3. **Hrishikesh K** (2016) Institute of Neuroscience- Kolkata. Interview conducted in January 21st, 2016.
4. **Bala A & Gupta BM** (2010) Mapping of Indian neuroscience research: a scientometric analysis of research output during 1999-2008. *Neurol India*. 58(1):35-41.
5. **Shahabuddin SM** (2013) Mapping neuroscience research in India – a bibliometric approach. *Current Science*. 104(12):1619-1626.
6. **Nature Editorial.** (2015) A nation with ambition. *Nature* 521(7551):125.

VARIETAS NUMQUID SCIEBAS...?

Jayanthiny Kangatharan
Lecturer,
University of Winchester

...what makes us human?

Although we are genetically and biochemically similar to many animal species, it is our executive functions in our brain that make us human. They allow us to spontaneously find alternative solutions to problems and advance culture through the retention and transmission of knowledge. However, what exactly are executive functions and how can we improve them?

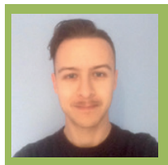
Executive functions such as planning and problem-solving consist of the core components inhibition, working memory and cognitive flexibility (1). For example, when you are being bombarded with information during shopping or when listening to a friend in a loud environment, executive functions will help you choose the products that you really need, and to selectively attend to your friend's speech whilst screening out auditory distractions (inhibitory control of attention). Moreover, they will allow you to keep information in mind and manipulate it, helping you make sense of it (working memory). Executive functions also can also assist you in thinking 'outside the box' (cognitive flexibility).

Thus, executive functions are essential as they predict success in any area of your life such as mental and physical health (2, 3). If you are stressed, sleep deprived, or physically unfit, this will have detrimental neuroanatomical and physiological effects on the prefrontal cortex, and behaviourally manifest in poorer executive functions such as problem-solving skills. So what can you do to generally improve your executive functions? Engaging in activities that require exerting self-control, being selectively attentive, and adapting quickly and flexibly to changing circumstances have been found to be beneficial (1). However, to see any gains, the demands on executive functions need to be regularly increased or improvement stops. Practice gives rise to expertise, hence repeated practice is crucial.

Nonetheless, once you gained expertise over an activity, the lateral prefrontal cortex that you initially recruited to learn something will be used the least (4). Consequently, once you are experienced you will be using very little top-down control. At this point applying executive functions is not always of advantage since it can hinder one's ideal performance.

1. **Diamond A** (2013) Executive functions. *Annu Rev in Psychol.* 64(1):135-168.
2. **Penadés R**, ***et al***. (2007) Impaired response inhibition in obsessive-compulsive disorder. *Eur Psychiatry*. 22(6):404-410.
3 . **Crescioni AW**, ***et al***. (2011) High trait self-control predicts positive health behaviours and success in weight loss. *J Health Psychol.* 16(5):750-759.
4. **Landau SM**, ***et al***. (2007) Regional specificity and practice: dynamic changes in object and spatial working memory. *Brain Res.* 1180(14):78-89.

VARIETAS QUID NOVI?



André Marques-Smith
Postdoctoral researcher,
King's College London

Casting light on brain circuits

Methods for precise neuronal stimulation are crucial for understanding how brain activity relates to behaviour. Traditionally, stimulation has relied on electrodes, but brain structures contain heterogeneous populations of neurons, and electrodes activate any neuron in their vicinity, hindering efforts to relate behavioural responses to circuits or cell types. Optogenetics introduced the use of light to stimulate neurons, taking advantage of channelrhodopsin. When exposed to blue light, the channelrhodopsin protein opens a pore, allowing ions to enter neurons and induce spiking. Channelrhodopsin expression can be restricted to particular neurons using genetic engineering, enabling cell-type-targeted control of spiking.

Patch-clamp recordings have high definition, but can only be used to target 1–8 neurons simultaneously. However, the mammalian brain has billions of neurons working to represent sensory information and execute behaviour. It would be advantageous to see the forest not just the trees, and track the activity of hundreds of individual neurons simultaneously. Spiking is accompanied by increases in intracellular calcium and can therefore be reported accurately by genetically encoded calcium indicators – proteins that increase brightness when calcium concentration rises. Microscopes equipped with photon detectors are then used to detect changes in brightness, which can be processed into images of neural activity, where active neurons appear brighter than silent ones. This technique (calcium imaging), allows visualisation of activity in hundreds of neurons simultaneously.

A team at UCL has succeeded in combining optogenetics and calcium imaging (1). Using spatial light modulation, the authors split a laser beam into several 'beamlets', concurrently stimulating tens of channelrhodopsin-expressing neurons. The effect of stimulating these neurons was monitored in hundreds of others using calcium imaging. Both techniques took advantage of two-photon microscopy, ensuring accuracy in three dimensions. This ground-breaking development allows scientists to reveal neurons active during particular behaviours and then evoke this behaviour by mimicking the same activity pattern using optogenetics. This could greatly advance understanding of the neural correlates of action, perception and cognition.

1. **Packer AM**, ***et al***. (2015). Simultaneous all-optical manipulation and recording of neural circuit activity with cellular resolution in vivo. *Nat Meth.* 12(2):140–6.

VARIETAS THE BNA CROSSWORD

How well do you know your brain?

Test your knowledge by completing the first BNA crossword on the theme of neuroanatomy. Answers will be revealed in the next edition.

Enter this edition's competition by sending your answers to jayanthinykangatharan@gmail.com.

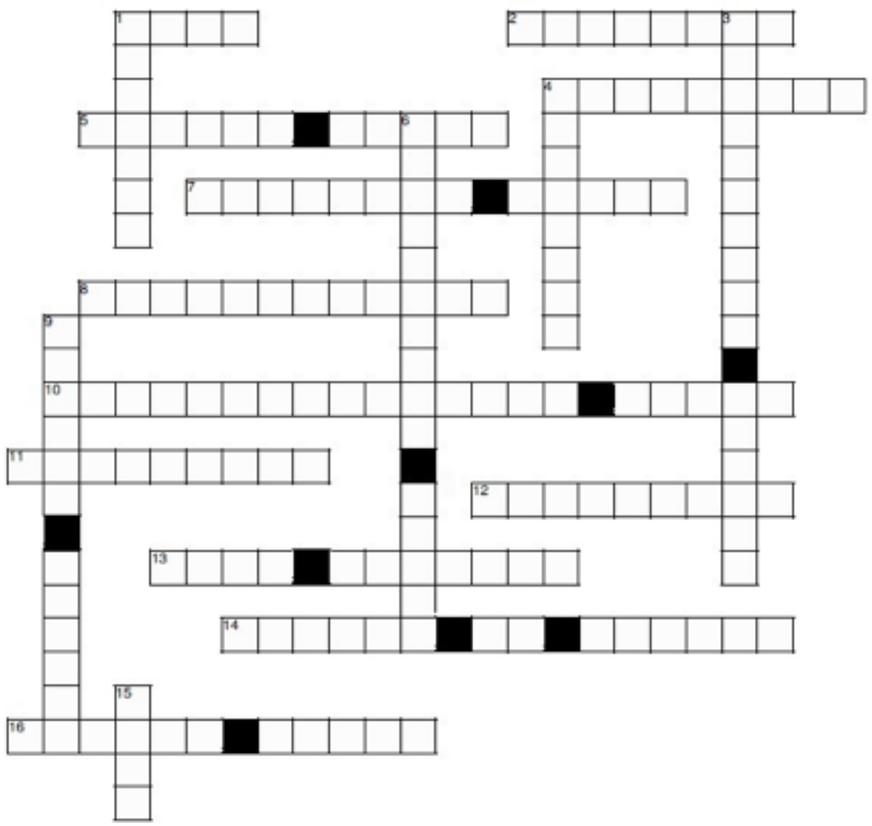
Entries received before the 1 May 2016 will be entered into a prize draw to win a unique contribution towards the 'Bright Brains' summer edition.

