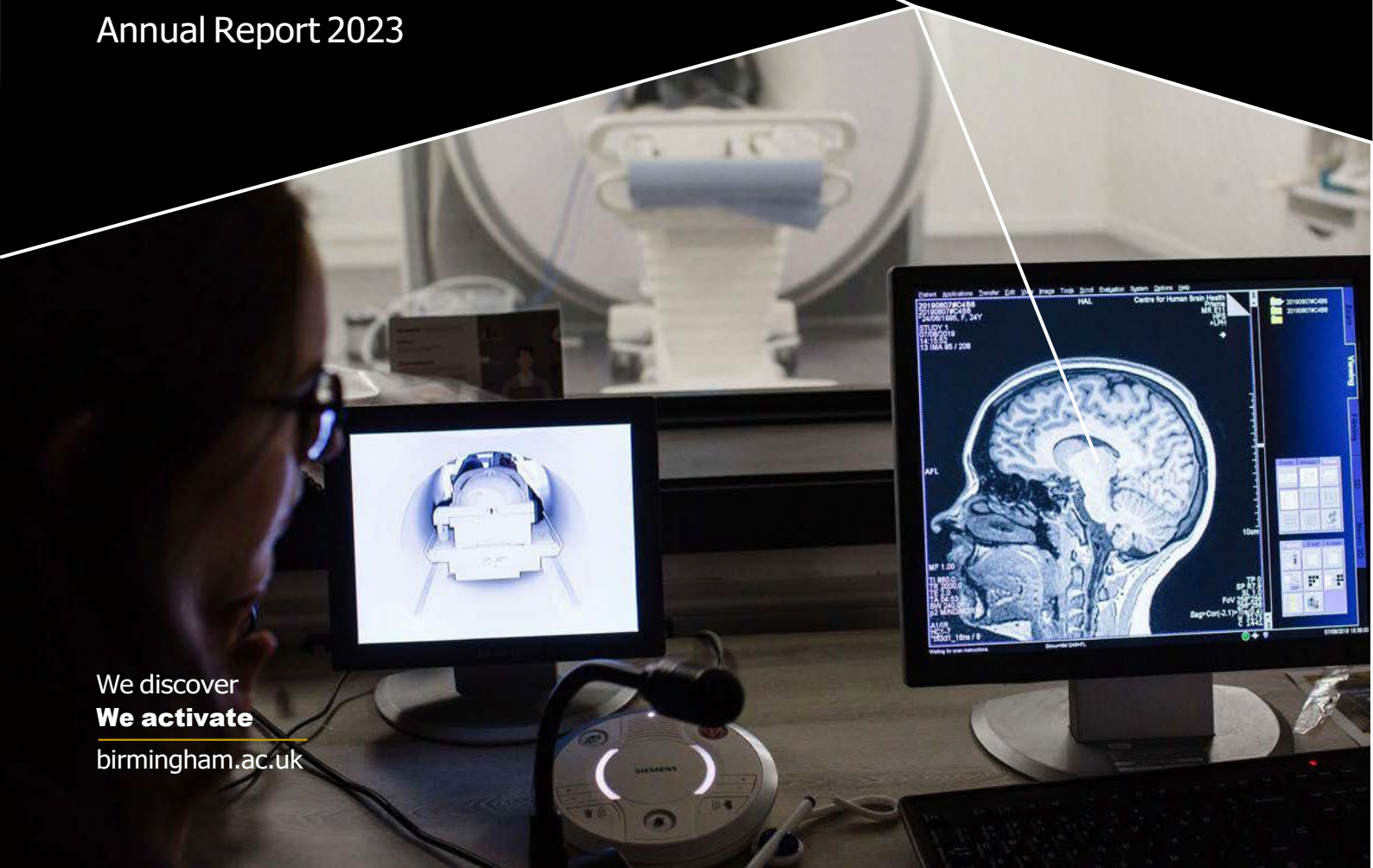
UNIVERSITY OF BIRMINGHAM

CHBH
CENTRE FOR HUMAN BRAIN HEALTH

Centre for Human Brain Health

Annual Report 2023



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Foreword from our Co-Directors

We are thrilled to present the Annual Report for the Centre for Human Brain Health. The Centre has fully recovered following the Covid lockdowns and our neuroimaging research studies are now back at full speed.

We extend our heartfelt appreciation to our exceptional Operations Team for their unwavering support in this endeavour. Over the past year, our researchers have published numerous papers in internationally renowned journals, reporting fundamental discoveries, methods development and translational research by employing various brain imaging and behavioural techniques, and developing cutting-edge data analyses, some of which are highlighted in this Annual Report.

This research has provided important insights into the mechanisms that support human cognition – from consciousness and social decision making to skilled performance, and falls under our six CHBH themes:

- Lifespan and brain health
- Cognitive computational neuroscience
- Social interaction and communication
- Learning, memory and performance
- Awareness, consciousness and sleep
- Neuroimaging methods and AI

We are particularly excited about the potential applications of this fundamental research in addressing issues related to neurological disorders and healthy ageing.

In 2023, CHBH researchers have been successful in securing over £12m in funding from the European Union, the UK research councils, and the Wellcome Trust, amongst other funders. This achievement is a testament to the creativity, research excellence, and hard work of our team of researchers. At the CHBH, we strongly believe that a welcoming, inclusive, and diverse team setting is a critical ingredient to achieve full potential and research excellence. Though there is still room for improvement, we are delighted to report that we have achieved a good balance of diversity at all levels of the CHBH, including the CHBH Directorship, the Strategy, Management and Operations Committees that steer the strategic and operational direction of our Centre.

Going forward, we are excited about the redevelopment of our sleep laboratories to support new research lines on sleep and circadian rhythms to brain health. We are also making significant progress in developing our OPM/MEG laboratory, with a particular focus on paediatric brain research, and installing cutting-edge brain modulation facilities which will allow us to image network activity across the brain, in addition to behaviour.

Looking ahead, we are confident that the CHBH is well-positioned to continue to meet its ambitious research mission in human cognitive neuroscience and its application to brain health, thanks to our infrastructure development, external funding success, as well as a diverse and talented team.

Katja and Ole | CHBH Co-Directors 2022–23

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Centre for Human Brain Health

The Centre for Human Brain Health (CHBH) is a leading interdisciplinary brain research facility established with the mission of understanding the fundamental mechanisms of the human brain as well as understanding what makes a brain healthy, how to maintain it, and how to prevent and reverse damage. Our vision is to cross the boundaries of traditional academic and clinical disciplines to transform our understanding of the human brain.

We recognise that to achieve the goal of personalised brain health we must first identify what constitutes a healthy brain and how lifestyle, developmental and societal factors interact and contribute to this endeavour.The CHBH is a vibrant neuroscientific community, which currently comprises 62 principal investigators and is supported by groups of dedicated post-doctoral researchers, research assistants and PhD students.

