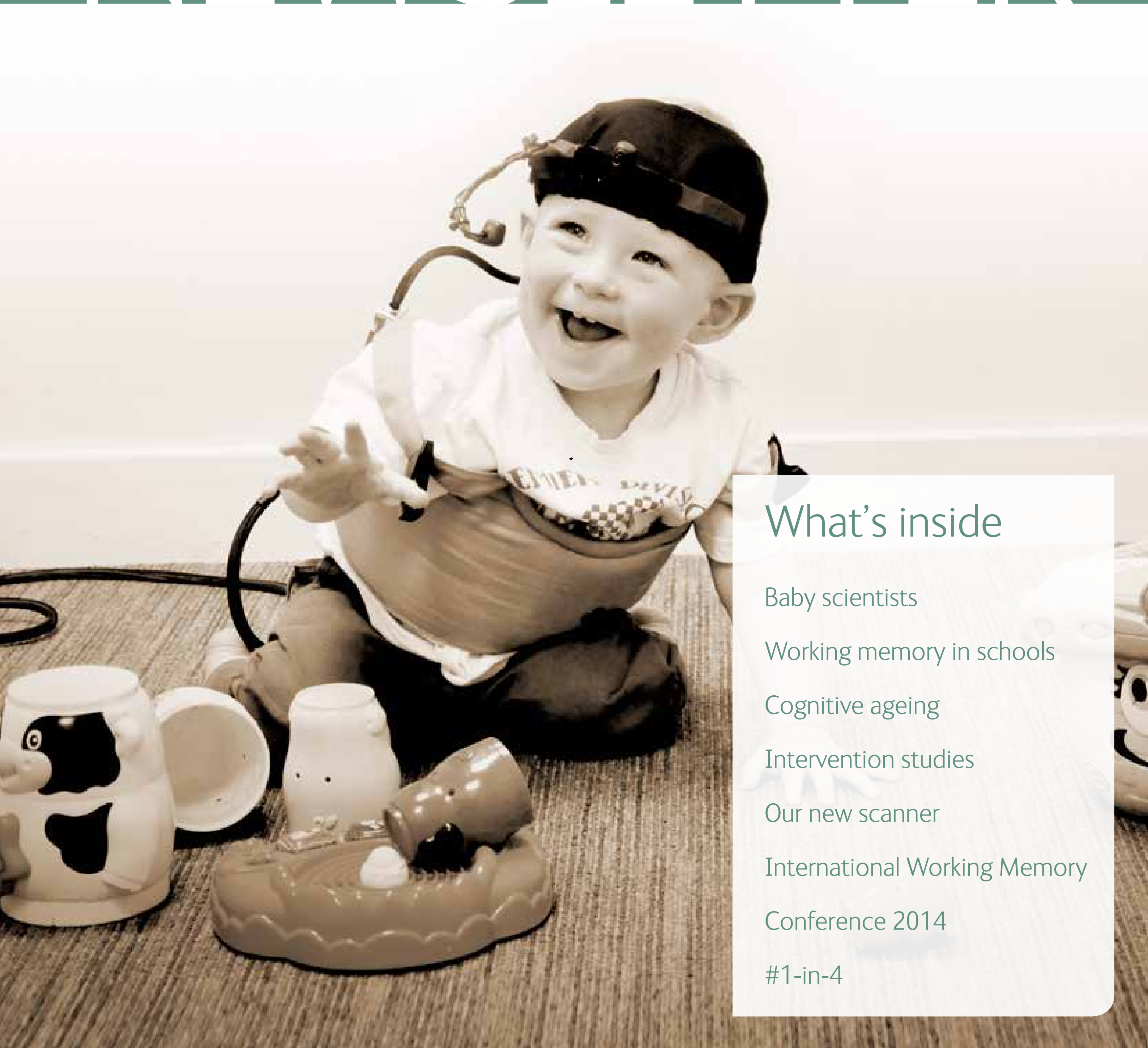
July 2015

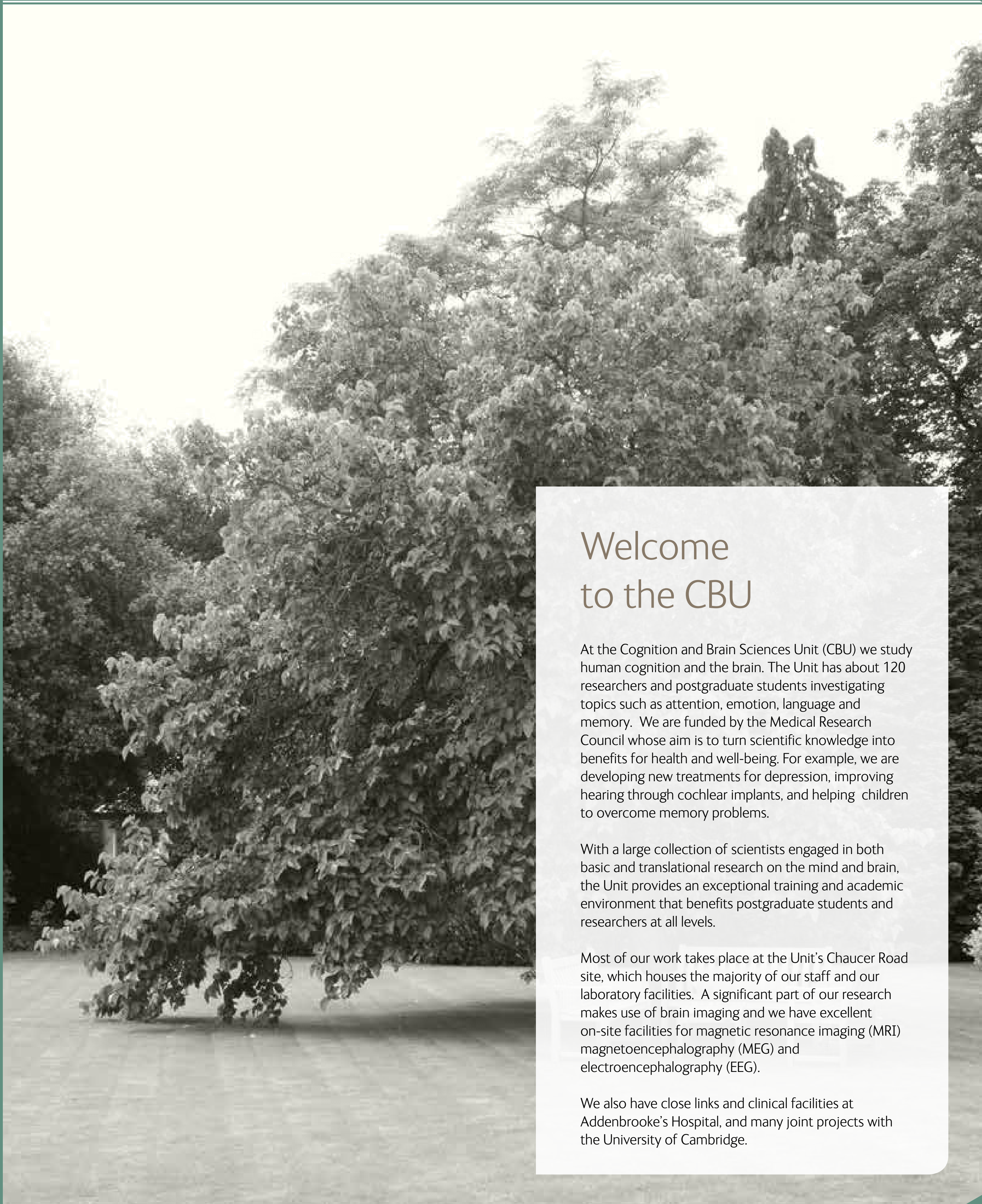
MRC Cognition and Brain Sciences Unit

MEDICAL RESEARCH COUNCIL COGNITION AND BRAIN SCIENCES UNIT

NEWSLETTER



What's inside



Welcome to the CBU

At the Cognition and Brain Sciences Unit (CBU) we study human cognition and the brain. The Unit has about 120 researchers and postgraduate students investigating topics such as attention, emotion, language and memory. We are funded by the Medical Research Council whose aim is to turn scientific knowledge into benefits for health and well-being. For example, we are developing new treatments for depression, improving hearing through cochlear implants, and helping children to overcome memory problems.

With a large collection of scientists engaged in both basic and translational research on the mind and brain, the Unit provides an exceptional training and academic environment that benefits postgraduate students and researchers at all levels.

Most of our work takes place at the Unit's Chaucer Road site, which houses the majority of our staff and our laboratory facilities. A significant part of our research makes use of brain imaging and we have excellent on-site facilities for magnetic resonance imaging (MRI) magnetoencephalography (MEG) and electroencephalography (EEG).

We also have close links and clinical facilities at Addenbrooke's Hospital, and many joint projects with the University of Cambridge.

Have you considered volunteering?

If you're reading this it could be because you've already been to the Unit and participated as a volunteer in one of our studies. If so, you've already done more than most people do to help our researchers advance their studies into many of the diseases and conditions that affect us all throughout our lives. At the CBU we would be unable to continue our work without your support - but we still need your help. We ask you to keep spreading the word. Statistics show that our biggest recruitment aid is you, i.e. word of mouth. So, keep telling your friends and family about your experiences of volunteering at the Unit and encourage them to join the Panel.

If you're new to the idea of volunteering for our research please read on...

Our volunteer panel, established over 30 years ago, is a unique resource within the neuroscience community in Cambridge. With several thousand volunteers of all age ranges it is an invaluable pool of volunteers for our researchers – but we always need new people to join. Many of our researchers need to test up to a 100 different people for a particular project without using the same person twice, which is why we need a constant supply of new volunteers.

So, if you've already been to the Unit and participated in a test – why not come again and do another one soon – and you don't even have to wait for us to contact you. You can sign up for studies directly on our online system, and may even be able to find two studies happening at the same time and come with a friend.

If you're reading about us for the first time, or have been thinking of volunteering but 'putting it off' – take action now! Most people find it a rewarding experience and enjoy learning a bit more about 'brain science'. Our researchers will always be happy to explain their study to you and will never expect you do anything you are not happy with.

If you are about to become a parent or currently have a child aged 0 to 24 months and you wish to volunteer your child to be part of our participant pool, then we would very much like to hear from you! Our studies ask a number of questions, such as:

- at what age do gender differences start to emerge between boys and girls?
- do hormone levels influence preferences for toys and certain types of motion?
- why do differences in babies' concentration abilities emerge, and is it possible to train babies to concentrate better?
- how do babies perceive actions, and is this different to how adults perceive actions?
- how do babies learn to search for hidden objects?

Some of the studies will involve you and your baby sitting and watching a computer screen that presents a series of animations and cartoon clips. Others will involve you and a researcher playing with your child. We will be making video recording of the games we play, and in some cases we will also record your child's heart rate and movement patterns. Others involve wearing a specially designed cap that tracks where your child looks as they crawl around.