VERTICAL

1. External portion of the lentiform nucleus (7).
3. A lens-shaped mass formed by the globus pallidus and the putamen (8,7).
4. Portal to the cerebral cortex (8).
6. Largest of the cranial nerves that includes both sensory and motor components (Latin: three twins) (10,5).
9. Nuclei that are the anterior linchpin of the limbic system (6,6).
15. Portion of the internal capsule between the anterior and posterior limbs that conveys corticobulbar fibres (Latin: knee) (4).

HORIZONTAL

1. Part of a relay between the cerebellum and the cerebellar hemispheres (Latin: bridge) (4).
2. Compact mass of nuclei buried close to the tip of the temporal lobe (Greek: almond) (8).
4. Part of the midbrain that leads from the substantia nigra to the cerebral aqueduct (Latin: covering) (9).
5. The area of greatest visual acuity (Latin: yellow spot) (6,5).
7. Gap that separates pre-and postsynaptic structures (7,5).
8. Base of the diencephalon (12).
10. Gyrus that forms the transition between the six-layered neocortex and the three-layered archicortex (15,5).
11. Important link among globus pallidus, septal nuclei, preoptic nuclei, raphe and interpeduncular nuclei (9).
12. Three white matter bundles linking the brain stem and cerebellum (9).
13. Superior portion of the midbrain with the corticospinal tract (4,7).
14. Organisation of blood vessels at the brain base (6,2,6).
16. Small neuroendocrine gland that is an outgrowth of the roof of the diencephalon (6, 5).



Let's (study) dance

Dance is a proving an unusual but profitable way to gain insight into brain function.

Emily Cross grew up with a love of dance and performance, and has danced professionally. Now, dance is a core theme of her research.

At university in the USA, she majored in dance, theatre and psychology. "Those things occurred in parallel in my life. I went to New Zealand to do a master's in cognitive psychology. I was dancing professionally there too – but that was separate from the work I was doing on gesture and language."

Her interests became entwined while she was studying for her PhD at Dartmouth College back in the USA, and also dancing with a contemporary dance company. "I happened to be speaking to my PhD supervisor about learning particularly complex choreography and he suggested I try to study the learning process. I said, 'no way, we study finger movements, tiny constrained movements that are easy to manipulate and to record. How am I possibly going to do this?' He said, 'figure it out'!"

Now at Bangor University, she stresses that fundamental questions about human brain function drive her research: "Our studies are not asking questions about dance per se. It's just that dance turns out to be a really good model for looking at complex action learning, and what's going on when you're developing expertise in the motor or visual domains."

Most research on action learning, she suggests, focuses on goal-directed actions – like reaching for food or using a tool. Dance is different, she suggests: "In dance, one could say that the goal of the movement is the movement itself. It's almost movement for movement's sake."

Much of her research focuses on how the brain responds when we observe others making movements, which activates sensorimotor cortical regions known collectively as the action observation network (AON). In particular, she is interested in how responses within the AON change with different kinds of experience – visual, motor or affective.

Although she has worked with expert dancers, mostly she studies individuals without a background in dance. Through an Xbox-based set up, participants can rehearse dance moves; motion capture allows their abilities to be quantified, and 'before and after' brain scanning can reveal how brain activity is modified by experience.

For example, activity in the AON is enhanced by familiarity with observed movements. Moreover, the experience of either listening to dance-related music, watching dance movements and practising dance actions all additively influence AON activation.

Dance has a strong aesthetic component, so Dr Cross has also explored how experience affects subjective perceptions. "It's a funny relationship," she suggests. In general, familiarity increases enjoyment. "But we've also found that people really like watching stuff that's not just unfamiliar but really crazy and not something they could ever imagine doing themselves." However, her team has also found that physically learning intricate moves leads to greater enjoyment while observing them – a finding dance companies might be tempted to exploit.

Emily Cross, taking part in a 'dancers among us' photo project.

Meet the robot

Recently, her work has expanded in a novel but related direction – how social experience shapes perception, as revealed by people's responses to humanoid robots. Humans are tuned to recognise and respond to other humans, and respond differently to non-human agents – a challenge for those designing robots to perform social roles.

Product designers typically aim to make robots as human-like as possible, but Dr Cross's research has highlighted a curious feature of our interactions with artificial agents. By manipulating participants' expectations about whether computer avatars were derived from people or computers, she discovered that prior knowledge influenced how human-like the avatars were thought to be. "It had a huge impact," she says. Whether participants thought an avatar looked like a human or a robot depended not just on its physical appearance but also by participants' existing beliefs.

Consistent with these findings, 'social' areas of the brain were engaged during interactions with avatars that looked like robots – but only when participants believed these avatars had human origins. With collaborators in Japan, Dr Cross is beginning a major programme of work funded by an ERC Starting Grant to examine how people of different ages, and from different cultures, interact with robots designed to perform social roles.

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A body of evidence

Two contrasting areas of research – on patients who refuse to accept they are paralysed and on sensual touch – are shedding light on how we build mental representations of our physical forms.


Steve Evans/Wikimedia Commons
Touch may help us to build a mental representation of our physical form.

During her PhD with Martin Conway in Durham, **Katerina Fotopoulou** found herself working with patients with frontal lobe damage who experienced a range of difficulties, from memory loss to delusions. One group in particular captured her attention – those with right hemisphere damage and left-side paralysis who were unaware of their condition (anosognosia). "I was very fascinated by that. That's what brought me to anosognosia."

Now at UCL, Dr Fotopoulou has worked with anosognosia patients (and those with related problems) ever since. Her work spans seemingly disparate topics, including pain and affective touch but, she argues, there is a common theme running through it: "Increasingly, everything I do is around how the brain combines all the sensory information it gets from the periphery into a more coherent, abstract, organised model of the body."