Since inception, the CHBH has generated funding from a wide range of sources, our top funders being:

- European Commission
- The Wellcome Trust
- Medical Research Council (MRC)
- National Institute for Health and Care Research (NIHR)
- Engineering & Physical Science Research Council (EPSRC)
- Ministry of Defence
- Biotechnology & Biological Sciences Research Council (BBSRC)
- Economic & Social Research Council (ESRC)
- The Royal Society
- Home Office

£12 million | **Total funding in 2023**

£4 million | The Wellcome Trust

£1 million | Biotechnology & Biological Sciences Research Council

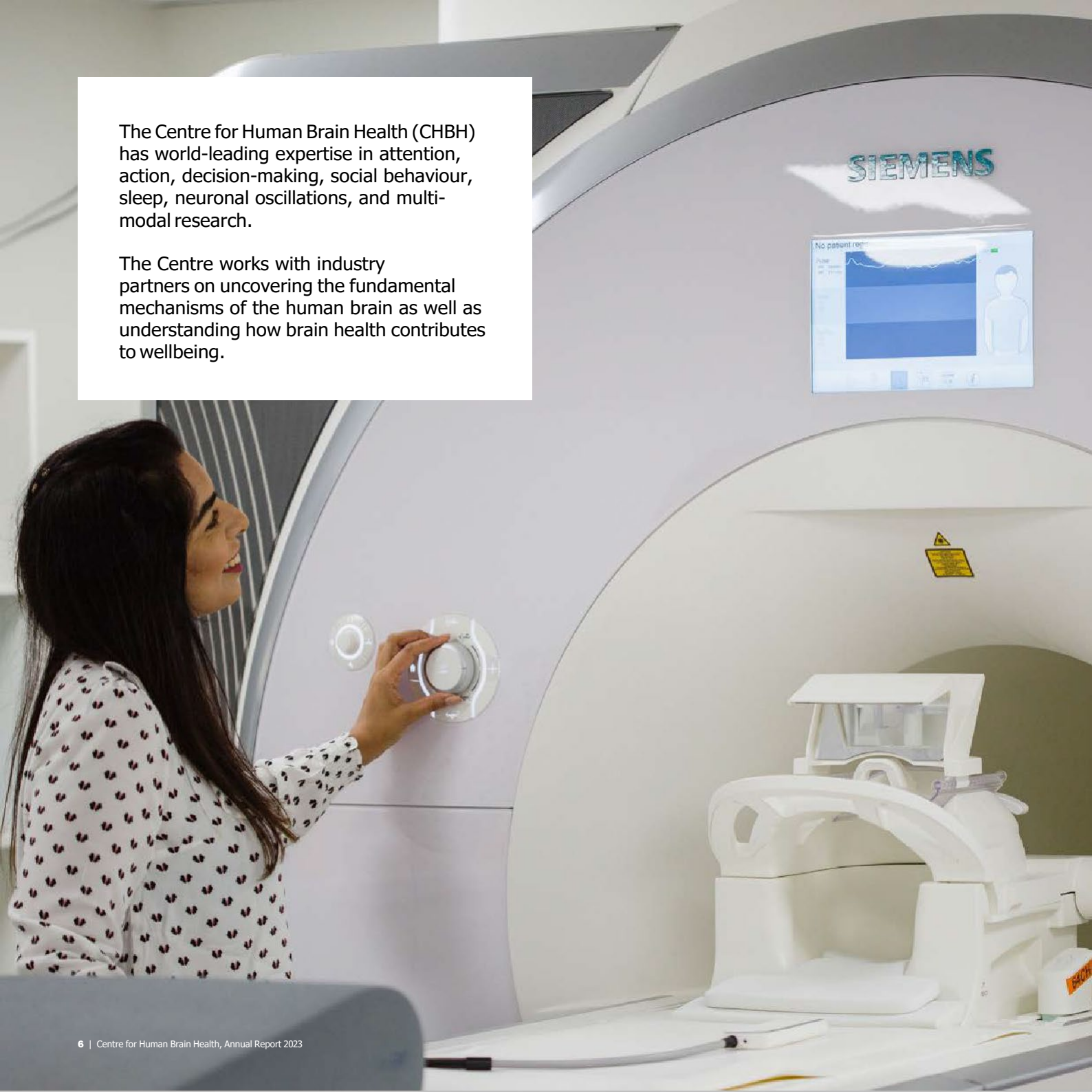
£1.3 million | Engineering & Physical Sciences Research Council

CHBH research themes

- Lifespan and brain health
- Cognitive computational neuroscience
- Social interaction and communication
- Learning, memory and performance
- Awareness, consciousness and sleep
- Neuroimaging methods and AI

The Centre for Human Brain Health (CHBH) has world-leading expertise in attention, action, decision-making, social behaviour, sleep, neuronal oscillations, and multi-modal research.

The Centre works with industry partners on uncovering the fundamental mechanisms of the human brain as well as understanding how brain health contributes to wellbeing.



Research facilities within the CHBH

The Centre is home to state-of-the-art brain imaging facilities, which are used to uncover the mechanisms supporting cognition in both the healthy and the dysfunctional brain. These include:

- **Magnetic Resonance Imaging (MRI)**, providing a range of options for stimulus delivery and physiological and behavioural recordings
- **Magnetoencephalography (MEG)**, which allows for continuous recordings of ongoing brain activity with a millisecond time resolution and advanced analysis tools to identify where in the brain the measured electrophysiological activity is generated
- **Electroencephalography (EEG)**, a high-performance EEG laboratory for accurate timing and application of auditory and visual stimulation (concurrently or separately)
- **Sleep laboratories**, equipped with 64-channel EEG amplifiers and peripheral equipment for experimental testing and stimulus delivery
- **Functional Near-Infrared Spectroscopy (fNIRS)**, housing the Imagent (v2) system that allows non-invasive functional imaging of the brain
- **Optically Pumped Magnetometer (OPM) laboratory**, where we are developing new sensors to be used for magnetoencephalography (MEG) using quantum technology, as well as installing a whole-head system using commercial sensors
- **Non-Invasive Brain Stimulation**, housing all the equipment required for both transcranial magnetic (TMS) and electrical (TES) non-invasive brain stimulation experiments as well as new Focused Ultrasound Stimulation (FUS) equipment, which has the capability to combine ultrasound brain stimulation with fMRI

Research output

Researchers at the CHBH have published ~95 papers over the last year in internationally peer-reviewed journals.

The research that received the most extensive coverage was from the lab groups of Professor Ole Jensen, who reported that transcranial photobiomodulation improves visual working memory capacity, Dr Patricia Lockwood on the links between national identity and public health support in a global pandemic, and Dr Katja Kornysheva on understanding the hierarchical control of skilled movement sequences and how information in brain areas unfolds across planning and execution.

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Participate in brain research at the CHBH **birmingham.ac.uk/chbhvolunteer**

To find out more contact us **birmingham.ac.uk/chbh**

Welcoming new principal investigators to the CHBH team

Over the past year we've welcomed several new colleagues who bring exciting new approaches to the CHBH. We've also cemented our relationships with other Centres and Institutes within and external to the University, to develop a vibrant community of brain researchers.

Dr Romy Fröemer
Assistant Professor in Psychology

Dr Froemer completed her undergraduate and graduate degrees at Humboldt-Universität zu Berlin. Following a one-year postdoc with Professor Abdel Rahman at Humboldt-Universität zu Berlin, she worked with Amitai Shenhav at Brown University as a postdoctoral fellow and subsequently senior research associate. She joined the University of Birmingham as an Assistant Professor in January 2023.

There are many ways to achieve our goals, and there are many ways in which we may fail to do so. People can vary how much effort they invest in giving a correct answer, how long they gather information before committing to a decision, or how they treat feedback they receive for their actions. Most of these higher order decisions will depend on what they know about the context they are in: whether they will be rewarded for getting the answer right and how much reward they will get, whether their answer will matter for getting rewarded, whether they think that gathering more information will improve their decision, and what they know about the source of that feedback. Ultimately, that means that people flexibly and adaptively change how they interact with the exact same stimuli. How are these higher order decisions determined? How does the brain represent the relevant inputs, transform them into decisions and then implement those to guide thought and action? Dr Fröemer's 'Adaptive Control of Cognition and Behaviour Lab' studies exactly that.

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Dr Arkady Konovalov
Associate Professor in Psychology

Arkady Konovalov received his training at the Ohio State University and the University of Zurich and has a background in behavioral economics and cognitive neuroscience. His interdisciplinary research focuses on neuroeconomics and decision-making in general, including models of the value-based choice process and social interactions. His work uses a variety of methods of computational neuroscience including fMRI, EEG, and eye-tracking. His most recent work investigated the neural underpinnings of strategic decisions and the process of individual choice in cooperative situations.