Your child will be with you at all times during your visit. All of the studies we run are designed to be fun, engaging and interactive. The techniques we use are of course completely safe for you and your child, and everything will be explained to you before you agree to take part. You will be free to opt out of any part of the study, and if for any reason you feel uncomfortable, you will be free to withdraw your child at any time.

Sign up for studies now using the link below or scan the QR code at the top of the page using your smart phone and a free code reader app :

http://mrc-cbu.sona-systems.com or contact our Panel Manager on 01223 355294.

Volunteers are vital to our studies and without them we wouldn't have the same world leading research as we do now. Your help makes all the difference. We always need more volunteers so if you haven't yet, please sign up and let others know too.

News in brief

Cambridge Science Festival – Science evening at CBU

An entertaining and educational evening of demonstrations and lectures was held at the CBU in March. Our annual science open evening, this year titled "Exploring mind and brain" is given as part of the Cambridge Science Festival and featured lectures from three of our leading scientists highlighting our varied research, plus the chance to take part in some of our experiments exploring how the mind and brain work, with time to meet the scientists and students doing the research. Hands on activities were run for the first hour, followed by three short talks. The evening was a great success with some very positive feedback from our audience. "All of lectures were truly awesome" and "Detailed explanations of the experiments were very impressive". Joe Bathelt, who joined us last year as a junior researcher can be seen here giving one of those detailed explanations.

CBU gains Athena SWAN Bronze Award

We are delighted that the Equality Challenge Unit announced on April 23rd 2015 that the Cognition and Brain Sciences Unit had received a Bronze Athena SWAN award. The Athena SWAN Charter has been developed to encourage and recognise commitment to advancing the careers of women in STEM research and academia. The award recognizes actions taken by institutions to monitor and combat unequal representation and evidence of prospective steps enhance future equality of opportunity. The CBU's Athena Swan Application Committee and many other members of staff including the Equality and Diversity Committee worked hard throughout 2014 putting together the application and are delighted with the outcome. This recognition itself forms a positive sign to existing and applying students and job applicants and will encourage us to continue and deepen our measures to ensure equality of opportunity.

Athena SWAN Bronze Award

Low working memory and ADHD: same or different?

Working memory is vital for holding information in mind in the course of many everyday activities. Children with weak working memory skills often fail to remember vital information in classroom activities, and are slow to learn in key areas of the curriculum such as reading and maths. To their teachers, these children often seem as though they are not paying attention. Indeed, they are sometimes identified as having ADHD.

CBU researchers Joni Holmes (seen right) and Susan Gathercole have recently compared directly children with ADHD with those who have weak working memory skills alone. The cognitive and learning abilities of the two groups were remarkably similar. They shared common memory problems, poor academic progress, and were not very effective in abilities known as 'executive functions' which involve planning and controlling mental activities. However, they did differ in two key respects. Children with ADHD were more likely to break rules and their behaviours were more impulsive and hyperactive, while individuals with poor working memory alone were slower to respond across many activities.

These findings have important implications for how best to support the learning needs of these children, who are found in most classrooms. First, although children with ADHD are more difficult to manage within the classroom and therefore more likely to receive additional support than those with weak working memory alone, the learning challenges they face are very similar. They may therefore merit equivalent resources. Second, despite striking differences in their behaviour, the underlying cognitive problems of the two groups appear to be very similar. The same intervention approaches may therefore prove to be effective in boosting learning.