Body models

How we know where our body ends and the outside world begins has fascinated philosophers and scientists for centuries. Dr Fotopoulou has a particular take on this fundamental question: "Instead of higher order stuff, inspired by anosognosia I'm thinking 'well, what is it that influences our cognition from bottom-up ways, from the body to the mind as it were'."

Interoception is naturally central to this thinking. "But it's not only interoception – it's also what we see, what we hear, what we touch, all the signals that say to the brain 'here's what's happening to you, good or bad'."

Anosognosia is a curious condition. Patients may refuse to accept they have a problem even when told by a doctor. They may believe they can walk, and do not understand why they fall over when they try to stand. Hence, there appears to be a mismatch between patients' bodies and their perceptions of their bodies.

Dr Fotopoulou has helped to develop therapies to improve patients' awareness. Showing patients their problems from an external perspective, for example through use of video, has been particularly effective.

In addition, in a range of studies, she has attempted to shed more light on the neurobiology of anosognosia and the nature of the cognitive deficits associated with it. She has developed a theory, based on predictive coding, that explains many of the curious features of the condition. In essence, she proposes that the brain creates an internal representation of the body that is in effect a prediction or inference based on past experience and is constantly updated with information from our internal (and external) sensory systems. In anosognosia, she suggests, there is a general breakdown in these updating mechanisms, leaving patients with out-of-date representations of their bodies.

Pain and touch

A further theme of her research has been pain. There are multiple aspects to pain, she suggests. At one level it is a sensory phenomenon, but it is also an intense bodily sensation with a strong emotional component and sensitivity to social interactions.

Lately, her attention has shifted to the recently discovered 'C-tactile' neural system that specifically responds to sensual or affective touch, such as slow stroking. Again, at one level, this system is a sensory detection mechanism but it also triggers a strong emotional reaction and has an important social component: "That sounds a lot like pain," she says. But, unlike pain, it provokes positive emotions.

Her group recently showed that the C-tactile system is responsible for a curious illusion: when people slowly stroke the skin of another, it feels softer than their own skin – a phenomenon she has dubbed the 'social softness illusion'. This may be a mechanism that promotes social physical contact.

Dr Fotopoulou believes that the sense of touch has been neglected of late: "As a society we've forgotten a little bit about this aspect of the self because our culture is increasingly visual." Indeed, she suggests, the social softness illusion may illustrate the importance of touch not just to social bonding but also to the development of internal models of our body. These models rely on the integration of internal signals, but humans are such intensely social animals they may also be shaped by physical interactions with others.

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Giles Hardingham

Radical solutions

Neurons are curiously ill-prepared to manage oxidative stress on their own – but targeting their support cells may be a way to boost their antioxidant defences.

Reactive oxygen species and other free radicals generated by cellular metabolism are generally seen as A Bad Thing, and cells have evolved multiple mechanisms to limit the harm they cause. It is odd, then, that neurons – which are metabolically highly active and also extremely long-living – seem to have such poor antioxidant defences. In Edinburgh, **Giles Hardingham** has come up with a possible explanation – as well as a potential way to enhance their antioxidant defences and protect against neurodegenerative and neurodevelopmental disorders.

"One of the overarching interests we have in the lab is the capacity of the brain's homeostasis," says Professor Hardingham, "in other words the ability of the brain's neurons to survive and function for many decades – for a post-mitotic cell to do that is remarkable. It points to the capacity of a neuron and surrounding cells to adapt to potentially challenging conditions and to mediate adaptive responses to tune their requirements, be they metabolic or antioxidant, to their needs at that time."

Cellular metabolism inevitably creates reactive oxygen species with the potential to inflict damage on cell structures. Cells have evolved a host of antioxidant systems to protect themselves, including molecules such as glutathione that help to neutralise potentially harmful reactive oxygen species.

But, Professor Hardingham points out, these antioxidant defences have to be deployed with caution. "People always talk about free radicals and reactive oxygen species in a harmful sense, but redox signalling is a very important part of normal physiology. If it wasn't, cells would just cram themselves full of glutathione or other antioxidants to keep redox potential on the reducing side and avoid any problems with oxidative stress. The reality is they don't."

His group has been exploring how neurons manage this redox balancing act: "One of the things we're interested in is the capacity of neurons, astrocytes and the brain in general to monitor and regulate their own antioxidant defences."

In 2008, his group identified a neat mechanism by which cellular levels on antioxidants are tailored to the needs of the cell. Signalling through the NMDA receptor was found to ramp up production of glutathione in a neuron. "This is an example of homeostasis," says Professor Hardingham. "A neuron that is electrically active is metabolically active and will generate more reactive oxygen species than a less active neuron. By making these antioxidant genes responsive to neuronal activity, the cell effectively has a feedback regulatory mechanism that enables the antioxidant defences to be tuned to the activity status of the neuron."

It is also known that neurons receive a helping hand from nearby astrocytes. In these cells, a key role is played by a signalling pathway that detects oxidative stress and activates the transcription factor, Nrf2, which switches on a suite of genes that boost the cell's antioxidant defences.

Curiously, neurons seem to rely on a supply of antioxidants from astrocytes: "It's been known for a while that neuron's own antioxidant defences are not terribly strong," says Professor Hardingham. One reason, it transpired, is because the Nrf2 gene is repressed in neurons, by epigenetic mechanisms.

It might seem odd that a neuron would deliberately limit its antioxidant responses. The reason it does, Professor Hardingham discovered, was because a neuron's redox balance is critical for the development and differentiation of neurons, particularly early in development.

Linking antioxidant production to NMDA receptor signalling could be one way of accommodating this need while also providing additional defences during times of need: "One of the things we speculate is that although neurons don't have the Nrf2 pathway as an adaptive regulator of antioxidant genes, to a certain extent neuronal activity plays a similar role, in that it can turn up or down antioxidant genes in response to demand."

Oxidative stress and schizophrenia

These insights could have important implications for neurodegenerative and neurodevelopmental disorders, particularly schizophrenia. It is known that oxidative stress affects the development of a particular class of interneurons (parvalbumin-positive interneurons, PVIs), abnormal function of which can disrupt the brain's inhibitory–excitatory balance and ultimately contribute to the symptoms of schizophrenia. It is also known that abnormally low levels of signalling through the NMDA receptor can also affect PVIs. But, points out Professor Hardingham, NMDA receptor hypofunction also renders cells more vulnerable to oxidative stress: "The two things may well be mechanistically linked."

Furthermore, oxidative stress also inhibits NMDA receptor activation. "So you can get this vicious circle, whereby oxidative stress causes NMDA receptor hypofunction, and NMDA receptor hypofunction causes oxidative stress. If this happens within a critical window in development, this could in theory lead to aberrant maturation of this class of interneurons."

Oxidative stress has long been thought to be an important contributor to neurodegenerative and neurodevelopmental disorders. Yet antioxidant therapies have had limited success – hardly surprising, suggests Professor Hardingham: "It's becoming clear that a single antioxidant molecule like vitamin C or N-acetylcysteine, even if you assume it can get into the brain at biologically significant levels, can't hope to mimic the extremely complex antioxidant systems that exist in all cells. The brain and other tissues express hundreds of genes devoted to redox regulation that have highly specialised functions."