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Dr Tom Marshall | Assistant Professor in Psychology (Multimodal Neuroimaging)

Tom Marshall completed his PhD at the Donders Institute in Nijmegen, followed by a postdoc at the Wellcome Centre for Integrative Neuroimaging, University of Oxford. Tom's postdoctoral work focused on the role of frontal and parietal cortex in decisions to move the eyes, combining biophysical modelling, neuroimaging, and transcranial brain stimulation. Tom joined the School of Psychology as an Assistant Professor in 2023.

Tom Marshall is a computational cognitive neuroscientist interested in neuronal oscillations; rhythmic patterns in the brain that allow its different parts to work together to enable cognitive functions like attention, memory and decision-making. By combining biophysical modelling with neuroimaging, Tom's research programme seeks to understand how we can alter and optimise oscillatory activity by stimulating the brain to improve our cognition and health. Tom is also interested in improving the ways we analyse and visualise brain data to make neuroscience more reproducible and reliable.

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Dr Paul Muhle-Karbe | Assistant Professor in Psychology

Dr Muhle-Karbe obtained a Diploma in Cognitive Neuroscience from the Humboldt University of Berlin and a PhD in Experimental Psychology at Ghent University under the supervision of Prof Marcel Brass. He then undertook postdoctoral research at Duke University (with Professor Tobias Egner), and Oxford University (with Professor Mark Stokes and Professor Christopher Summerfield), funded by fellowships from the Wellcome Trust, Research Foundation Flanders, and Linacre College Oxford. In 2022, he joined the School of Psychology and the CHBH as Assistant Professor.

Dr Muhle-Karbe's Computational Cognitive Neuroscience lab studies the building blocks of human intelligence. He focuses on basic cognitive functions, such as attention, planning, or working memory, that underpin most forms of higher cognition and that are essential for mental health. He builds computational models to formalise different ways in which neural circuits could implement these functions and uses brain imaging to work out which mechanism the human brain actually uses. His vision is to build precise mechanistic theories that specify how the brain forms, maintains, and uses flexible representations for goal-directed behaviour, and to translate these theories to better understand human development as well as atypical brain function in mental illness.

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Dr Barbara Pomiechowska | Assistant Professor in Psychology

Barbara Pomiechowska completed her PhD at Birkbeck, University of London, advised by Dr Teodora Gliga. She then held postdoc positions at Central European University, advised by Professor Gergely Csibra and Dr Agnes Melinda Kovacs. She joined the University of Birmingham in May 2023.

Barbara is a developmental cognitive neuroscientist with expertise in infancy and early childhood.

Her work aims to understand human learning and creativity. She studies how we learn (sometimes very abstract things such as maths, genetics or neurochemistry), how we create new knowledge and use what we know in innovative ways.

Barbara is fascinated by the powerful learning abilities of infants and young children. She believes they can teach us a great deal about the nature of human learning and the origins of our knowledge.

She investigates how infants acquire new concepts and develop new skills, and how these processes are implemented in the developing brain.

She uses infant- and child-friendly neuroimaging techniques, eye tracking, and behavioural experiments.

Her long-term objective is to contribute to improving early education by translating the insights from experimental work into policy and educational practice.

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Dr Andrew Quinn | Assistant Professor in Psychology

Dr Andrew Quinn completed his PhD in 2014 at the University of York under the supervision of Professor Gary Green and Professor Piers Cornelissen. He then moved to Oxford to work as a postdoctoral scientist with Professor Kia Nobre and Professor Mark Woolrich at the Oxford Centre for Human Brain Activity (OHBA). Following eight years at OHBA, Dr Quinn started as an Assistant Professor at the University of Birmingham in 2022.

Andrew Quinn works on time-series analysis methods for electrophysiological recordings of brain activity. He specialises in analysis of neuronal oscillations and how we can go beyond standard analysis approaches to better quantify dynamic, non-linear, and network features of neuroimaging datasets. These methodological approaches are developed alongside software and statistics to enable straightforward application to new datasets. Dr Quinn applies these methods to research questions such as how complex sounds are perceived and how rhythmic brain activity changes across the lifespan and in neurodegenerative disorders.

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Dr Lei Zhang |
Associate Professor in Psychology

Dr Lei Zhang received his PhD (summa cum laude) with Dr Jan Gläscher at the Institute of Systems Neuroscience, University Medical Center Hamburg-Eppendorf, Germany. Between 2016 and 2017, he was a Roche intern for Scientific Exchange (RiSE) at F. Hoffmann-La Roche AG, and then completed a postdoc with Professor Claus Lamm at the Social Cognitive and Affective Neuroscience Unit (SCAN-Unit), University of Vienna. Dr Zhang joined the Centre for Human Brain Health as an Associate Professor in winter 2022.

We live in a complex social environment, and we are able to flexibly adapt our behaviours to such highly dynamic social contexts. However, it is striking that we lack a comprehensive understanding of the computational mechanisms underlying these social behaviours, and how our brain implements the computation of social information. Lei's interdisciplinary research addresses the fundamental question of the 'adaptive brain' by studying the cognitive, computational, and neurobiological basis of social learning and decision-making in healthy individuals and in psychiatric disorders (i.e. Computational Psychiatry).

At the CHBH, combining state-of-the-art neuroimaging and computational modelling, Lei is developing an independent line of research to:

1. Establish a comprehensive understanding of the neurocomputational underpinnings of decisions and flexible learning under social and non-social contexts
2. Assess the maladaptation and dysfunction of such processes within psychiatric disorders such as autism and mood disorders
3. Characterise potential biomarkers that will inform precise diagnoses and personalised interventions. Lei's long-term goal is to examine the same computational problems with a highly translational approach across developmental stages. This research will precisely characterise cognitive processes in an individual, and provide new computationally informed insights into psychiatric disorders.

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Research highlights
Past, present and future research in the CHBH

Reimagining 'muscle memory': Insights from an fMRI study challenge common beliefs

CHBH research theme: Learning, memory and performance

Understanding the neural control of skilled movements is important for effective training and neurological rehabilitation, e.g. of stroke and Parkinson's patients. There is a common assumption that skilled sequences produced from memory become automatic – a 'muscle memory' controlled as one integrated action, e.g. a handwritten signature or a password on a computer keyboard.

However, recent fMRI findings published in the Journal of Neuroscience by CHBH Principal Investigator Katja Kornysheva and PhD student Rhys Yewbrey revealed that motor areas in the human brain automatically separate out the order and timing of movements when participants retrieve a skilled sequence from memory. This happens very rapidly and automatically in the hundreds of milliseconds before the action starts and each time a movement sequence is retrieved from memory. In contrast, the integration of movement timing and order can be observed in those brain areas only during movement production.

Researchers believe that the brain separates sequence order and timing as 'what' elements representing higher-level control of action, which are then combined to define 'how' exactly the task should be performed. This separation of a skill into its constituent features might help us to stay adaptable for rapid adjustments e.g. if we need to change the speed or timing of movements of an upcoming action. These new results will help us to better understand how everyday skills such as typing, tying shoelaces, and playing a musical instrument are stored and controlled by the brain, and how they can be made flexible and resilient through targeted training.