Dementia and neuroscience research at Cambridge receives major funding boost

A major new collaboration project between the CBU and the University of Cambridge has been awarded £7m by the Medical Research Council to provide the most advanced brain scanning facilities for the next generation of dementia and neuroscience research. It is part of a £25m award to the University of Cambridge by the Medical Research Council's Clinical Research Capabilities and Technologies Initiative, announced in October 2014 by the Chancellor of the Exchequer.

Professor Susan Gathercole, Director of the CBU says: "In a single step, this investment in ultra-high field human neuroimaging will allow us to break new ground in understanding the microstructure of the brain during health, disease and development. This award is simply transformational for Cambridge neuroscience."

The award will provide one of the most powerful brain scanning facilities in the world, supported by expertise across the CBU and University of Cambridge. Conventional MRI brain scanning has already revolutionised the study of the brain over the last twenty years. The new ultra-high field MRI '7T' scanner is a great advance on existing technology, allowing researchers to study the structure and function of the human brain in much greater detail.

The new scanner is dedicated to research into dementia, mental health and neuroscience. Researchers will be able to detect changes in the structure, function and chemistry that occur even before dementia starts and which respond to new treatments for dementia. This will make a major contribution to the UK Dementia Platform, a national initiative to join up dementia research across the country's specialist centres and to work with companies developing new treatments in the fight against dementia.
The new scanner will also help neuroscientists understand how the brain represents and controls perception, memory and actions in the healthy population. CBU and University scientists will study how this brain systems change during the lifespan, in mental illness, and with genetic variation between people.

Infant eye movements link to autism

A recent Medical Research Council study found that babies whomove their eyes more often when they are young are more likely to develop Autism when they are older. The study iooks for early warning signs for Autism. Researchers examined how often babies (aged 6-8 months) shifted their eyes when they were examining a scene. Typical infants make small eye movements approximately two times a second when they are viewing a new scene. In infants who later received a diagnosis of Autism, in contrast, they found that these eye movements were more frequent – about 3 times a second.

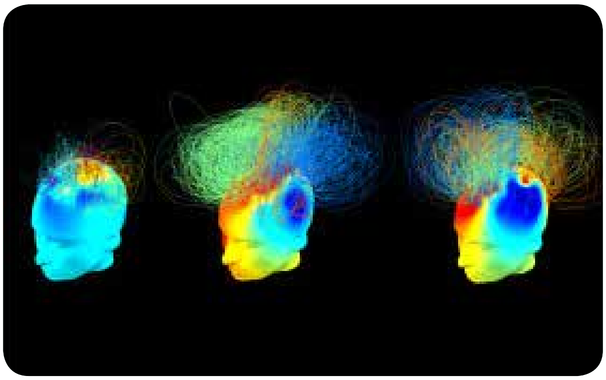
Dr Sam Wass, the lead author on the study said "We don't know exactly what causes this. Generally, faster responses in young infants are a sign that a baby is going to be clever when it's older. This research could link to the fact that people with Autism can process visual information faster than typical people can. Alternatively it could be that these babies need a higher level of stimulation, so they move their eyes more frequently to get more stimulation. Or it could be that they are not managing to engage with things that they look at in a typical way. Either way, this study is part of a growing body of evidence that suggests that subtle warning signs for Autism can be detected early in development." The study was originally hosted at Birkbeck, in London, and Sam now continues his work with infants at the CBU.

Identifying hidden minds in impaired consciousness

This study uncovers hidden signatures of brain networks that could support consciousness in patients who are unresponsive and seemingly vegetative, but who demonstrate signs of covert awareness. CBU and University of Cambridge researchers Dr Srivas Chennu, Dr Tristan Bekinschtein and their collaborators employ the science of networks to characterise the brain networks that support human consciousness and how they are affected in pathological states of low awareness, like the vegetative state.

In a study published in October 2014, the authors analyse brain networks in 32 patients diagnosed as vegetative and minimally conscious, measured with electroencephalography, and compare them to healthy adults. They show that the rich and diversely connected networks that support awareness in the healthy brain are characteristically impaired in patients. However, some unresponsive vegetative patients (who show signs of hidden awareness by following commands like imagining playing tennis) have well-preserved brain networks that look similar to those of healthy adults.

Identifying the neural signatures of consciousness remains an elusive yet fascinating challenge to current cognitive neuroscience, but it takes on an immediate clinical and societal significance in patients diagnosed as vegetative and minimally conscious. This research could improve clinical assessment and help identify patients who might be covertly aware despite being uncommunicative.The researchers say: “Being able to detect the recovery of brain networks in patients, alongside or even before they show behavioural signs of improvement, is very promising. However, further work is essential to translate these scientific advances into viable tools that can be reliably used at the patients’ bedsides to accurately inform and guide their clinical care.”



Brain networks in two behaviourally similar vegetative patients (left and middle), but one of whom imagined playing tennis (middle panel), alongside a healthy adult (right panel).

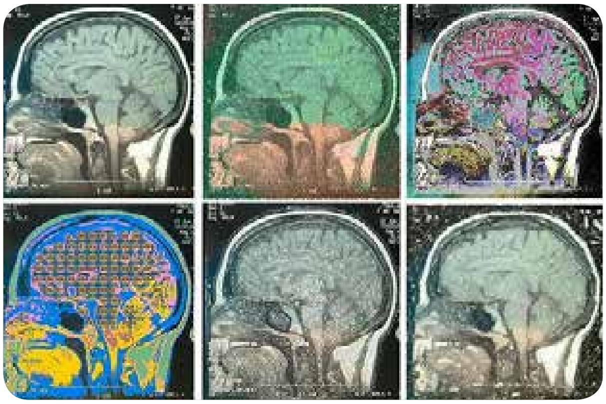
Human brains age less than previously thought

Older brains may be more similar to younger brains than previously thought. A new joint study between BBSRC-funded researchers at the CBU and the University of Cambridge has shown that changes in the ageing brain previously observed using functional magnetic resonance imaging (fMRI) – one of the standard ways of measuring brain activity – may be due to changes in our blood vessels, rather than changes in the activity of our nerve cells, our neurons.

Given the large number of fMRI studies used to assess the ageing brain, this has important consequences for understanding how the brain changes with age and it challenges current theories of ageing.

The study addresses fMRI issues of measuring neural activity indirectly through changes in regional blood flow. Without careful correction for age differences in vascular reactivity, differences in fMRI signals can be erroneously regarded as neuronal differences. The unique combination of an impressive multimodal data set across 335 healthy volunteers over the lifespan, as part of the CamCAN project (www.cam-can.com), allowed colleagues to validate a method for correction, which is suitable for fMRI studies of ageing. Their findings clearly show that without such correction methods, fMRI studies of the effects of age on cognition may misinterpret effect of age as a neurocognitive, rather than neurovascular, phenomena.

The study was jointly funded by BBSRC, the Medical Research Council and the Wellcome Trust.



Welcome!

Each October we have a new intake of PhD students here at the CBSU, coming from all over the world to perform research at the Unit and to gain their PhD from the University of Cambridge. Last October we welcomed ten new faces to the Unit, including both MRC-funded students and externally funded ones, several of whom won prestigious scholarships to come to Cambridge.