On the other hand, targeting the Nrf2 pathway could boost the whole panoply of host defences. "In other words, it's helping the brain to help itself," says Professor Hardingham. Agents already exist that target the Nrf2 pathway (NFE2L2 pathway in humans), including dimethyl fumarate (Tecfidera), recently licensed for the treatment of multiple sclerosis. (Tecfidera was developed by Biogen; Professor Hardingham's is one of five Edinburgh groups collaborating with Biogen but he receives no personal remuneration from the company.)

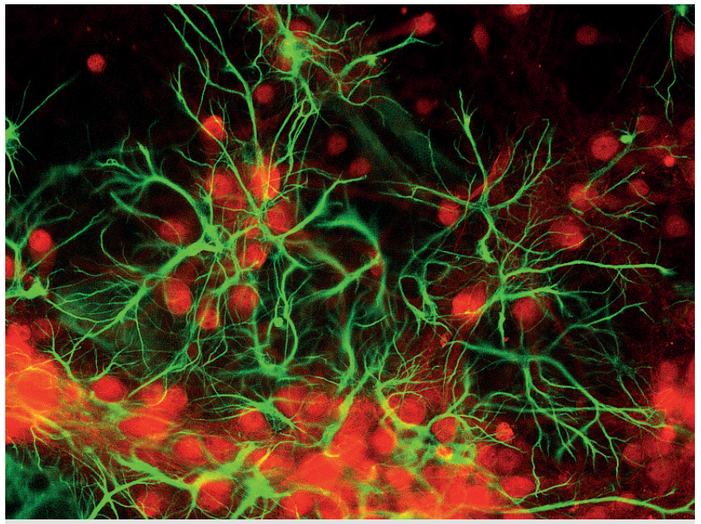
Stuffing ourselves full of foods rich in antioxidants is thus unlikely to do much for our risk of developing a neurodegenerative or neurodevelopmental disorder. But a better understanding of the brain's antioxidant defences could lead to more rationally designed therapies.

With the Nrf2 pathway held in tight check in neurons, attention is likely to focus on non-neuronal cells – particularly the astrocytes that deliver antioxidant support to neurons (and the surrounding extracellular matrix). Professor Hardingham is keen to discover more about interactions between these cell types, and how they impact on antioxidant defences.

One key question is how neuronal synaptic activity affects astrocytes. "Synaptic activity controls neuronal gene expression, but we currently know little about whether synaptic activity changes gene activity in other cell types. Can an active neuron signal to nearby astrocytes to control gene expression? The answer to that is yes it can."

His preliminary findings suggest that neuronal activity triggers widespread changes in gene expression in non-neuronal cells. "This in turn can impact on the ability of non-neuronal cells to support the neuron." Notably, these responses also appear to be disrupted in models of neurodegenerative disease.

Rather than just neurons, then, he is interested in how collectives of cells – neuronal and non-neuronal – respond to the dynamic challenges posed by oxidative stress. "Understanding what the basics of that are, and how it goes wrong in both neurodegenerative diseases and neurodevelopmental disorders, is something that we're very interested in moving forward."



A co-culture of neurons (red) and astrocytes (green).

"...IT'S HELPING THE BRAIN TO HELP ITSELF..."

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Joachim Gross

The rhythms of speech

Rhythmic qualities of speech show a striking concordance with brain oscillations.

Now based at the University of Glasgow, **Joachim Gross** initially studied physics in his native Germany. "Then I did something that was a bit unusual at the time, which was a joint project between the medical school and the department of physics on MRI imaging. It was a medical topic but analysed with physics methods. That was my first encounter with imaging." For his PhD, he switched from MRI to magnetoencephalography (MEG) and language processing – themes that have remained central to his research to this day.

"The thing that has continued through most of my career has been my interest in dynamic signals in the brain and in brain oscillations, in rhythmic activity in the brain," he explains. With its high temporal resolution (and reasonable spatial resolution), MEG is an ideal tool for examining such dynamic brain processes.

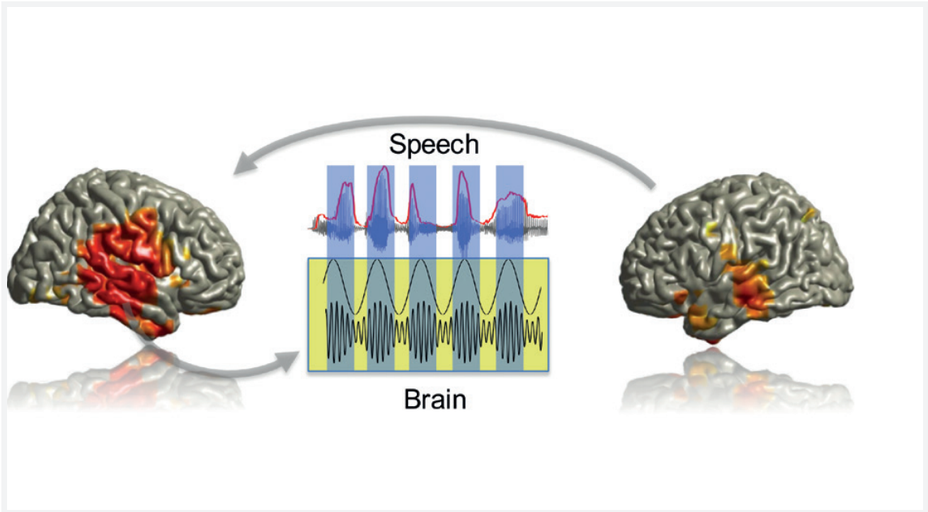
EEG and MEG can readily detect periodicity in brain activity at distinct frequencies (alpha rhythms at 8–13 Hz, delta rhythms at 1–4 Hz, beta rhythms at 13–30 Hz and gamma rhythms at 30–70 Hz). "These brain oscillations have been known about for a long time," points out Professor Gross. "They were recorded by Hans Berger in the 1920s, using crude EEG methods. Even with these simple methods, he could see brain oscillations, particularly in occipital areas."

Recording on his son, Berger noticed that the oscillations were sensitive to eye opening and closing. Since then they have been associated with many cognitive and other brain functions, but for many years it was not clear whether they were revealing anything meaningful. "You can see them in the raw signal without any sophisticated analysis, but people didn't really know what to make of it. Is it just an epiphenomenon, does it mean anything, does it have anything to do with the way the brain transforms information or processes information?"

Professor Gross suggests that recent research has finally begun to confirm that brain oscillations deserve serious attention. "The key developments have been made in the last 20 years, and particularly the last five years, where we have some evidence that these brain oscillations are causally related to information processing in the brain. That makes them much more interesting."