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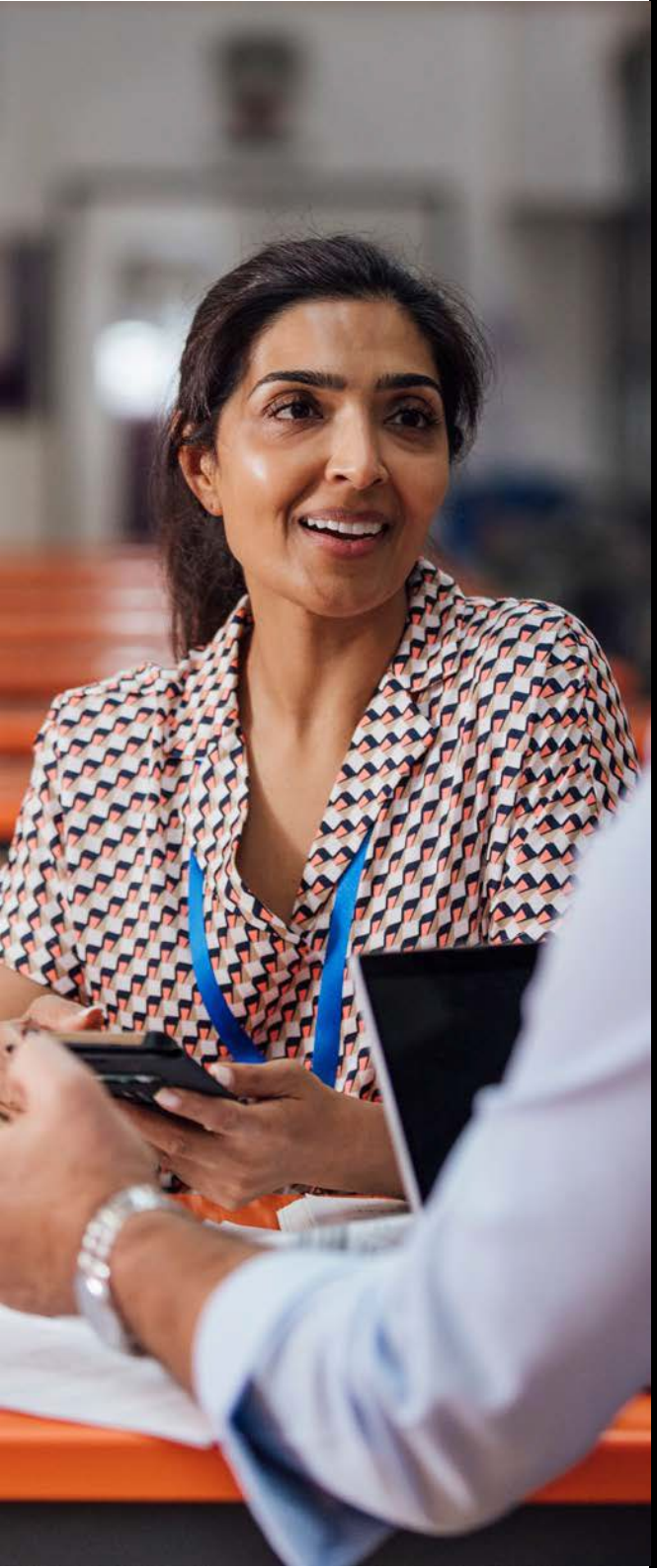
The press release for this article can be found here: **bit.ly/brainzip**

Yewbrey, R., Mantziara, M. and Kornysheva, K. (2023). Cortical patterns shift from sequence feature separation during planning to integration during motor execution. Journal of Neuroscience. [online] doi:https://doi.org/10.1523/JNEUROSCI.1628-22.2023.



Dopamine helps in identifying emotions

CHBH research theme: Learning, memory and performance

Body language quickly communicates how we feel: we tend to walk slow when sad and fast when angry. Recognising body language cues can be difficult for people with particular clinical conditions such as Parkinson's Disease, Schizophrenia and Tourette's Syndrome. One thing these conditions have in common is they have all been linked to differences in the functioning of the dopamine system. In a recent study we asked: Is dopamine causally involved in recognising emotions from body language cues?

33 healthy adult volunteers took 2.5mg of a dopamine receptor blocker called haloperidol and completed an emotion recognition task. On a separate day they did the task under placebo. To shed light on potential mechanisms underlying any drug effects, participants also completed timing and body movement tasks.

We saw that changing the function of the dopamine system causally affected emotion recognition, but this depended on baseline dopamine function. For those with low estimated dopamine levels, haloperidol enhanced their ability to recognise emotions. In contrast, haloperidol diminished emotion recognition for people with high baseline levels. These effects were linked to effects of the drug on individuals' ability to process time, thus suggesting that dopamine may influence emotion recognition via its effects on temporal processing.

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Schuster, B.A., Sowden, S., Rybicki, A.J., Fraser, D.S., Press, C.A., Holland, P.V. and Cook, J. (2022). Dopaminergic Modulation of Dynamic Emotion Perception. *The Journal of Neuroscience*, 42(21), pp.4394–4400. doi:https://doi.org/10.1523/jneurosci.2364-21.2022.

Research highlights
Past, present and future research in the CHBH

Kids and teens learn differently from actions and punishments but not reward

CHBH research themes: Cognitive computational neuroscience, social interaction and communication

Adolescence is a phase of life thought to be marked by a stronger reaction to rewards and acting on impulses. However, it's tricky to tell if the way people learn from rewards is different from just being impulsive based solely on their behaviour. Using computational modelling helps us go beyond just observing behaviour. It lets us figure out the cognitive processes that drive how people make decisions. In a recent study, we looked at how young people in different age groups learn from rewards and punishments and how impulsive actions change as they get older. We gave a learning task to 742 kids and teenagers (aged 9 to 18) from 11 European countries. They had to learn by deciding whether to press a button or not when shown different shapes. Pressing the button was the right choice for some shapes, which got them a reward.

Not pressing was better for other shapes, which avoided losing points. Surprisingly, we found that while the ability to learn from rewards stayed the same, learning from punishments got better as kids got older. At the same time, acting on impulsive urges became less common as they grew up.

This shows that the seemingly stronger response to rewards during teenage years could sometimes be due to impulsive behaviour rather than better learning about rewards.

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Pauli, R., Brazil, I., Kohls, G., Klein-Flugge, M., Rogers, J. C., Dikeos, D., ... De Brito, S. & Lockwood, P. L. (2023). Action initiation and punishment learning differ from childhood to adolescence while reward learning remains stable. *Nature Communications* (Accepted), doi: https://doi.org/10.1101/2022.05.05.490578

Developing markers that can accurately predict outcome after mild Traumatic Brain Injury

CHBH research theme: Lifespan and brain health

This year saw the start of participant testing for mTBI-PREDICT, a large multi-site study aimed at identifying biomarkers to predict outcome after mild Traumatic Brain Injury (mTBI). mTBI, commonly referred to as concussion, accounts for 1.4 million hospital visits annually in the UK. Almost one third of those affected develop long-term aftereffects, including persistent headaches, cognitive deficits ('brain fog'), and poor mental health, and are unable to return to work even years after the injury. mTBI-PREDICT will assess up to 800 patients over eight years with a comprehensive programme of clinical and neuroscientific methods to learn how to best identify those who are at risk of long-term complications, so appropriate clinical resources can be allocated to them. With funding from the Ministry of Defence, the CHBH is leading on the development of magnetic resonance imaging (MRI) and magnetoencephalography (MEG) biomarkers, in collaboration with colleagues at the University of Nottingham's Sir Peter Mansfield Imaging Centre and Aston Institute of Health and Neurodevelopment. Biomarkers are objective and quantifiable measures that indicate a clinical state. Before they can be used for clinical decision making, it is crucial to demonstrate that they are accurate and reproducible, that is, they give the same answer if measured more than once or with different equipment. This year our team of five postdoctoral researchers, two research assistants, and nine principal investigators are working to identify the most reproducible markers to be subsequently assessed in our 800-patient cohort.

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More information on MTBI-PREDICT can be found at: **bit.ly/mtbipredictuob**

Research highlights

Past, present and future research in the CHBH

Promoting open science and replicable research

CHBH research theme: Neuroimaging methods and AI

At the CHBH, Magnetoencephalography (MEG) is a brain imaging technique used for clinical and cognitive neuroscience research. Signal processing and source modelling are essential components of this technique. Despite the availability of several community-developed toolboxes, the many options can pose a challenge for reproducible research and researchers new to the field. To address this, the FLUX pipeline has been developed to make analysis steps explicit for standard analysis in cognitive neuroscience. MNE Python, a Python toolbox, is used in the pipeline, and a data set on visuospatial attention is used to illustrate the steps. MNE Python is a free alternative to other toolboxes which rely on costly software like Matlab. The FLUX pipeline aims to democratise research by providing state-of-the-art analysis tools to researchers who may not be able to afford Matlab.