MRC funded students are fully supported through three years of study, with the places restricted to UK nationals and other EU candidates who have lived in the UK for three years prior to study. One of our new MRC-funded students, Elizabeth Byrne, is already well known around the Unit having worked here as a Research Assistant for a year before deciding to do her PhD here too. The new students are already taking part in Unit research and conducting their own experiments, working on diverse topics across the attention, language, memory and methods groups.


Elizabeth Byrne

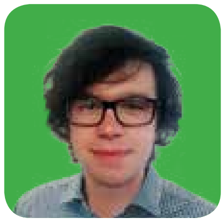

Amy Johnson


Hunar Abdulrahman


Floris de Vries


Heidi Solberg-Okland


Patrick McClure


Jiri Cevora


Yuhua Guo


Ben Goodall

Goodbye!

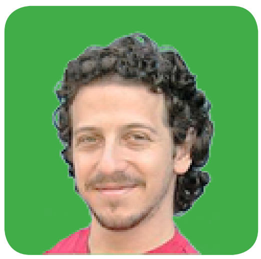
This April we bid goodbye to two key members of our support team. Marion Ormandy had worked in the General Office, on Reception, as the Facility Manager, at an offshoot on the Addenbrooke's site and latterly looked after our Resources, Technical and IT teams. And speaking of IT, we also said goodbye to our IT Manager, Rob Anthony, who had worked here for 10 years, becoming IT Manager in 2010. We will greatly miss their dedication and enthusiasm.

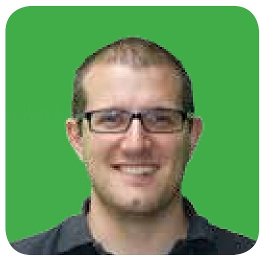
Tristan Bekinschtein left the CBU last year to join the University Department of Psychology but continues to work on many consciousness projects with us and can still be found brewing coffee in the kitchen most weeks.

Richard Meiser-Stedman left to join the University of East Anglia where he is continuing his vital work on Post Traumatic Stress Disorder in children and adolescents.


Marion Ormandy


Rob Anthony


Tristan Bekinschtein


Richard Meiser-Stedman

Awards for CBU staff and students

Wellcome Trust Strategic Award for Tim Dalgleish

We are delighted to report that Tim Dalgleish and colleagues in Oxford and Exeter have been successful in their application for a large Wellcome Trust Strategic Award entitled entitled 'Promoting Mental Health and Building Resilience in Adolescence: Investigating Mindfulness and Attentional Control'. This will fund work and staff to be based in Cambridge, and is a very exciting development for the CBU. Congratulations to all involved.

Dorothy Hodgkin Fellowship awarded to Yaara Erez

Many congratulations to Yaara Erez, who has been awarded a Dorothy Hodgkin Fellowship from the Royal Society. This gives Yaara up to five years of independent funding to pursue her work with us, following on from her previous support from EMBO. Yaara plans to combine multivariate analysis and computational modelling of single cell data from Oxford with similar data from intracranial recordings in epilepsy patients. We are delighted she has received this prestigious award.

Susan Gathercole elected as FBA

We are delighted that our Director, Professor Susan Gathercole, has been made a Fellow of the British Academy, in recognition of her pioneering work on developmental disorders in cognition, and implications for education.

Stroke Association grant awarded to evaluate new cognitive treatments in strokes

Polly Peers, Tom Manly, Duncan Astle, John Duncan and Andrew Bateman (Cambridgeshire Community NHS Trust) have been awarded a Stroke Association grant to investigate the effectiveness of new on-line attention and working memory training packages for people who have had a stroke. Stroke, a temporary block to the brain's blood supply, is the biggest single cause of long-term disability in the UK and affects approximately 150,000 people each year. Cognitive problems following stroke are common.
This three year study will employ two researchers to evaluate both whether regular home-based online training is effective and, crucially, whether participants enjoy it and are motivated to continue.

The Stroke Association (http://www.stroke.org.uk) is the UK's leading charity for the condition and undertakes tireless fund raising to support research, resources for stroke survivors and their families, and campaigns such as FAST (Facial weakness? Arm weakness? Speech problems? Time to call 999).

BBSRC grant awarded to study ageing

Rik Henson, together with Jon Simons at the University of Cambridge Psychology Department, has been awarded a BBSRC project grant to "characterise encoding and retrieval contributions to age-related memory impairment". This three year grant (led by Jon Simons) will allow one post-doctoral researcher to run a number of MRI experiments at the CBU. This work will continue a long-standing and fruitful collaboration between the CBU and the University Cambridge on the neural bases of memory and ageing.

Rogier Kievit awarded a four year Sir Henry Wellcome Postdoctoral Fellowship.

Rogier, a postdoc at the CBU, did his PhD at the University of Amsterdam with Professor Denny Borsboom, developing psychometric models to relate measures of brain structure to cognitive abilities, and is currently a postdoc on the BBSRC funded Cam-CAN project (Cambridge Centre for Ageing and Neuroscience) led by Professor Lorraine Tyler. During this four year Wellcome fellowship, based at the CBU, Rogier will study how brain development impacts on executive such as reasoning, cognitive control, working memory and attention.

His project will use psychometric models to determine how changes in brain structure and function affect executive functions during two key periods of the lifespan, adolescence and old age. This work will be done in close collaboration with the Institute for Computational Psychiatry and Aging at UCL in London (collaborator Professor Ray Dolan), the department of Developmental Psychiatry at the University of Cambridge (collaborator Professor Ian Goodyer), the Max Planck Institute of Human Development in Berlin (collaborator Professor Ulman Lindenberger), the University of Umeå (mentor professor Lars Nyberg) and the MRC Cognition and Brain Sciences Unit (collaborator Professor Richard Henson).

Rubicon Fellowship for Linda Geerligs

Linda Geerligs has been awarded a prestigious Rubicon fellowship from the Netherlands Organisation for Scientific Research. Linda is a postdoc at the CBU working with Rik Henson on the CamCAN project on the ageing brain. During the two year fellowship, she will study how static and dynamic functional connectivity changes with age, and investigate how these changes relate to the effects of ageing on cognitive performance.

Anne Cutler awarded Fellow of Royal Society

Congratulations to Professor Anne Cutler who has been made a Fellow of the Royal Society (FRS). Anne worked at the CBU for 10 years during the 80s and 90s before leaving the Unit to become director of the Max Planck Institute of Psycholinguistics in Nijmegen. She is currently back in her native Australia where she is a Research Professor at the MARCS Institute, University of Western Sydney.

Becoming an FRS is one of the most prestigious scientific achievements for scientists in the UK and the Commonwealth. The text of the Royal Society's announcement states that "Anne Cutler has explained some of the major puzzles concerning how listeners decode speech. She was the first to demonstrate that the mother tongue determines the way speech is segmented into units and that these units are different in different languages (syllable, stress, mora, respectively in French, English and Japanese). She has demonstrated that listeners adapt quickly to phonemic categories with different speakers and that this is done on the basis of abstract representations, and not episodic exemplars. She has also shown how prosodic context aids segmentation of the speech stream and has embedded a vast array of experimental findings into a coherent and widely accepted theoretical framework."