Oscillations and speech

One area in which brain oscillations appear to be playing a key role is in speech processing. "The speech signal that we produce during natural conversation is rhythmic to some extent, it has rhythmic components," Professor Gross points out. Syllable production recurs at a frequency of about 3–8 Hz, intonation or prosody at around 1 Hz and phonemes have faster components at about 40 Hz. These correspond remarkably well with the families of oscillations seen in the brain: "So you have different rhythmic or quasi-rhythmic components in the speech signal that match more or less what we see in the brain."



During conversation, rhythmic features in speech become entrained with brain oscillations.

"...YOU HAVE DIFFERENT RHYTHMIC OR QUASI-RHYTHMIC COMPONENTS IN THE SPEECH SIGNAL THAT MATCH MORE OR LESS WHAT WE SEE IN THE BRAIN."

Speech production relies on exquisitely fine control of the larynx and other structures: "Our motor system somehow imposes this rhythmic structure on speech, and this in turn is perceived by the listener. What we've found now in a couple of studies is that these rhythmic components in speech entrain the brain activity in the listener."

Indeed, says Professor Gross, when we are engaged in conversation, our brain oscillations become temporally aligned to match the vocal patterns generated by a speaker. "This is interesting because you can consider it like establishing a communication channel between two people. It's like talking on an intercom or radio – you have to match the frequency of the sender and the receiver otherwise you can't talk."

Nevertheless, there could be trivial explanations for this phenomenon: "Some people say, well, you have a rhythmic input so you get a rhythmic brain response. There's nothing really special going on. A lot of recent work has tried to address that point."

One line of evidence that something more interesting is going on is the fact that alignment is influenced by factors such as attention – as illustrated by the 'cocktail party' effect, which enables us to selectively attend to and comprehend one stream of speech among a background hullaballoo. Moreover, Professor Gross has used whole-brain MEG imaging to identify brain regions having a causal influence of oscillations in the auditory cortex. "We see a clear marker of top-down control. We found it mostly in two areas – left motor cortex and left inferior frontal gyrus. These two brain areas send rhythmic signals to auditory cortex to align brain activity to the speech input."

Speaking and listening

These results are interesting for a range of reasons. For a start, they add to the growing evidence that motor cortex – and hence speech production – and speech comprehension are more closely linked than had been thought. When motor cortex is silenced with transcranial magnetic stimulation, for example, listeners experience difficulties with speech comprehension.

Furthermore, suggests Professor Gross, the motor cortex representation may be evidence that, during conversations, the brain is generating a predictive model to help interpret speech. "It's like making use of my experience of speaking to understand what you are saying and the way you are saying it."

The periodicity of oscillations provides an excellent mechanism for anticipating the timing of future events, and prediction is certainly crucial to conversation. Turn-taking in conversations is generally so rapid that we rarely notice any gaps – responses are typically made within around 200 ms. This would be impossible to achieve if we were waiting for someone to finish talking, planned a reply, and then enacted the motor programme to speak our chosen words.

Recently, Professor Gross has also begun to look at how other forms of sensory input, particularly vision, influence speech perception. In conversation, we also respond to lip movements and other visual cues. "So we have an auditory channel of information and a visual channel and somehow they must be integrated, merged."

Furthermore, he is excited by the potential of information theory to address one of the shortcomings of traditional MEG analysis. While it may be revealing fundamental mechanisms of information transfer across the brain, it has so far not been possible to determine what actual information is being transferred. Information theory may provide a way to infer this information: "There might be a way to decode the content, and that would be exciting."

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Jamie Ward

Senses working overtime

Studies of synaesthesia may tell us much about how the brain processes sensory information.

In 2013, James Wannerton finished his life's work – a Tube map showing the tastes he experiences at each station. Blackfriars, for example, tastes of spam fritters and Farringdon warm semolina; less positively, Bethnal Green tastes of boiled cabbage and Mile End fingernails. Wannerton has synaesthesia, a condition in which sensory information gets scrambled in the brain.

The condition has been extensively studied by **Jamie Ward** at the University of Sussex. "The thing that drew me to synaesthesia is the idea of using unusual things in order to explain the way that the typical brain works," he explains. He began work on conditions such as amnesia and aphasia but found himself drawn to synaesthesia: "We take this unusual way of experiencing the world and try to figure out what that means for how the senses interconnect with each other, or how the brain generates conscious experience."

Extra sensory experience

Unlike amnesia and aphasia, synaesthesia is not a deficit in function. One question that Professor Ward is interested in is whether the 'extra' experience of synaesthesia interferes with other abilities, such as visual perception: "If when somebody's listening to music and they're seeing colours and shapes, does this affect the way their normal visual function works? And the answer seems to be no – if anything they appear to have more enhanced visual functioning."

Something similar may be happening with memory: "One of the things that's been documented anecdotally over the years is that synaesthetes have better memory. You might think this is because they can use their extra experiences strategically – and there is some evidence for this." So a violinist, for example, might use visual cues elicited by sounds to help them know when they have hit the right note. However, synaesthetes also typically perform well even on more general memory tests.

So what might be the basis of synaesthetes' special abilities? "We know that the brains of synaesthetes do differ," says Professor Ward. "Often it's more localised differences in the brain, so for instance synaesthetes who experience colours they tend to have more grey matter in certain visual regions of the brain involved in colour processing, and they tend to have greater organisation of their white matter, not globally but in particular parts of their brain."

The condition runs in families but inheritance patterns are complex and no genes specifically associated with synaesthesia have been identified. Notably, though, while synaesthetes are likely to have relatives with the condition, they don't necessarily have the same form: "It's not the case that you have some families who have synaesthesia for flavours and some who have synaesthesia for colours. What you have is a general disposition to synaesthesia."

It is therefore unclear what dictates which sensory systems are affected: "The best guess is it's a common set of genes and it's probably environmental factors that determine why somebody goes down one route and not another."

Synaesthesia generally arises developmentally – synaesthetes typically report first experiences in childhood. This suggests that synaesthesia may reflect incomplete pruning of interconnections between sensory pathways during development or abnormalities in the way that sensory cortex matures, in effect rendering it hypersensitive. It can also be acquired, for example after sight loss or stroke,


Giovanni Dall'Orto/WikiMedia Commons

Mirror-touch synaesthetes experience the sensation of touch when they see someone being touched.

possibly as a result of compensatory mechanisms in the brain: "If you're not getting rich enough signals in your visual cortex from your eyes, you try to amplify that signal using other pathways in the brain, which might include using information from the auditory cortex to switch on your visual cortex."

Professor Ward has also begun to examine what happens to abilities such as memory during ageing – specifically, whether the use of additional neural pathways might lead to a shallower rate of decline. As well as shedding light on ageing and memory generally, this kind of information would be directly relevant to a significant number of people: "It's not vanishingly rare – we think it affects a few per cent of the population. So if you put all the synaesthetes together, they would fill one of our major cities."

