REF2021

Institution: University of Glasgow

Unit of Assessment:UoA4

1.Unit context and structure, research and impact strategy

Context, Structure, and Strategic Developments

UoA4 achieved an outstanding outcome in REF2014 by GPA of outputs. In terms of research power, we were equal first alongside University College London.

Since REF2014, we have been strategically expanded and now encompass four research centres. Three of these centres, namely *Cognitive Neuroimaging* (CCNi, comprising 16 PIs), *Neuroscience* (CforNS, 12 PIs) and *Social, Cognitive, and Affective Neuroscience* (cSCAN, 14 PIs) together form the Institute of Neuroscience and Psychology (INP). The fourth, *Mental Health and Wellbeing* (MHW, 14 PIs), is part of the Institute of Health and Wellbeing (IHW).

The **inclusion of the MHW research centre** constitutes an important expansion of UoA4's portfolio of research themes. Given that mental health has increasingly been in research, clinical and societal focus over recent years, a central component of UoA4's strategy over the current REF-period has been to enhance psychological science at the University of Glasgow (UofG) by developing more formal links with psychologists and psychiatrists at our cognate research Institute of Health and Wellbeing (IHW), thus working across mental health from molecular mechanisms to clinical interventions. Indeed, incorporation of MHW into both the return and, more importantly, into everyday interactions with staff and students from the three INP-centres has induced effective learning on ways to promote and develop impact from basic research, as well as on how to integrate findings, methods, and technologies from basic science into more applied research. For example, Gumley (MHW) has collaborated with Uhlhaas (CCNi) on research grants throughout this REF period, and Papies (cSCAN) has an ongoing collaboration with Pell (IHW) on recycling behaviours. This closer synergy between mental health-related research themes on the one hand and fundamental Neuroscience and Psychology on the other is also consistent with the broader strategic planning of the IHW's MHW research group (see further below).

An additional key strategy for the current submission has been to further develop the three research themes of *cognitive neuroimaging* within CCNi (with the new key development of **7T High-Field Imaging**), *social, cognitive, and affective neuroscience* within cSCAN (with the new crucial advancement of **Social Robotics**) and *neuroscience* within CforNS (with the new key development of **Animal MRI**, by merging with the Glasgow Experimental MRI Centre, GEMRIC). As a result of the above developments, UoA4 at UofG represents a Scottish hub for macro and meso imaging measurement technologies in the healthy brain that is also ideally suited for mental health research, incorporating unique platforms for social behavioural measures, stimulus generation, data science, and health informatics.

To facilitate sharing of best practice, and to enhance research-support across centres in general, we established three **Support Groups** within the current REF period, which thematically cut across all four Centres. These groups are the *Paper Writing* group, the *Grant Writing* group, and the *Methods and Statistics* group. Section 2 provides more detail on their roles, their organisation, and their contributions to our research culture.

Our unit's income strategy over the current REF period has focused strongly on **large, long-term individual awards** that can support the generation of 4*-research. This approach has been supported by the Grant Writing support group (Section 2) and was demonstrably successful, leading to, e.g., three Wellcome Investigator awards, six 5-year ERC awards, plus another 4 long-term awards, two from NIHR. Indeed, UofG is ranked 5th in the Russell Group for Research Income per FTE over the current REF-period for HESA Cost Centre 104 Psychiatry and Behavioural Sciences.

In addition, we further improved on REF2014 by **enhancing recruitment, support, and development of early career researchers** (ECRs), as is evidenced by 22 individual research

fellowships and by increasing the proportion of ECRs from 9% in REF2014 (3 ECRs out of 35) to 13% (7 ECRs out of 53) of total staff in REF2021.