The instructions in FLUX are implemented in Jupyter, providing justifications and graphical outputs for each essential step. Additionally, suggestions for text and parameter settings are provided to improve replicability and facilitate pre-registrations. The FLUX pipeline is designed to be used for education, either in self-studies or workshops. We hope that the FLUX pipeline will standardise basic analysis steps and strengthen the field of MEG. Furthermore, education and training will be provided to support new researchers entering the field. We are currently working on a clinical version of the FLUX pipeline, providing guidance for translational MEG research.

More information on FLUX can be found at: neuosc.com/flux

Ferrante, O., Liu, L., Minarik, T., Gorska, U., Ghafari, T., Luo, H. and Jensen, O. (2022). FLUX: A pipeline for MEG analysis. *NeuroImage*, [online] 253, p.119047. doi:https://doi.org/10.1016/j.neuroimage.2022.119047.

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Individual bilingual experiences and their effects on cognitive control **CHBH research theme:** Social interaction and communication

Being bilingual does not only mean one can communicate in more than one language. Like other intensive experiences, bilingualism also leads to adaptations of the brain. Maybe not surprisingly, changes occur in language areas of the brain. However, juggling two languages is cognitively highly demanding. Bilingualism therefore also leads to changes in brain areas associated with domain-general cognitive control. Related to this, bilingualism seems to train cognitive control, as bilinguals often outperform monolinguals on cognitive control tasks.

What is often ignored is that bilingualism is a multi-dimensional phenomenon, with variations such as intensity and diversity of language usage and duration of second language use. In our study with 239 speakers, with a wide variety of language experiences, we revealed for the first time how individual differences in bilingual experience lead to adaptations in brain functioning which in turn affect cognitive control behaviour.

Frequent language switches and using two languages in diverse environments showed reduced neural control demands, which was beneficial for the control of interference in an attention task. In contrast, duration of bilingual engagement showed increased control demands and was detrimental to interference control. Our study exemplifies how the complexity of individual experiences, here bilingual experiences, plays a fundamental role in brain function.

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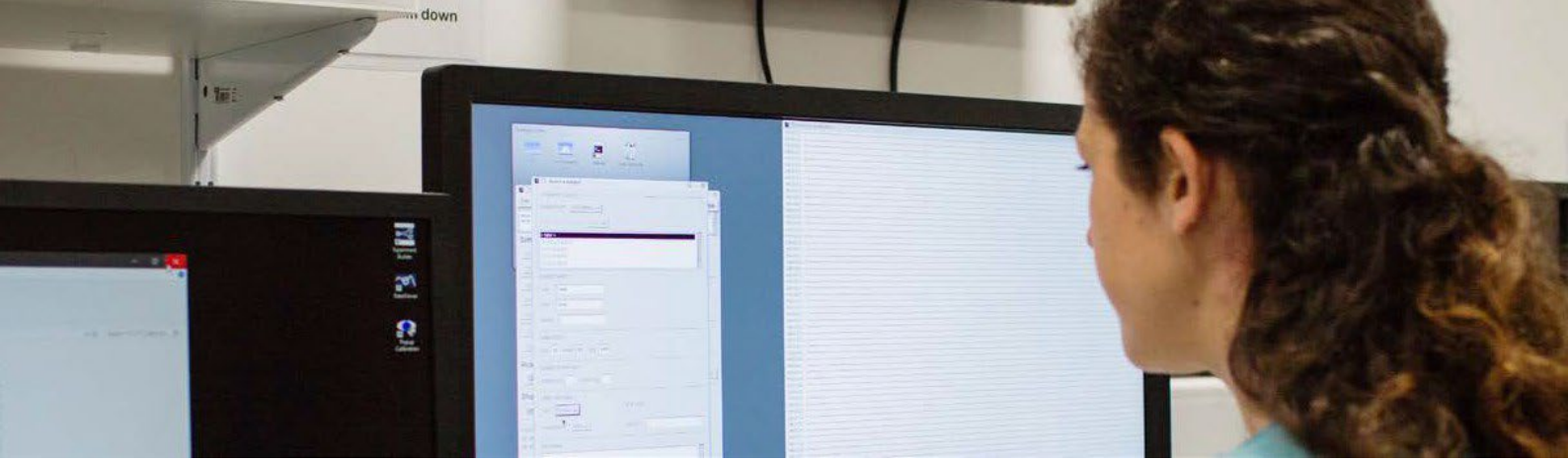
Carter, F., DeLuca, V., Segaert, K., Mazaheri, A. and Krott, A. (2023). Functional neural architecture of cognitive control mediates the relationship between individual differences in bilingual experience and behaviour. *NeuroImage*, [online] 273, p.120085. doi:https://doi.org/10.1016/j.neuroimage.2023.120085.



Research highlights Past, present and future research in the CHBH

The next generation of brain-computer interfaces

CHBH research theme: Neuroimaging methods and AI

A Brain-Computer Interface (BCI) is a computer-based system that can be used in assistive technologies and in clinical applications. Development of BCI requires brain imaging and computing equipment alongside expertise in multiple disciplines including human neuroscience, computer science, engineering and therefore, the CHBH is an ideal place to develop and implement such systems.

The underlying principle of BCI is based on our ability to voluntarily change electromagnetic activity of the brain by performing mental 'actions'. For instance, one could control the position of the cursor in a video game by simply shifting their attention in the desired direction, and BCI only needs to decode the direction of attention from electromagnetic activity of our brain and translate it into a computer command (e.g. move cursor to the right).

Following this idea, Dr Marion Brickwedde and I developed a novel approach where the brain activity was first enhanced by invisible visual flicker and then this activity was accurately mapped using 306 magnetoencephalography sensors. Our BCI demonstrates a number of advantages over traditional systems including lower fatigue and higher communication speed. Crucially, this system provides a lower chance of provoking a seizure and therefore, has potential for a wider range of applications.

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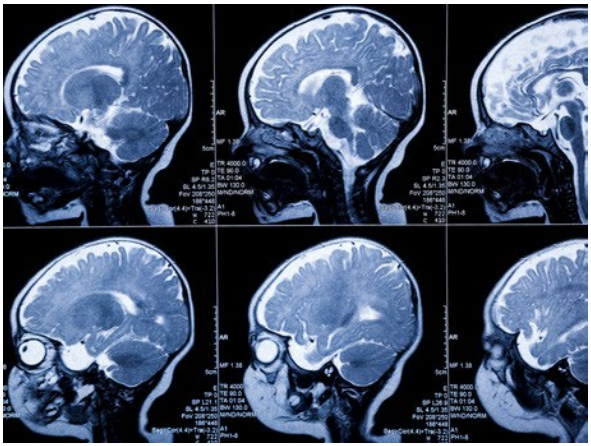
Brickwedde, M., Bezsudnova, Y., Kowalczyk, A., Jensen, O. and Zhigalov, A. (2022). Application of rapid invisible frequency tagging for brain computer interfaces. *Journal of Neuroscience Methods*, [online] 382, p.109726. doi:https://doi.org/10.1016/j.jneumeth.2022.109726.

The helpful brain: how your brain chooses to work hard for others

CHBH research theme: Social interaction and communication



Every day we make lots of decisions about whether to help somebody else out. Do you hold the door open for the stranger behind you, or help a friend move boxes into their new home? A lot of these 'prosocial' acts require us to think about whether we are willing to put in the effort for another person to benefit. However, how the brain makes these prosocial choices and whether there is a part of the brain that is involved in making them only when other people benefit from the effort, was unknown. In this study we used functional MRI to measure patterns of activity in people's brains when they made decisions about whether to exert different amounts of effort to help win themselves money or to win money for a stranger.

We found that there is a specific part of the brain, the anterior cingulate gyrus (ACCg), that is involved in making decisions, and motivating us, to exert effort when another person will benefit. But this brain area isn't involved when we make decisions about whether to exert effort to benefit ourselves. These results provide a new understanding of what in people's brains makes them be helpful to others.