Much of this research began during her time here at the CBU and she is still actively involved in collaborations with scientists at the Unit.

We would like to congratulate all our recent winners and achievers.

What baby scientists can teach us?

Kaili Clarkson

Research at the CBU has traditionally focused on adults, but in the summer of 2013, following the conversion of an annex building from offices to a state-of-the-art new Centre for Attention Learning and Memory (CALM), the CALM babylab opened its doors to a much younger set of volunteers. Since then over 100 babies aged between 6 and 18 months have taken part in research looking at various aspects of learning and development.

Working with babies brings a range of challenges, not least the need to develop research methods that are appropriate for infants. The design and implementation of suitable methods requires a certain amount of creativity, and considerable piloting is required to ensure that methods are both practical from a technical point of view, and appropriate to the age and ability of the participants. The methods we currently use in CALM include eye tracking, as gaze direction can be used to monitor where baby's attention is directed and to assess learning, and EEG (electroencephalography) which allows for the measurement of brain responses to different stimuli.

Eye tracking

In CALM we have both a remote and a head mounted eye tracker. The remote eye tracker is a neat piece of equipment which sits below a computer monitor and tracks the direction of gaze across the screen by monitoring the position of the pupil relative to light reflections on the cornea. The baby sits on a parent's knee in front of the monitor, and a curtain is drawn so that baby, parent and eye tracker are enclosed in a dark booth to minimise visual distractions. The eye tracker has a mercifully wide range and so is relatively tolerant of wriggly babies.

Happy baby wearing an eye tracker in the CALM building

The head mounted eye tracker is a special infant-sized cap with two cameras attached (as pictured) and allows us to track gaze direction in a natural environment, such as while the baby is playing with toys. A forward facing camera positioned in the middle of the forehead captures the scene in front of the child, while a second camera on a little arm records a picture of the baby's eye. Merging information from the two cameras allows us to track exactly where the baby is looking. As anyone who has tried to make a recalcitrant one-year-old wear a sun hat will appreciate, the challenge with this method is to stop the baby from continually pulling the hat off. To this end we have developed a number of distraction techniques and a reasonably high success rate, even when parents assure us that the child has never before tolerated a hat of any sort.

EEG (Electroencephalography)

The brain generates very weak electrical signals as part of its natural activity, and we can measure these signals using EEG. This involves attaching sensors to the baby's scalp. These sensors are covered in gel to ensure a good contact between the sensor and the skin and act like little microphones, picking up the electrical activity in the brain. Challenges with this method include identifying the optimal positioning of the sensors to measure the particular activity under investigation, and ensuring that the sensors are placed in the same position on each baby despite differing head sizes and shapes. Generally once the sensors are in place the baby forgets all about them. In some cases where baby's automatic responses (such as to sound) are being investigated, EEG recordings can even be made while the baby is asleep!

We currently have two major baby projects running: Sam Wass and Kaili Clackson are investigating the development of attention and learning, and Vicky Leong from the University Department of Psychology is studying how face-to-face interactions stimulate language learning. Sam uses eye tracking technology to assess babies' attention control – in other words, their capacity to choose what they pay attention to and what they ignore – as well as their learning abilities. In one task, for example, a smiley face appears alternately on each side of the screen, with a short pause between each presentation. By monitoring whether baby correctly

anticipates where the face will appear next (and so looks at that side of the screen before the face appears) we can see whether, and how quickly, the baby learns the pattern.
Sam has also developed new gaze-contingent paradigms that aim to strengthen aspects of attentional control, such as the ability to ignore distractions. In one 'odd-one-out' type activity babies see an array of stars, one of which contains a character. When baby looks at the different star he is rewarded with a flashy picture and happy music. Once baby has learned to look for the different star, the task becomes more difficult, with the other stars becoming more visually interesting, moving about and even flashing so that to gain the reward the baby has to overcome the impulse to be distracted and focus on finding the character star. Sam's previous work has shown that such attentional control training can improve performance on learning measures, and development of this work could have important implications for early interventions with infants at risk of developing attention disorders such as ADHD.
Previous research has shown that certain aspects of language learning develop during live play with an adult, but not through watching television, even when the audio-visual input is equivalent. To examine how this happens in real time, Vicky uses EEG to measure baby's brain activity during live interactions with his mother (where mum's brain activity is measured too) and compares this to when baby is watching television. Her previous research has shown that during periods of close engagement between mother and baby, aspects of their brain activity become synchronised, showing that mothers are literally 'in tune' with their babies, and highlighting the importance of face-to-face interaction during early development.

Our baby scientists are recruited through our baby volunteer database and we are always seeking to recruit new babies - and even bumps - who might be interested in taking part in research. If you know a potential baby scientist (aged 0-18 months), please pass the word on (see Baby Scientists flyer for contact details). We're unable to pay them for their participation (apart from travel expenses), but the babies get to sample our well stocked toy box, and take home a funky t-shirt as a thank you.

We'd like to say a huge thank you to all our wonderful baby scientists and their parents, particularly those who have attended multiple visits. Without their support none of this research would be possible.

An image from an 'odd-one-out' type activity where babies are rewarded for looking at the stars without characters

Age-related changes in higher cognitive abilities: It doesn't all go together when it goes

Rogier Kievit, Rik Henson

Cognitive abilities change across the lifespan at different rates. Some abilities, such as language and general knowledge are hardly affected, whereas others, including certain types of memory and reaction time often show declines. The goal of our project, the Cambridge Centre for Ageing and Neuroscience (www.Cam-CAN.com), is to better understand the neural and demographic underpinnings of healthy cognitive ageing. In collaboration with the University of Cambridge we examined a large cohort of almost 3000 healthy volunteers from the general population.

In this study, we wanted to understand age-related changes in a class of cognitive abilities known as 'executive functions', which includes higher cognitive abilities such as reasoning, decision-making and planning. These skills are particularly important because they are closely related to the (in)ability to live and function independently into old age (e.g. paying your bills, planning a shopping trip). We examined a subset (about 500) participants to see how their brain structure related to lifespan changes in two types of executive functions, namely reasoning ability and multitasking.

The first test measured fluid reasoning, or the ability to solve abstract puzzles that don't require any particular knowledge beforehand (Figure 1a).

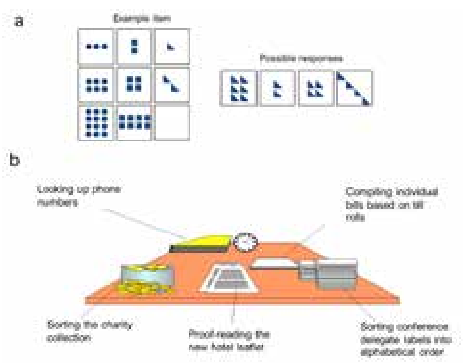


Figure 1. a) A fluid reasoning puzzle, where participants had to figure out which response best fits into the empty square. b) The mock hotel. Participants were asked to perform all managerial duties for the same amount of time.