Touch

As well as visual anomalies, Professor Ward has also examined bodily experiences, touch and pain – so called mirror-touch synaesthesia: "That's when people see someone being touched they feel that on their own body. So if you see somebody being prodded on their cheek you would say 'oh yeah, I can feel a tactile sensation on my own cheek.'"

The condition is linked to heightened activity in the somatosensory cortex and again is associated with enhanced sensory acuity – mirror-touch synaesthetes are typically good at distinguishing closely spaced tactile stimuli. Structural imaging suggests that they have less grey matter in the temporo-parietal junction, a region implicated in the switch from 'self' to 'other' perspectives.

"...IF YOU'VE GOT A RED OBJECT WHAT SOUNDS DO USE TO REPRESENT IT?"

This system is of particular interest in social cognition because of the insight it may give to empathy. When we observe something happening to others, to an extent we also mirror it within ourselves.

But while we all put ourselves in others' shoes to some degree when we see them receiving painful stimuli, people with mirror-touch synaesthesia go a step further and actually physically experience the pain. This has potentially interesting consequences, suggests Professor Ward. It could strengthen feelings of empathy, as synaesthetes have a true sense of the pain others are enduring. But if they cannot avoid unpleasant sensations, they might want to distance themselves from their source.

Mirror-touch synaesthesia can also be acquired. Phantom limb pain is common after amputation, but around a third of patients also experience mirror-touch synaesthesia. Deprived of its usual inputs, the somatosensory cortex may respond by attempting to boost other signals it receives, including visual ones: "It's almost as if the cortex is trying to amplify its inputs," suggests Professor Ward.

He has also explored a related phenomenon, contagious itch. Witnessing someone scratching causes most people to experience its trigger, an itch. Functional imaging studies revealed that this experience is accompanied by activation in brain networks associated with 'genuine' itchiness, including the insula as well as somatosensory cortex.

Even more extreme are individuals who experience severe skin discomfort without any obvious dermatological cause. Recently, Professor Ward has been part of studies identifying activity in the brain of such individuals, even in the absence of a dermatological trigger: "Just because there isn't an obvious external trigger doesn't mean that the symptoms aren't real – it may just mean that the symptoms are generated by the brain circuits responsible for skin sensations."

Sensory augmentation

Inspired by synaesthesia, Professor Ward has also been examining whether technologies can be used to generate supplementary sensory experiences. One application would be devices that convert visual information into an aural soundscape, for people with visual impairment.

"One of the things that interests me is the idea that you can use knowledge from synaesthesia to answer questions like, if you've got a red object what sounds do use to represent it? Which sounds like a crazy question but actually there are certain rules that tell you what sounds go with red and so on."

Such devices might be of more general use: "We fool ourselves into thinking that we have a very rich and full representation in our brain of what the world looks like, but we don't." Auditory information to augment visual sensory information could provide additional support for those analysing complex visual scenes, such as machine operators dealing with complex instrumentation.

Professor Ward often receives requests for help from parents when they discover their child has the condition – one reason he is keen to get at the early-life roots of synaesthesia: "The developmental angle of synaesthesia is a really important one we need to grapple with. Partly as information for parents but partly because that's where synaesthesia comes from, it comes from the developing brain. If we're ever going to understand it, that's where we going to have to look."

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Alan Palmer, entrepreneur and BNA Non-Executive Director

Alan Palmer: Making neuroscience count

BNA Non-Executive Director Alan Palmer retains a lifelong fascination with neuroscience – and a desire to see the fruits of research benefit patients.

Alan Palmer has had remarkable success in launching a string of biotech firms, all in the neuroscience arena. Yet, despite an early fascination with the brain, he initially studied biochemistry at Warwick – "There were no degrees in neuroscience at the time – they just didn't exist."

After an MSc in neurochemistry at the Institute of Psychiatry, he began to look for a suitable PhD topic and supervisor: "What I was particularly keen on was to find somebody who did neuroscience but did it with a view to coming up with a product or an idea that would benefit people with brain disorders. That's really been the driver of my career – translational neuroscience."

He found the ideal man in David Bowen. "He was probably the first person in the UK to study Alzheimer's disease systematically in terms of neurochemistry," Professor Palmer suggests. His work identified a cholinergic deficit in Alzheimer's disease, which led to a number of new medicines to correct this deficit. Professor Palmer's project focused on monoamine neurons in Alzheimer's disease. He mostly used post-mortem human brain tissue, although a collaboration with colleagues in Manchester also provided access to biopsy samples: "We would pack up the lab in a transit van and drive up to Manchester and measure things like noradrenaline and serotonin uptake, along with acetylcholine synthesis. This information proved very valuable as it allowed us to draw conclusions about neuronal changes at a fairly early stage of the disease."

After postdoctoral work at the Institute of Neurology, Professor Palmer became a faculty member at the University of Pittsburgh, which had a good reputation in Alzheimer's disease research. While there, he and his colleagues branched out into traumatic brain injury, establishing what is now one of the USA's leading centres for head injury research. The new centre pioneered therapeutic hypothermia – cooling the body to protect the brain after injury – now widely used in the USA.

Return to the UK

Industry first beckoned when, looking to return to the UK, biotech pioneer Chris Evans (now Sir Christopher Evans) – who happened to be an old school friend – offered to help him establish a company. "I didn't know much about biotech at the time," Professor Palmer recalls, "so I thought I'd be better off joining a pharmaceutical company first."

He ended up joining Wyeth in 1994, working on CNS drug discovery. Within a year, however, Wyeth changed direction, ending its UK CNS work. Professor Palmer was one of 20 employees offered positions in the USA: "I decided to stay, and with Chris Evans and four people from Wyeth we formed the UK's first neuroscience start up company, Cerebrus."

Cerebrus went on to secure £27m in funding, growing rapidly to employ 100 or so people. In 1999, it merged with Vanguard Medica, forming Vernalis – a company listed on the London Stock Exchange.

As well as Cerebrus, Professor Palmer has helped to establish a host of other companies, including Cerexus with researchers from the Wolfson Institute for Biomedical Research at UCL and Pharmidex, a contract research company specialising in drug metabolism and pharmacokinetics, with particular expertise on the blood–brain barrier. In 2008, he co-founded MS Therapeutics, which is developing treatments for multiple sclerosis. He has also set up a consulting business, Cerebroscience, specialising in translational neuroscience.

Alongside this commercial work, which earned him the title of 2005 London Biotech Entrepreneur of the Year, he is also helping to develop the entrepreneurial skills of students at Bristol, where he is life science entrepreneur in residence. He is also a visiting professor at UCL and Reading, and sits on the board of One Nucleus, a not-for-profit membership organisation supporting life sciences and healthcare companies in the UK.

Does he think scientists can succeed in business? "Yes, I believe that science provides an excellent foundation for a life in business. In science you need to be able to look at data in minute detail but also be able to pull back and look at the bigger picture, integrating lots of diverse information. That's a very useful skills set to have in business."