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sdn-lab.org

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Research highlights Past, present and future research in the CHBH

What makes us conscious (and what does not)?
CHBH research theme: Awareness, consciousness and sleep

The nature of our conscious experience poses an intriguing question in neuroscience: How does the brain generate our experiences? What causes the absence of conscious awareness, such as during sleep or after severe brain injuries?

Dr Oscar Ferrante, a Postdoctoral Researcher at CHBH, is part of the COGITATE consortium (arc-cogitate.com), an international project focused on testing the predictions of two prominent theories of consciousness using an adversarial collaboration approach. Recently, the consortium presented the final results of the first experiment at a public event in New York City during the annual meeting of the Association for the Scientific Study of Consciousness. These findings, which are openly available online, revealed the specific strengths and weaknesses of the two theories, providing valuable insights for future research and inspiring new avenues of exploration. Notably, the project has garnered significant media attention, with prominent coverage by *The Economist* and *The New York Times* (arc-cogitate.com/press).

Dr Damian Cruse, an Associate Professor at CHBH, applies this foundational knowledge to the challenging clinical situations that arise in the Intensive Care Unit (ICU). After the most severe types of brain injury, many patients will awaken in the ICU to a state of disordered consciousness, where it is unclear whether they are conscious of themselves or their surroundings. By measuring patients' brain responses to external stimuli, Dr Cruse and his team search for theory-driven evidence of consciousness that may be hidden from standard clinical assessments, thus helping ensure the most appropriate clinical decision-making.

By combining fundamental theoretical approaches with clinical translation, the CHBH is at the forefront of both improving our understanding of the human experience and improving patient care around the world.

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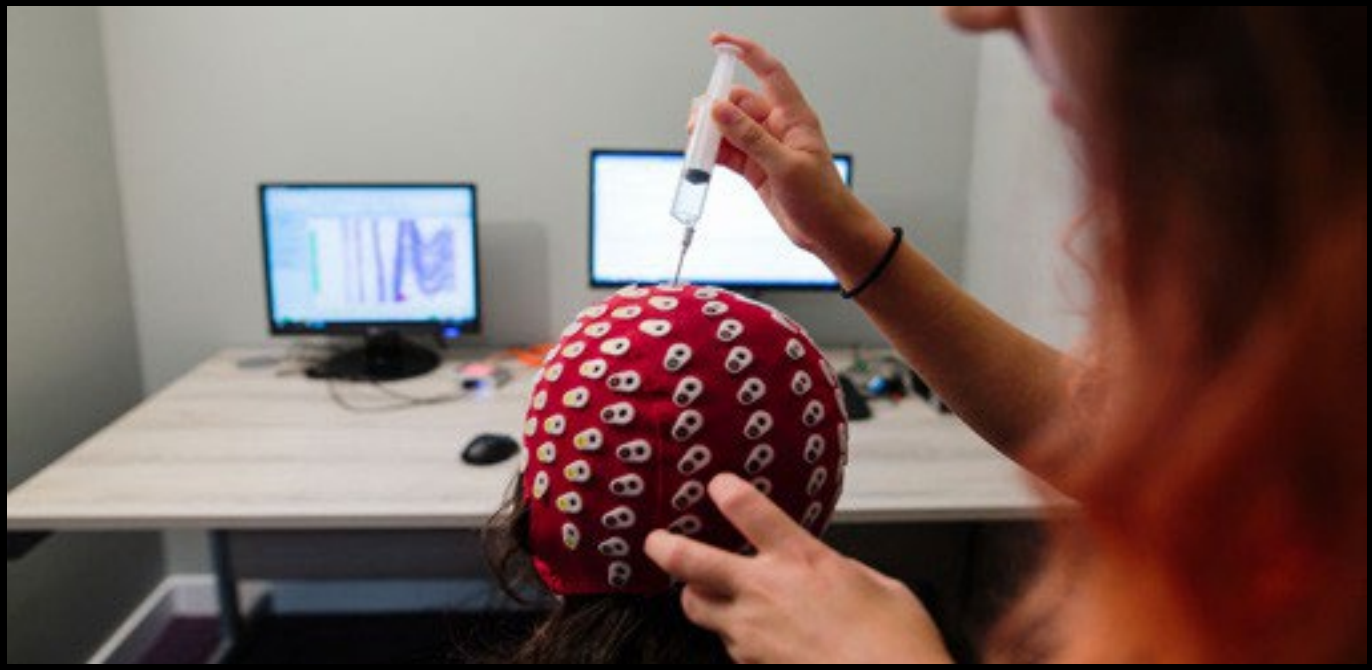

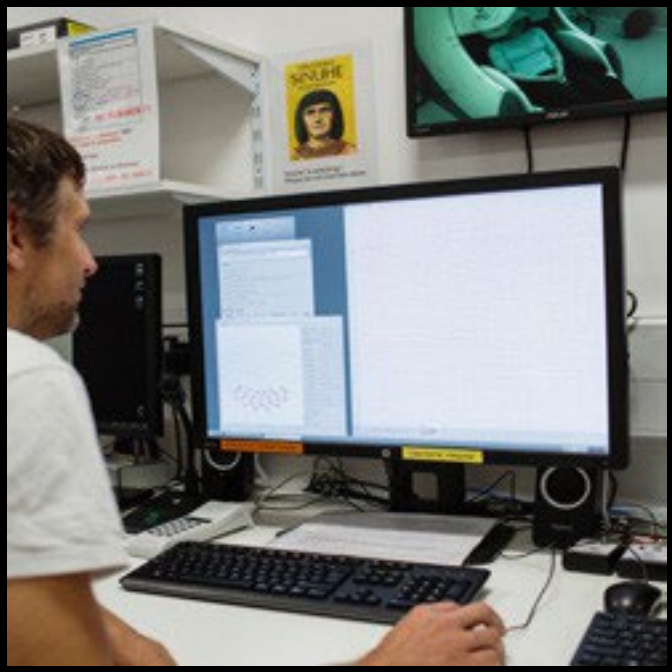

Research highlights Past, present and future research in the CHBH

Non-invasive electrical stimulation to restore responsiveness after severe brain injury

CHBH research theme: Awareness, consciousness and sleep

Patients in prolonged disorders of consciousness (PDOC) such as the vegetative state are presumed to be entirely unaware of themselves and their surroundings. While this is indeed the case for most patients, up to 20% retain high levels of cognitive functioning and awareness and are simply unable to demonstrate this behaviourally, trapped in their unresponsive bodies. This catastrophic disability is in many cases permanent and there are no available therapies to improve outcome. To address this, we are developing non-invasive brain stimulation protocols that can be combined with physical rehabilitation to restore external responsiveness in this challenging patient group.

As a first step, and with funding from the Medical Research Council, we conducted a series of studies (involving over 800 hours of MRI testing!) where we assessed whether transcranial direct current stimulation (tDCS) can successfully modulate the brain networks known to be associated with external responsiveness in PDOC. For example, in a recent study, a group of healthy participants received five consecutive sessions of stimulation with each of two modulatory conditions and a placebo condition while receiving a simple mobilisation intervention in the MRI scanner. We also recorded their brain activity while they voluntarily moved their thumb in response to external instructions. We showed that tDCS can indeed enhance the brain dynamics associated with responsiveness in PDOC. We started this work by testing healthy volunteers to develop a good understanding of the mechanisms underlying our proposed stimulation protocols. As a next step, we are now testing our protocols in PDOC patients themselves in an exciting collaboration with the Wellington Hospital in London (RAINDROP trial).