Secondly, we wanted to know how well people could multitask. To test this ability, we simulated a mock hotel environment (Figure 1b), where participants had to juggle various managerial duties such as looking up phone numbers, arranging reservations, and organising loose change. Although each individual task wasn't complicated, we wanted to examine how well people could keep their eye on all duties simultaneously without neglecting any.

After performing these tasks, participants were scanned in a Magnetic Resonance Imaging (MRI) scanner, so that we could examine the anatomy of their brains and relate it to cognitive ability. We specifically focused on the frontal cortex, the area of the brain thought to be important for these types of tasks, and more importantly, a region of the brain that often declines with age more quickly than the rest of the brain. What we wanted to understand was whether different aspects of the frontal cortex – such as different sub-regions and different types of brain tissue (white matter and grey matter) – impacted people's fluid intelligence and ability to multi-task, and whether regions within the frontal cortex might age at different rates.

We looked at two aspects of brain structure: How many cell bodies people had in certain regions (by measuring grey matter volume), and how well different regions of the brain were interconnected by axons (called white matter). Specifically, we looked at grey matter in the frontopolar cortex (at the very front of the brain; the green region in Figure 2), as this region is known to be involved in certain types of reasoning, and in the Multiple Demand system, a set of regions (in blue in Figure 2) that are known to be active whenever people perform any kind of demanding task). We then used a technique called Diffusion Tensor Imaging (DTI) to measure the connections between brain regions. We hypothesized two tracts would be particularly important: the Forceps Minor (red in Figure 2), which connects the left and right frontopolar regions, and the Anterior Thalamic Radiations (yellow in Figure 2), which connect parts of the frontal cortex to deeper areas in the brain.

Using statistical models we discovered several fascinating patterns. Firstly, we found that fluid reasoning and multitasking age at different rates, with multitasking being comparatively more preserved across the lifespan. Secondly, we showed that different types of frontal brain structure were important for fluid reasoning compared to multitasking. Moreover, the four brain regions age at different rates. In other words, the brain and the mind don't decline 'as a whole': The brain shows different patterns of ageing, and these patterns affect which of your cognitive abilities will be more preserved than others. Finally, we showed that grey and white matter in the frontal cortex play partially independent roles in supporting fluid reasoning ability.

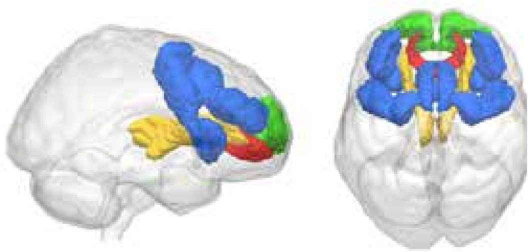


Figure 2. Four brain regions of interest. Frontopolar cortex (green), the Multiple Demand system, (blue), the Forceps Minor (red) and the Anterior Thalamic Radiations (yellow).

In other words, it is not enough to consider only the cell bodies (grey matter), or only the connections between them (white matter). This finding is important, as certain types of cognitive and physical exercise are known to have different effects on grey and white matter. Our findings fit into an emerging picture of ageing that is much more nuanced and positive than commonly reported. By understanding how our brains change as we grow older, and what makes some people age better than others, we hope to be able to determine what lifestyle and behavioural habits are most important to ensure we age well, so that more people will age happily, healthily and independently.

The Cambridge Centre for Ageing and Neuroscience (Cam-CAN) research was supported by the Biotechnology and Biological Sciences Research Council (grant number BB/H008217/1). We are grateful to the Cam-CAN respondents and their primary care teams in Cambridge for their participation in this study. We also thank colleagues at the MRC Cognition and Brain Sciences Unit MEG and MRI facilities for their assistance. These findings were also described in our Lab News (2015), April edition, http://www.labnews.co.uk/features/how-age-affects-your-mind/

Kievit, R. A., Davis, S. W., Mitchell, D. J., Taylor, J. R., Duncan, J., Henson, R. N., & Cam-CAN Research team. (2014). Distinct aspects of frontal lobe structure mediate age-related differences in fluid intelligence and multitasking. Nature Communications, 5. http://www.nature.com/ncomms/2014/141218/ncomms6658/full/ncomms6658.html

Putting working memory to work in Cambridgeshire schools

Agnieszka Jaroslawska, Francesca Woolgar, Erica Bottacin

One of the most important cognitive abilities for learning is working memory. This is an active mental workspace that allows us to juggle multiple thoughts. Working memory enables us to carry out many everyday activities such as following directions or understanding what we read. It has a limited capacity, which means that there is an upper limit to the amount of information that we can hold in our minds at any given time. Children who have small working memory capacities for their age often forget what they have to do in the classroom, which can lead to poor school progress. We conduct research in local schools to help us better understand the causes and consequences of working memory problems in childhood. This enables us to develop interventions to help children overcome some of the problems caused by their memory difficulties.

Actions speak louder than words

One of our goals is to understand how working memory deficits have a practical impact for children as they are learning. During their typical school day children have to complete a variety of learning exercises set by classroom teachers. In order to see those exercises through to completion they have to remember large amounts of information and carry out lengthy instructions. Limited working memory capacities are frequently overloaded in such situations. As a result, children with poor working memory skills often fail to follow instructions or to keep track of their place in complicated tasks. Over time frequent task failures impair learning and may result in slow academic progress.

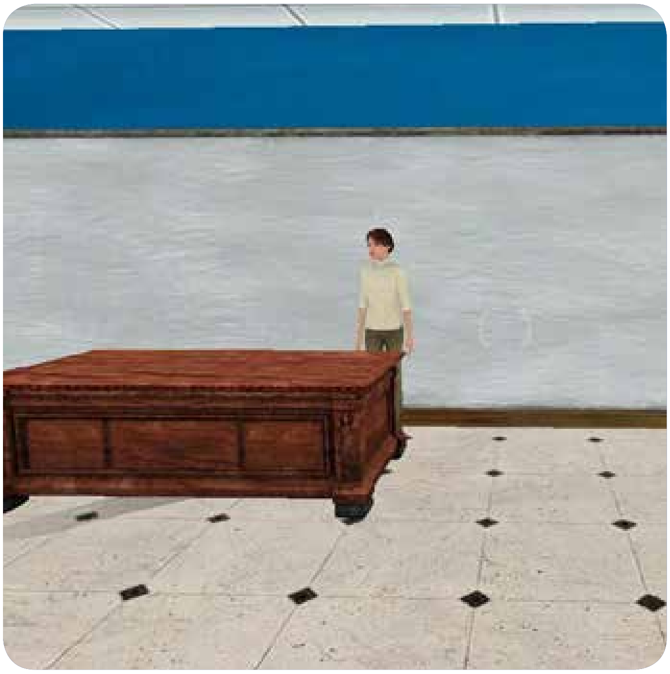
In a research project conducted in collaboration with two primary schools in Cambridge we found that children use verbal working memory to remember spoken instructions. This means that a child with a small verbal working memory capacity is likely to struggle to

Pictured above is a following instruction task remember lengthy instructions given by a teacher in the classroom. The good news is that physically performing instructions, which does not depend on verbal working memory, improves children's ability to remember instructions. This important work suggests that presenting classroom instructions in formats that involve physical movement is likely to improve children's ability to remember what they have to do in each lesson. This may, in turn, minimise task failures and enhance learning opportunities in children with working memory problems.