While acknowledging that the retreat of big companies from neuroscience has been a setback, he suggests that there have been a number of positive changes as research charities have become more involved in drug discovery and more public money has flowed towards translational studies.

He remains enthusiastic about new opportunities, recently helping to establish a new company, Cerestim, associated with Imperial College, which is developing a therapy based on transcranial brain stimulation technology, initially for treatment-resistant depression.

His commercial experience has brought a more business-like rigour to the BNA. Adding yet more to his workload has brought its own rewards, however: "It's a lot of fun being involved with the BNA, I really enjoy it."

Q&A: Kathryn Mills

Kathryn Mills won the BNA's Postgraduate Award 2015.

Q: What did you discover in your research?

A/ My doctoral research at UCL used brain-imaging methods to investigate typical developmental trajectories between childhood and adulthood, as well as behavioural experiments to investigate how humans navigate the social environment in adolescence and adulthood.

This work demonstrated that adolescence is a period of substantial development in terms of both social navigation and brain structure. The empirical studies provided support for the theory that adolescence is possibly a sensitive period to social signals in the environment, as my findings provided evidence for the continued development of both cognitive skills and regions of the brain involved in social development between childhood and adulthood. For three of my thesis studies, I focused on the structural development of brain regions implicated in complex social cognition. Overall, this work highlighted the need to consider individual differences in brain development patterns when relating brain measures to cognition or behaviour. In order to understand these individual differences, I used cutting-edge statistical and analytic techniques needed for large, longitudinal brain-imaging datasets. Further, my behavioural research used multilevel modelling to understand how complex social cognitive processes develop between adolescence and adulthood.

Overall, my thesis work shed new light on, and challenged current theories of, brain development and its relationship to behaviour by employing novel and rigorous methods.

Q: What did you think when you heard you'd won the BNA award?

A/ My first thought was of my PhD supervisor Sarah-Jayne Blakemore. I would not have stood a chance at winning this award if I hadn't had the support and guidance of Sarah – not to mention the fact that I wouldn't have been in the running had she not thought to nominate me. Thus I found it fitting for her to collect the award in my absence. I feel incredibly lucky to have had Sarah as my PhD supervisor, and I think winning this award is simply a product of her mentorship.

Q: What are you doing now?

A/ I am currently a postdoctoral researcher in the Behavioral Neuroscience Department at Oregon Health and Science University, USA. My current project focuses on the role of genetics in brain development patterns, with a specific emphasis on how genes influence the patterns of structural and functional brain development in clinical groups such as individuals with attention deficit hyperactivity disorder (ADHD). After this project, I will move to the Psychology Department at the University of Oregon to work on a longitudinal project investigating the relationship between brain development, social cognition, puberty and mental health in female adolescents.

Q: What are your long-term plans?

A/ My long-term plan is to head a laboratory that collaborates with adolescents to let them steer the research. Adults conduct most research concerning adolescent development, but I'd like to work with adolescents to facilitate their ability to have an impact on research question formation and the interpretation of results.

Q: What do you enjoy doing outside science and medicine?

A/ Outside of science I enjoy spending time with my partner Joe and our daughter Celilo (who was born a few months after I defended my thesis). We love to travel, and have already taken Celilo to four different countries, as well as on many road trips to experience the beautiful landscapes of Oregon.

Making sense of neuromarketing

Joe Devlin and John Hogan are helping marketing and advertising professionals get to grips with the murky world of neuromarketing.

Among the ever-proliferating family of 'neuro-' subdisciplines, neuromarketing is growing in popularity. Any number of companies now offer neuromarketing services, and an international Neuromarketing Science and Business Association has been established. Inundated with requests for advice, Joe Devlin and his student John Hogan have developed a course at UCL designed to help marketing professionals navigate the potentially perilous waters of neuromarketing.

The key idea behind neuromarketing is that neuroscience technologies can provide privileged access to the subconscious, and hence a more 'unfiltered' view of consumer attitudes and behaviour. "A lot of companies are very enthusiastic about that," says Dr Devlin, "but they're also aware that there's a lot of snake oil out there."

Dr Devlin has found himself increasingly fielding enquiries from companies interested in either developing or using neuromarketing techniques – though they often have only a hazy idea of what is possible: "'We need to do something with the brain' is the usual expression they use."

There is a lot of confusion, he suggests, but also an appetite to learn: "What was striking to me, being new to marketing and advertising, was that there were a lot of really bright people who were very interested and more than capable of understanding what's available if they had anybody who could offer it. That seemed to be what was missing."

John Hogan (right) demonstrating TMS.

Many of the people contacting Dr Devlin are enthusiastic about neuromarketing: "Marketing people get excited by a lot of hype – and boy it's easy to hype this." But there is also a fair degree of scepticism. One company approached Professor Devlin when one of their competitors ran a neuromarketing campaign: "They said, 'First of all, we don't understand it, but we do think it's nonsense'."

During 2015, the UCL pair developed a one-day workshop, which runs through the basics of brain function and the technologies used to study it. Participants have a chance to see fMRI, EEG and transcranial magnetic stimulation (TMS) in action. More bespoke team workshops are also arranged.

One important message is the variety of tools available, and what they can and cannot show. "Neuromarketing companies typically offer a one-size-fits-all solution," points out Dr Devlin: "'I've got an EEG system, I'm going to use it.' One thing we say to people is that's not the way science works." He highlights the importance of choosing the right tool for the right question. "Those kinds of simple messages resonate. But at the moment they just don't know what the options are in terms of neuroscience, or why you would use one tool over another."

A key aim is to encourage a rigorous view of neuromarketing. It is not hard to find examples of dubious practice. Dr Devlin points to an advert made by Porsche, which likens driving one of their cars to piloting a fighter plane – with an EEG headset somehow providing information about dopamine release: "It's a great advert, very engaging, but the neuroscience is completely specious." It is also, he points out, a good example of neuroscience as marketing rather than neuromarketing per se.

Good examples are harder to find, although Dr Devlin highlights Read Montague's adaptation of the 'Pepsi challenge' – using fMRI to examine brain activity as participants tasted different colas. When they thought they were drinking Coke, distinctive regions of participants' prefrontal cortex were activated – suggesting there is a region of the brain sensitive to brand. Strikingly, the 'Coke bias' could be abolished by TMS targeting this region. "Companies are interested because they like to know that brand really matters," says Dr Devlin, although it is not immediately obvious how this insight could be exploited commercially.

Joe Devlin explains the mysteries of fMRI.

Course participants get to see a brain scanner in action.

Dr Devlin views neuromarketing through the lens of the 'Gartner hype cycle'. New technologies take off with a burst of interest, reaching 'the peak of inflated expectation'. "To a large extent that's where we are with neuromarketing," he suggests. This peak is usually followed by a crash as disenchantment sets in and then a gradual recovery to a 'plateau of productiveness'. "Our thinking is that by sharing our expertise we can get to this plateau quicker."

www.ucl.ac.uk/consumer-neuroscience/

A vision of vision

Matthew Sugrim's animation 'Do We See the Same Red?' won the Society for Neuroscience's 2015 video competition – even though he had only a few weeks' experience of animation software.