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The press release related to the commencement of this study can be found here **bit.ly/raindroptrial**

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Celebrating our early career researchers

CHBH PhD Paper of the Year 2022

Dr Alicia Rybicki | Dopaminergic challenge dissociates learning from primary versus secondary sources of information in *eLife*, 2022

'It was a great honour to win the CHBH PhD Paper of the Award. This paper, which marked the culmination of several years of work by both my PhD supervisor, Professor Jennifer Cook, and me, was published at the end of my PhD. Huge thanks to Jen, and to all collaborators from the Cook Lab! I also want to thank all the participants and the support staff in CHBH, without whom this study and paper would not have been possible. Their involvement and assistance were instrumental in carrying out this research. I hope to build on this work in my new role in the near future in the Motivated Cognition Lab, with future research focusing on further exploring the role of dopamine in cognition.'

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CHBH Postdoctoral Paper of the Year 2022

Dr Ruth Pauli | The computational psychiatry of antisocial behaviour and psychopathy in *Neuroscience & Biobehavioral Reviews*, 2022

'I was very happy to win the CHBH Postdoctoral Paper Award for my recent paper with my previous postdoctoral supervisor, Dr Patricia Lockwood. We wrote the paper because we wanted to draw attention to the importance of a transdiagnostic approach to antisocial behaviour across the lifespan, and it was great to have the importance of this topic recognised by the CHBH Paper Award Committee. I would like to thank Dr Patricia Lockwood for collaborating with me on this paper as senior author, and for her supervision and support with my work more broadly. I hope this paper will be useful for others working on antisocial behaviour and computational modelling.'

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Embarking on a PhD: Experiences unveiled

We asked two of our current PhD students about their research and experiences in the world of academia so far

Maille Gracey | Understanding facial expression recognition in people with Parkinson's

As a PhD student supervised by Professor Jennifer Cook, I focus on facial expression recognition in Parkinson's Disease. My ambition was driven by a personal connection as my mum has Huntington's Disease, thus I am dedicated to enhancing understanding of neurodegenerative conditions.

My initial study examined facial expression recognition in people with Parkinson's (PwP). I found that when PwP were off their dopaminergic medication they had challenges recognising happiness. As a result of this, I'm now gearing up for a second study in collaboration with Professor Jennifer Cook, Dr Clayton Hickey, and Dr Alicia Rybicki. This investigation, conducted at the CHBH, involves acquiring data from participants via a visual perception task, using the MEG laboratory, and aims to unravel why facial expression recognition appears to be different for PwP.

My PhD journey has been marked by several highlights, including delivering presentations at international conferences in Madrid and St. Pete Beach, Florida. Notably, I secured the Best Seminar Presentation accolade at the Midlands Integrative Biosciences Training Partnership Symposium 2023. Looking ahead, my aspiration is to advance the literature on why facial expression recognition is different for PwP.

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Harry Cook | Designing new quantum sensors for neuroscience applications

Since joining the Quantum Neuroscience lab in late summer 2022, the past year has been a blur of exhilarating scientific exploration. To have access to state-of-the-art equipment in a new lab is a physicist's dream, and I feel incredibly lucky to be putting it all to use.

Our aim is to build new types of Optically Pumped Magnetometers (OPMs), an exciting technology that allows us to measure the brain in new and improved ways. Our recent focus involved building a gradiometer, which precisely gauges the surrounding magnetic field, isolating brain signals from interference like vehicles and lifts. My first major responsibility for this sensor was to develop the heating system, which now works successfully and has enabled us to measure the brain.

My journey here was rather linear, having pursued an Undergraduate Master's degree in Physics at the University of Nottingham, renowned for its applied medical physics legacy. There, I gained hands-on experience with some of the first OPM sensors built for neuroscience. This then led me to my current PhD studentship at CHBH, which is an incredible opportunity. I am also a member of the wider, interdisciplinary Neuronal Oscillations group which allows me to collaborate with future users of our technology such as prominent neuroscientists, and in turn provides invaluable insights when developing physics tools with a distinct human focus.

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Event and engagement spotlight

UoB-Netherlands workshop on development and decision-making

The University of Birmingham School of Psychology's Centre for Human Brain Health, Institute for Mental Health and Centre for Developmental Science recently hosted a workshop with colleagues from across universities in the Netherlands. The workshop was attended by the European Research Council Vice President Professor Eveline Crone as well as researchers from Leiden University, the University of Amsterdam and the Erasmus Medical Centre in Rotterdam. Conference delegates worked together in a micro-seed funding round table to generate five new collaborative groups of researchers. Symposia were held on key topics of overlap including development, mental health and decision-making. We are excited to foster further links and collaboration through a future joint Summer School.

Forging connections beyond the brain

Every year, hundreds of individual participants step through the doors of the CHBH, generously volunteering their own time to propel our understanding of the brain. Often invited to solo sessions, many may never get the chance to meet others from research studies they were part of.

On less-frequent occasions, certain studies offer a unique opportunity to bring together such participants from a particular project to share experiences and socialise. The main volunteer cohort for the Fitness, Ageing and Bilingualism (FAB) study got together earlier this year to do just that. Their 'FAB Reunion' allowed researchers to share findings from the study, as well as showcasing future research opportunities volunteers may be eligible for at the CHBH and University in the coming years. Over food and refreshments, volunteers also had the opportunity to share their experiences and even formed a longer-term social media group to keep in touch beyond the study itself.

Such occasions are a wonderful reminder of the profound impact research can have, beyond the physical testing, data analysis, and results publications. Funded by the Research Council of Norway, the FAB study investigates how physical exercise might bestow protection against age-related decline in cognition.

To find out more about the FAB study, visit their website **fab-study.com**

Quantum Neuroscience: Inauguration of the OPM facility at the CHBH

Last year was eventful for the Quantum Neuroscience (QN) Group. We were given lab space in the Gisbert Kapp basement, our magnetically shielded room has been assembled, and we moved to the new facility. Additionally, thanks to funding from the University's College of Life and Environmental Sciences and the School of Psychology, we acquired a commercial OPM-MEG system consisting of 70 sensors and a smart helmet.

To celebrate and officially kick-off the OPM Lab, we hosted a symposium: 'Quantum Neuroscience: Inauguration of the OPM facility at the CHBH' on 13th of October 2022. We invited UK leaders in OPM research as well as our CHBH collaborators to present their research outcomes and directions. Dr Anna Kowalczyk started the event by presenting overall research directions of the QN group. Our guest lecturer Professor Lauri Parkkonen from Aalto University discussed what OPM-MEG can do for neuroscientists. Professor Gareth Barnes showed the progress his group at University College London is making towards brain and spinal cord recording during natural behaviour. Dr Elena Boto (University of Nottingham) discussed triaxial OPMs as the next generation of OPM-MEG and Professor Erling Riis from the University of Strathclyde presented overall progress of OPM development using MEMS cells in the magnetometry branch of the Quantum Hub. Our own Dr KyungMin An showed her results on auditory response recordings with OPM systems and Dr Lari Koponen discussed our progress towards TMS-MEG with OPMs.

This event attracted around 100 participants from various disciplines and the Queen Elizabeth Hospital Birmingham. It was a great opportunity to demonstrate the technology developments and innovations carried out in the UK in the OPM field and showcase to our neuroscientists and clinicians what OPMs have to offer right now. We also discussed the current challenges but also brainstormed new research ideas to keep the QN lab busy for the next few years!

Keep up-to-date with the latest on what the CHBH's Quantum Neuroscience Group are up to: @QN_lab

Reflecting on Brain Awareness Week 2023 at the Midlands Art Centre

Researchers from the University of Birmingham's CHBH, Medical School (Neuroscience, Trauma and Ophthalmology) and School of Biosciences (Alicia Hidalgo Lab) once again came together to introduce the public to the enlightening mysteries of our most vital organ, as part of the international Brain Awareness Week (BAW) celebration.

Researchers met with the next generation of scientists and their families at the Midlands Art Centre and engaged in the following activities:

- Participate in a live study about touch
- Experience the 'Rubber Hand Illusion'
- Medical neuroscience: Neurodegeneration, brain trauma, tumours and trials
- Brainiversity Challenge
- Looking into the brain of a fly to understand our own
- The CHBH in MINI: take a look at our labs in 3D!
- Brain-Boosting Crafts for Kids
- Sign-up for future brain studies!