No train, no gain?

We know that working memory deficits are common in children who struggle in reading and maths, but we don't know whether their working memory problems are the core impairment causing their difficulties or whether interventions designed to improve working memory can help them at school. To understand this we are currently running a very large study with children with poor reading and maths skills in seven schools in Cambridgeshire. In the first part of this study, children are completing many cognitive assessments that measure how quickly they can process verbal and non-verbal information, how much information they can remember and how well they can pay attention. In the second part, the children are completing a computerised working memory training program. This involves the children training on working memory tasks on the computer. The tasks get increasingly more difficult as the children get better - this means there is more information to hold in working memory each time. The children complete 20 sessions of training in school. Each session lasts between 30-45 minutes.

We are interested in understanding the children's profiles of cognitive strengths and weaknesses and investigating whether these impact on how useful working memory training is for boosting their cognitive abilities and their poor reading and maths skills.



Computerised memory training programme

Keep CALM and carry on referring

Our on-site child research clinic, which is housed in the Centre for Attention Learning and Memory (CALM), has been open for over a year now. In this time we have completed more than 100 cognitive assessments with children with difficulties in working memory, attention and learning. Many of the children have been back to the CBU recently with their families to have an MRI brain scan. The data we are collecting through the clinic will help us to understand the cognitive and brain processes that are important for learning.

An important part of our work in the CALM research clinic involves working closely with educational and clinical practitioners, including special educational needs co-ordinators (SENCos) in local schools. They refer children to the clinic and in return we are able to provide them with valuable cognitive and behavioural data that summarises the children's strengths and weakness. This information can be used to aid ongoing support for the child. As well as working with schools through the clinic, CALM acts as an information hub for scientists and professionals working in children's services to share ideas and knowledge. Over the past year we have hosted multiple outreach events and workshops at the CBU and we have more planned for the coming months. See our website for more information: http://calm.mrc-cbu.cam.ac.uk/

Intervention Studies

Duncan Astle, Kate Baker, Amy Johnson,
Joe Bathelt, Gemma Crickmore

We are a research group based at the MRC Cognition and Brain Science Unit studing how aspects of cognition – like attention and working memory – occur as a result of the functioning of the brain. We are interested in how these cognitive functions differ in children with neurodevelopmental disorders and how we can create interventions that could improve aspects of cognition.

Working memory training

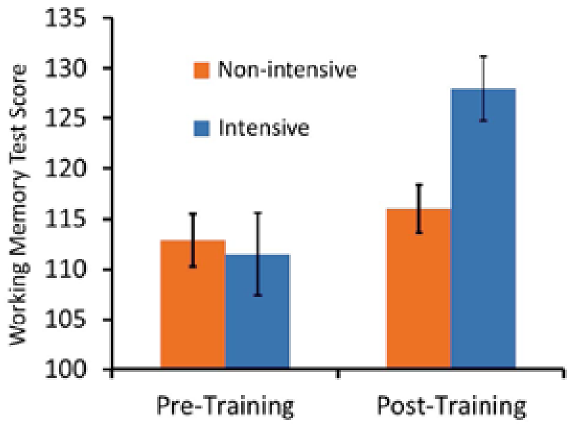
We are currently concluding an ongoing study focussing on working memory performance and the effects of cognitive training in children. Cognitive training programmes aim to improve aspects of cognition, for example, memory, attention, verbal or auditory processing. The training is usually presented as a series of computerised tasks or games. The current study has been exploring whether we can train working memory the ability to hold in mind and manipulate pieces of information over brief periods. Working memory is fundamental to learning and carrying out many day-to-day activities.

27 children aged between 8-11 took part in this study. Each child underwent 20 sessions of training at home. Before and after the training we assessed each child's cognitive ability and took two brain scans. We used a Magnetoencephalography (MEG) scanner, which measures naturally occurring electrical activity produced by brain cells.

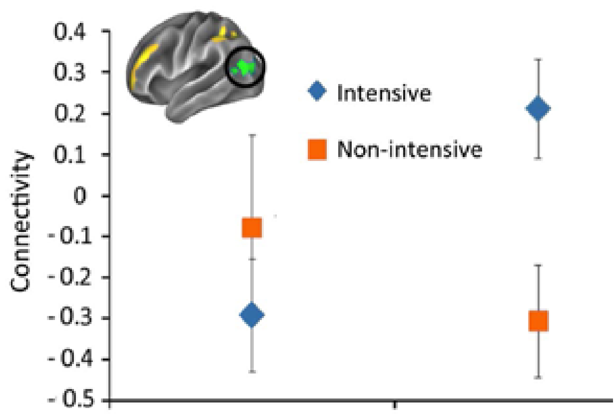
This image shows a participant in an MEG scanner.

During their training, some children experienced a programme that became gradually more intense as they progressed, whereas other children were given a low intensity version of the training. Following the training we found that children given the intensive working memory training had made substantial gains in working memory capacity, relative to the children in the low intensity group. We also found that the patterns of connectivity in the children's brains as they rested were altered by the training. There was an increased coordination in brain activity between areas at the front of the brain and areas for processing visual material.

Our first paper from this dataset has just been accepted for publication, and will be coming out in the Journal of Neuroscience later this year.



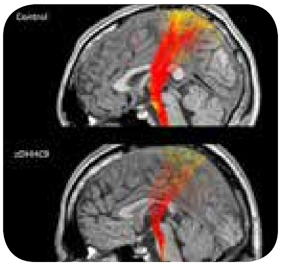
This graph shows the change in connectivity in one region of the brain following training.



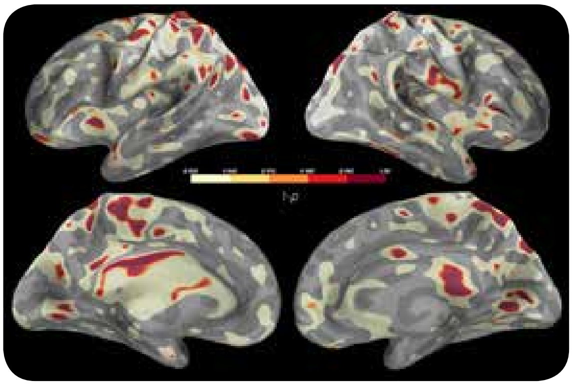
This graph highlights that there were improvements in working memory ability after training for both groups but a substantial improvement for those doing the intensive training.

zDHHC9: A Single Gene Mutation

As humans, each one of us carries unique genetic code in all of our cells that determines who we are. This code is DNA.
A gene is a section within an individual's DNA that contributes to determining some characteristic of that individual, for example eye colour. When genes become mutated it can change the way we develop. A mutation that occurs in a gene called zDHHC9 prevents the correct formation of a biological molecule, that is involved in transporting sodium channels to the surface membrane of brain cells. This is important because these channels are needed in order for the electrical activity of the brain cells to occur correctly.
If the electrical activity of the brain does not occur as it is meant to, this can lead to complications. For example, the zDHHC9 mutation is known to cause intellectual disabilities and difficulties in language production. We are currently looking at how the zDHHC9 mutation influences brain organisation, structure and function. It is important to understand how this mutation impacts upon the different pathways in the brain as it aids in our understanding not only of this specific condition but the functions of these pathways and how they may be used in everyday life.