The following sub-sections provide a more detailed account of strategic research, personnel, and infrastructure developments within each individual research centre:

Cognitive Neuroimaging (CCNi)

CCNi was recognised in REF2014 as being very strong, with particular strengths in **research on brain dynamics and brain oscillations**. CCNi's strategy in the current REF-period was to consolidate and expand its international reputation in cognitive neuroimaging research. We have built on our previous strengths by adding high-resolution imaging (7T) and interventional components (neuroimaging-guided brain stimulation), while using computational modelling for developing and applying new cognitive neuroimaging techniques. CCNi's mission is to unravel how information is communicated and represented in the human brain across the meso- and macro-scales, and to translate these developments into the health sectors. CCNi's total grant income has doubled from £7.6M to £15.6M since REF2014, and CCNi PIs can take advantage of a state-of-the-art equipment infrastructure (Section 3), which we expanded in the current REF-period as follows:

- In 2017, to maintain CCNi's internationally competitive edge in neuroimaging, the latest generation of 7-Tesla MRI scanners (Siemens Magnetom Terra 7T, 32-channel, to be upgraded to 64-channel in 2021; CE-labelled) was installed in a new £32M building (Imaging Centre of Excellence, ICE), supporting research in fundamental and clinical neuroimaging, including the appointment of expert academic and technical staff (Section 2).

- Further infrastructural developments include the conceptualisation and engineering construction of a unique 7T-MR compatible headcoil for concurrent EEG recordings, to combine dynamic with anatomical neuroimaging in the high field MRI (EEG-7TMR). This collaborative work involved CCNi and Radio Frequency Engineering at ICE (PIs Philiastides and Gunamony). It supports our ambition to conduct high-precision neuroimaging integrating imaging modalities (M/EEG, fMRI) and scales (macro to mesoscopic).

CCNi PIs have used this cutting-edge neuroimaging platform to conduct state-of-the-art research, covering topics in vision, memory and cognition, social signalling, decision making, plasticity, and disorders/disease. Their work has been published in 355 articles over the present REF-period, cited 6302 times. International recognition of CCNi PIs include the organisation of the CuttingEEG conference in 2017 by PI Philiastides (~300 participants from 20 countries and more than 100 institutions), and the 2017 Human Brain Project (HBP) meeting (~400 delegates) hosted by PI Muckli who is also leading a HBP work package. CCNi will host the 2022 Human Brain Mapping meeting (the largest neuroimaging conference worldwide, ~3,000 attendees expected). Our innovative information theoretic tools applied to neuroimaging have recently become integrated in the leading analysis platform for MEG/EEG data analysis (Fieldtrip).

Neuroscience (CforNS)

CforNS is internationally known for work on the spinal cord. Major strategic initiatives within the current REF-cycle involved new appointments to expand our research portfolio and **develop strength in brain circuits and cognition alongside spinal circuits**:

- Kohl and Craig bring **new approaches for interrogating brain function** (2-photon microscopy and miniscopes; slice electrophysiology and wireless chronic electrophysiology). They bring novel lines of investigation to the centre on themes that link with those pursued by members of CCNi, using non-invasive approaches in humans, but with greater mechanistic resolution. The main themes they develop include mechanisms of synaptic transmission and plasticity in cortical and hippocampal networks and brain circuits that underlie sensory information processing, learning and decision-making. They also collaborate with Morris (mechanisms of schizophrenia) on translational approaches to psychiatric and neurodegenerative disease. Their expertise will bridge not only with CCNi but also other groups studying brain function and cognition within/beyond UoA4.

- A further significant development has been the **merging of the animal MRI centre (GEMRIC) and CforNS**, with the aim of fostering closer interactions. For example, a BBSRC funded project connects high field functional imaging (Goense) with animal models of nerve injury to investigate **cortical plasticity after nerve trauma**. This runs in parallel with an MRC funded project (Goense, Riddell, and Hart who is an NHS surgeon) which investigates cortical plasticity in patients after surgical nerve repair using the 7T-scanner at ICE. Our goal is to bring together high field MRI in animals and humans to facilitate validation of cross-species mechanistic understanding of brain function in health and disease.