We give thanks to CHBH Postdoctoral Fellow, Dr Syanah Wynn, and the Dana Foundation/the Federation of European Neuroscience Societies for supporting this event, which enabled us to obtain vital resources to ensure this engagement was a success.

To catch-up on posts about the activities over the years, search #UoBBAW on X/Twitter.

Impact on education

MSc Cognitive Neuroimaging and Data Science

Since its inception, the CHBH has been at the forefront of research-led teaching, providing in-house training in cognitive neuroscience and multimodal imaging for both undergraduate and postgraduate students. 2023 marks the start of a new chapter in education at the CHBH. In December 2023, the last cohort of the Brain Imaging and Cognitive Neuroscience (BICN) MSc students will graduate. Since the CHBH opening, the BICN MSc has been the flagship programme affiliated with the Centre and runs alongside other MSc programmes at the School of Psychology. But from September 2023, the CHBH will be offering a new MSc programme, Cognitive Neuroimaging and Data Science (CNDS). As the CHBH grew, welcoming new staff and opening new research facilities, it was time to re-think our approach to education, aligning teaching even closer to not only our research themes but also our research philosophy of transparent and reproducible science, supported by open-source programming. CNDS MSc students will not only get hands-on experience with various neuroimaging tools (MRI, MEG, OPM, EEG, brain stimulation and fNIRS) housed at the CHBH, but also learn how to apply programming skills to analyse big and multimodal (neuroscientific/neuroimaging) data.

The new MSc programme has three unique features, with students having opportunities to:

1. Create a bespoke learning pathway by taking either a more cognitive or computational focus on neuroscience
2. Learning through small group teaching and hands-on experience
3. Develop data science skills transferable to other academic disciplines and applicable to commercial data science applications

Dr Magda Chechlacz | Assistant Professor in Cognition and Ageing and CHBH Education & CNDS MSc Programme Lead
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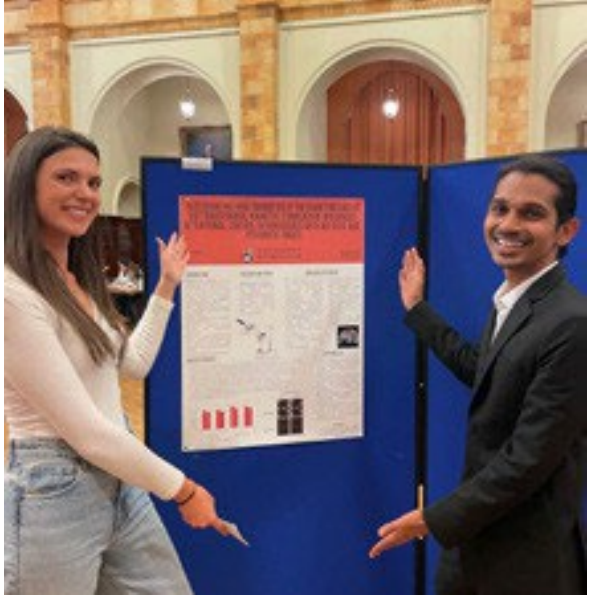

365 days of TMS, MRI and me!

During the past academic year, I had the distinct honour of collaborating with Dr Carmel Mevorach in the Transcranial Magnetic Stimulation (TMS) lab for my MSc dissertation. My focus was on delving into the role of the precuneus brain region in atypical attention control, especially concerning autism spectrum disorder and the sub-clinical psychosis population, using TMS. Coming from a Clinical Psychology background, this exploration was particularly enlightening and rewarding.

Furthermore, I provided mentorship to undergraduate students, guiding them in collecting and pre-processing MRI scans for their TMS projects as an MRI General User at the CHBH. Another highlight was assisting a dedicated PhD student in gathering EEG-TMS combined data across various studies. These experiences have culminated in the drafting of my PhD proposal in collaboration with CHBH researchers, aiming to venture into computational psychiatry using integrated neuroimaging methods.

My year at the University of Birmingham was not confined to the lab, I embraced opportunities to engage with the public, too! I proudly represented the School of Psychology at the Postgraduate Open Day and took an active part in Brain Awareness Week 2023. As the year draws to a close, I have also cherished the opportunity to mentor summer school interns, sharing insights about my MSc project and the transformative potential of TMS in clinical neurosciences.

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Inspiring the next generation of neuroscientists, work experience at the CHBH

This summer, the CHBH and its faculty had the privilege of welcoming a diverse cohort of work experience students, spanning from high schoolers to undergraduates. Through meaningful collaborations with programmes such as the SURE scheme and in2science, we take immense pride in fostering an environment that empowers and inspires youth from varied backgrounds to contemplate the realms of psychology and neuroscience research as they shape their future career horizons. Hear from a few of our work experience cohorts from this year below.

Tanisha Chauhan, undergraduate student

The placement captured my interest because it centred on a topic that resonated with me personally, fostering. This placement gave me hands-on experience in conducting experiments, analysing data, and contributing to meaningful discoveries about the brain's complexities.

The CHBH is renowned for its ground-breaking research, which provided me with invaluable insights into the field and allowed me to develop a wide range of skills that will undoubtedly shape my future career.

I've found a lot of enjoyment in participating in studies that involve the MRI scanner. It's given me a first-hand glimpse into the world of radiography and the chance to interact with a 3T MRI machine, which has been fascinating.

While I do not have concrete plans for my future at the moment, I am inclined towards a more clinical path, potentially within a hospital setting, focusing on the field of neuroscience.

Kimran Cheema, high school student

During my time at the Centre of Human Brain Health, I have gained significant knowledge and advice from the various researchers I have spoken to, about not only their aims and what they hope to achieve through their ground-breaking research, but the processes that they had undergone to attain their positions within their fields. This gave me a thorough insight into what I aspire to pursue in the future within the field of Psychology. By being given an understanding of the various impressive laboratories used to accommodate all research associated with the Centre, I have chosen to follow the path of Neuropsychology. Overall, it was an incredible experience and has educated me thoroughly into the various aspects of Psychology.

Overall, it was an incredible experience and has educated me thoroughly into the various aspects of Psychology.

Christabell Akuffo, undergraduate SURE student

I had the privilege of participating in the SURE placement, contributing to a research team investigating impulsivity in children. The prospect of applying the skills I've developed through my research methods modules in real-world settings and gaining practical experience in psychology attracted me to this opportunity. My interest was further piqued by the chance to make meaningful contributions to impactful psychological research.

> **I gained insights into various aspects of research including experimental design, data collection, entry, and participant recruitment.**

Throughout this experience, I acquired a diverse skill set such as coding in R studio, and using Excel more effectively. Additionally, I was fortunate to observe MRI procedure, enhancing my understanding of MRI safety protocols. Beyond the research setting, I enjoyed delivering engaging activities for visiting children on campus which was both fun and educational. This placement solidified my enthusiasm for psychological research, and I can now apply these new skills to my third-year research project and to further research endeavours in my future psychology career.

Intercalated BSc Human Neuroscience

In partnership with the University of Birmingham Medical School, each year the CHBH hosts medical students completing an intercalated BSc in Human Neuroscience.

These students pause completion of their medical degree for one year, commonly after the third year of their five-year programme, to complete the 1-year BSc.

They choose a set of academic modules offered by the Schools of Sport, Exercise, and Rehabilitation; Psychology; Biosciences; and Philosophy and complete a dissertation project under direct supervision of a CHBH faculty member.

This interdisciplinary programme is highly competitive, attracting academically strong medics with a view to future specialisation in fields like psychiatry and neurosurgery.

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Co-Directors

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Participate in brain research at the CHBH **birmingham.ac.uk/chbhvolunteer**

To find out more contact us **birmingham.ac.uk/chbh**

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