This image shows that for those with a zDHHC9 mutation (below) there is a reduction in connectivity in one of the pathways in the brain when compared to an individual without the mutation (above).



The coloured areas indicate differences in brain volumes between individuals with the zDHHC9 mutation in comparison to control participants.

Attention, Cognition and Education: A Study

We have recently started a new study that aims to investigate the neural, cognitive and environmental factors that enable children to succeed at school. These factors are important to understand because school attainment highly predicts future life prospects. This study involves children aged 7-11 that have been recruited from Cambridge primary schools. We will be collecting information about the children's home environment and upbringing. Each participant will also take part in a broad range of cognitive tests and an MEG scan. We will be using the MEG to measure attention, working memory and language. We hope that the results of this study will identify factors that are important in attainment and which can be targeted via interventions. Ultimately we hope that schools will be able to utilise the results to better support children that encounter difficulties with learning at school.

New arrival

Marta Correia, MR Physicist

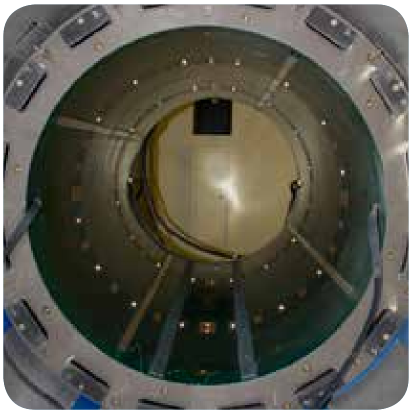
On the 8th of December 2014 the CBU welcomed PRISMA, a new MRI scanner, weighing around 13 tons.

After 9 faithful years, our old MRI scanner, TRIO, was beginning to show the signs of its age, and with the support of the Medical Research Council we were able to upgrade it to a new state-of-the-art system, PRISMA. The field strength (3 Tesla, or approximately 65,000 times the Earth's magnetic field) has remained the same, but with its new technology, electronics and computers, the new scanner will allow us to continue our research into the brain at higher resolution, providing more detail about brain structure and function.

See the transformation below:

The fMRI scanner before the upgrade

Out with the old



Inside the main chamber

The scanner ready to be upgraded

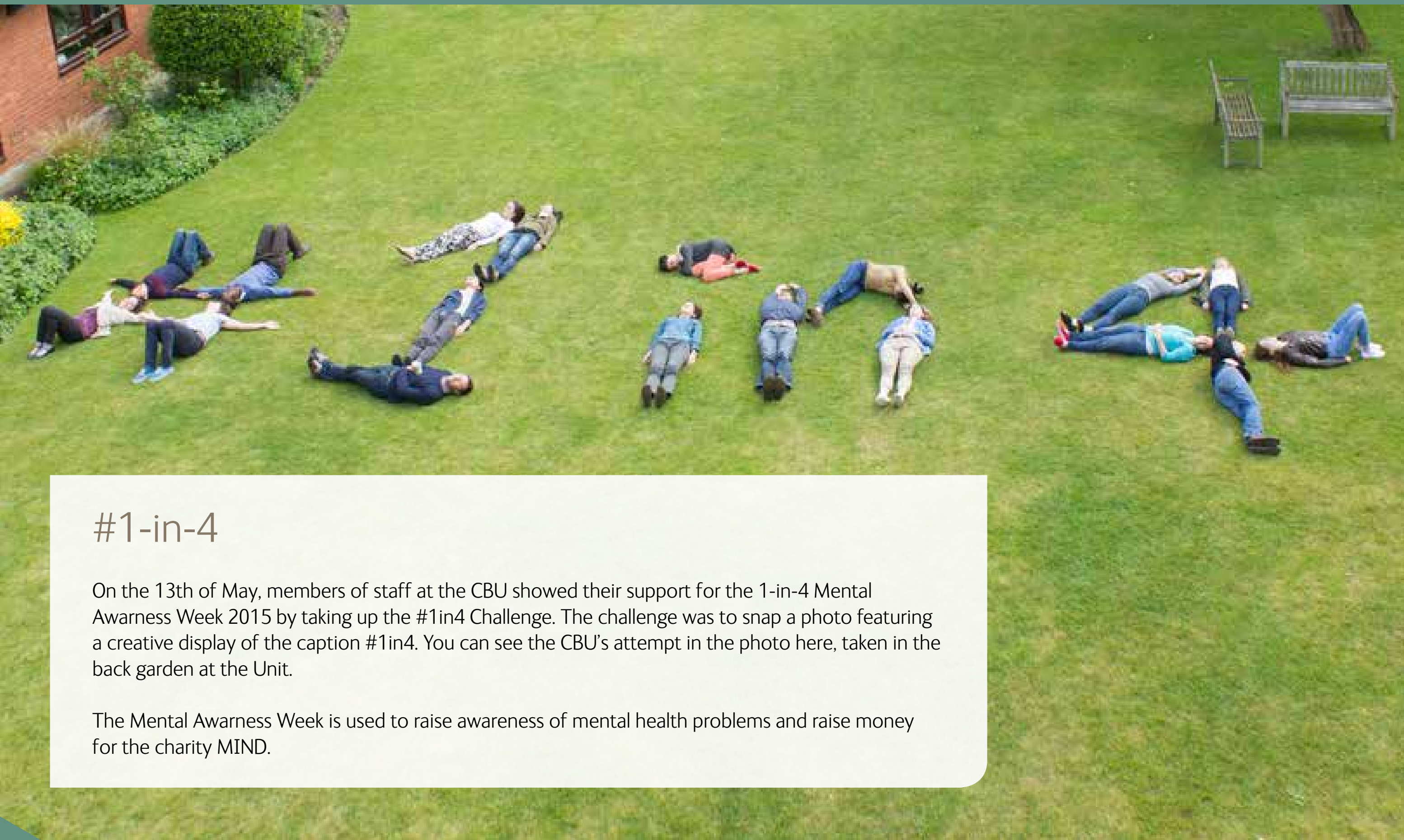
Almost done

The upgraded scanner

International Working Memory conference 2014

The international conference on Working Memory was held in Cambridge on 9th-11th July 2014, hosted by the Medical Research Council Cognition and Brain Sciences Unit.

This conference was held in celebration of the exceptional contributions of Alan Baddeley and Graham Hitch, on the 40th anniversary of the publication of their model of working memory in 1974. The conference covered the full range of theoretical and empirical approaches to the understanding and study of working memory. A group photo from the CBU Reception Party can be seen above.



#1-in-4

On the 13th of May, members of staff at the CBU showed their support for the 1-in-4 Mental Awarness Week 2015 by taking up the #1in4 Challenge. The challenge was to snap a photo featuring a creative display of the caption #1in4. You can see the CBU's attempt in the photo here, taken in the back garden at the Unit.

The Mental Awarness Week is used to raise awareness of mental health problems and raise money for the charity MIND.

Join our research now!