Matthew Sugrim receiving his award from the Society for Neuroscience.

After graduating from the Open University at the end of 2014, Matthew Sugrim concluded it was time for a new challenge: "I decided after years of studying that I wanted to find a way to communicate complicated 'sciencey' things. People around me were always asking me about what I was studying, but it was always quite difficult to get it across in a way that people found interesting."

The brain in particular seemed to capture people's attention, but persuading them to engage more deeply proved difficult: "No one I personally know will read an article about neuroscience. They're interested, everyone wants to know how the brain works, but no one really cares enough to spend time finding out."

Undaunted, he experimented with other ways to get the message across: "I dabbled with a few things like setting up websites and making computer programs and things while I was studying." Eventually, he settled on animation: "I'd never made an animation before but I thought video was the way to go."

Keen to experiment, he needed a subject. "My little cousin set the question," he recalls. "He was about 10 and he said, 'do we see the same colours?' I spent about a day with him and managed to explain it, and he went 'I kind of get it…' I thought, 'this isn't working'. So I made it for him."

There was only one small problem: he had never actually produced an animation. Having studied architecture, he had a reasonable grasp of graphics, "but I'd never made anything move before."

Realising that Adobe Creative Cloud was the standard animator's tool, he plundered the web for advice and taught himself how to use it. His girlfriend, an illustrator familiar with graphics-related competitions, suggested looking for a suitable video competition. "I literally typed in 'neurosciences video competition' and lo and behold there happened to be one in just a few weeks."

This concentrated his mind: "That set my deadline, my timetable for the project. I knuckled down, spending a lot of hours on the internet working out how all this software stuff works, and put together a video."

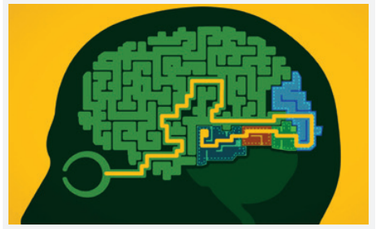
'Do We See the Same Red?' is an engaging and informative account of the neuroscience of colour vision. The Society for Neuroscience was sufficiently impressed to award it first place in its annual brain awareness video competition. How did he feel when he had heard he had won? "Absolutely elated. We cracked open a bottle of champagne that had been taking up space in the fridge."

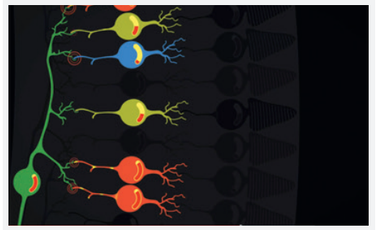
His victory enabled him to attend the Society for Neuroscience congress, the spectacular annual neuroscience jamboree. "I've never seen so many people in one hall listening to one speaker before," says Matthew. "It was amazing." It was also a chance to listen to talks and pick up possible ideas for new videos: "I fitted in as much in as I possibly could."

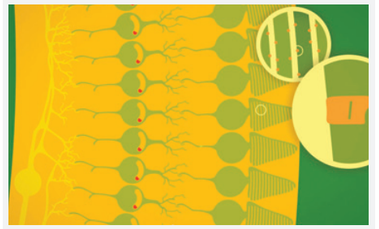
His second animation, on genetics and genetically modified organisms, was launched at the end of January 2016. It was inspired by his experience when living in Bristol of some activists' almost visceral loathing of genetic modification. He has also been considering themes for future neuroscience-related animations, such as gender differences and male and female brains.

He is also keen to enter the Society for Neuroscience competition again, although the organisers may need persuading: "They think it might be unfair if I'm eligible to win two years in a row. My personal take is that's ridiculous as I feel they should be getting the best videos they can. Hopefully, if I do produce good videos for them that will encourage other entrants to up their game a bit."

For the time being, he is developing his portfolio and working out whether he can use his new skills to establish a career in science communication. "If not, I may have to get a real job…"







Screenshots from Matthew's winning animation.

https://www.youtube.com/watch?v=v4AuBgKYPEA&feature=youtu.be

Q&A: Veselina Petrova

Veselina Petrova (Cambridge) won the BNA's Undergraduate Award 2015.

Q: What did you discover in your research?

A/ In Alzheimer's disease, the complex interaction between amyloid-β peptides and tau proteins is still largely unresolved. In Tara Spires-Jones's lab at Edinburgh, I characterised pathological changes – such as neuronal loss, astrogliosis and microgliosis – around amyloid-β plaques in a novel mouse model of Alzheimer's disease. This is the first animal model in which the amount of wild-type tau protein can be selectively controlled, which also offers an opportunity to examine the interaction between tau proteins and amyloid-β peptides *in vivo*.

My findings indicated that there is not a straightforward dose-dependent effect of tau on amyloid-β-mediated astrogliosis and focal neuronal loss. Nevertheless, I helped validate a novel experimental model as a suitable platform for future studies of amyloid-β–tau interactions.

Q: What did you think when you heard you'd won the BNA award?

A/ I felt extremely proud that I was winning the prize for the University of Edinburgh for a fourth year in a row. This said, I'd like to thank all staff and students at the University of Edinburgh for the incredible support and inspiration over the years. I'm especially grateful to Jane Haley, Tara Spires-Jones and Richard Ribchester. Moreover, I was also very happy that my effort and motivation throughout my undergraduate career were recognised by such a fantastic group of neuroscientists that is the BNA.

Q: What are you doing now?

A/ I am a PhD student in James Fawcett's laboratory in Cambridge. We are interested in improving the intrinsic capability of adult CNS neurons to regenerate after spinal cord injury. So far, we have identified integrins as key molecular players in the regenerative process. Integrins, however, are actively excluded from axons in transport vesicles as neurons mature, and we believe that this is one reason why adult CNS neurons have poor regenerative capabilities.

In my project, I am hoping to be able to design strategies to redirect these transport vesicles containing integrins and other essential regenerative molecules back to the tip of the regenerating axon, which would hopefully enhance regeneration.

Q: What are your long-term plans?

A/ My ultimate aim is to teach and inspire others. This is why I plan to establish my own research group and to be actively involved in teaching for an academic institution. Another passion of mine is reaching out to the public and presenting our research, and this is why I am determined to find more innovative ways to bridge the gap between neuroscientists and the public.

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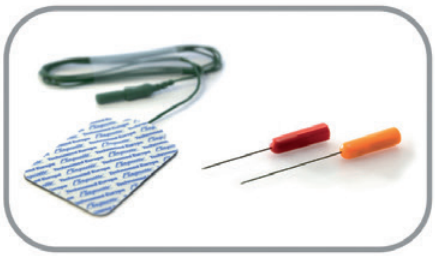

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