- Another strategic appointment (Sampaio-Baptista) has been made to further develop the animal-human brain imaging approach. Sampaio-Baptista has interests in **myelin plasticity during motor learning and aging** studied in animal and human brains, and her skills and expertise strengthen and complement others in the Centre. She uses animal MRI in GEMRIC and human MRI in CCNi and ICE. GEMRIC also collaborates with groups in other Institutes working on small-vessel disease, stroke and gliopathies.

- Two strategic new appointments have added expertise on the **sensory inputs** that feed into spinal circuits **and their modulation**. Hachisuka has developed a unique skin-attached in vitro spinal cord preparation for studying cutaneous inputs mediating pain and itch, while Weir (MRC/UofG Lord Kelvin Adam Smith (LKAS) Fellow; patent ownership) brings expertise in the **molecular modulation of sensory pain fibres**. The tools (some patented) that Weir brings to pain control are complemented by a new industrial collaboration with IPSEN Bioinnervation (Riddell) which investigates the use of toxins (modified and native) for blocking pain signalling.

- A further initiative within the pain theme has been the development of clinical links for **translational studies of chronic pain mechanisms after spinal cord injury** (Riddell, Goense, Rousselet in collaboration with NHS spinal cord injury consultants).

The **Spinal Cord Group** (Hughes, Riddell, Todd) is recognised for research on **spinal processing of pain and itch**. The advances they have made in unravelling spinal dorsal horn circuitry is widely used by laboratories around the world as a basis for studies striving to understand the spinal mechanisms that lead to chronic pain conditions. The group is also recognised for their experimental work in the field of **cell therapies for repair of the spinal cord** (with Barnett, Institute of Infection, Immunity, and Inflammation, UoA1) which has been influential in defining the utility of stem cell therapies. The group has received extensive UKRI and Wellcome Trust strategic-award funding and involves a multidisciplinary approach that extends from exploring synaptic circuitry, through electro-physiological investigation of defined neuronal populations, to behavioural studies. Multiple genetically-modified mouse lines are used in studies that employ novel optogenetic and chemogenetic techniques to interrogate spinal circuits that underlie somatosensory mechanisms, in particular pain and itch. The group identified inhibitory pathways underlying the control of both itch and low threshold mechanoceptor sensation and has defined functional populations among the numerous excitatory interneurons in the superficial dorsal horn. CforNS has produced 164 outputs over the current REF-period and was cited 2254 times.

Social, Cognitive and Affective Neuroscience (cSCAN)

cSCAN brings together international researchers who study **social interaction, cognition, communication, and affect**, creating synergy across these areas and related sub-disciplines at multiple levels of explanation using the most sophisticated scientific tools available (Section 3). *cSCAN*'s research focuses on (i) Social Perception and (verbal as well as nonverbal) Interaction and (ii) Social Robotics. Indeed, developing the **Social Robotics** research theme has been the centre's primary strategy over the current REF period. To achieve this, we made a number of key appointments:

- Marsella (Chair of Excellence, UofG) brings considerable expertise for the applied dimensions of Social Robotics, creating synergies with Computing Science.

- Cross (Chair in Social Robotics) combines research on artificial agents with neuroscientific methods, creating synergies with CCNi.

- Barsalou (Chair in Social Cognition) is internationally recognized for his foundational work on embodied social cognition.

- Papies (Senior Lecturer in Behaviour Change) brings expertise in research on the regulation of health and consumer behaviour, creating synergies with MHW.

A key success of this strategic development over the current REF-period has been the joint award (with UofG Computing Science) of **a UKRI Centre for Doctoral Training in Socially Intelligent Artificial Agents** (£4.8M funding for 50 PhD UofG studentships, 2020-2025), which adopts a decidedly interdisciplinary approach to doctoral training: each student works with a team of advisors that are from different academic disciplines at UofG and/or partners in industry, thus creating an environment that fosters interdisciplinary collaboration and potential for future societal and economic impact.

cSCAN comprises its own suite of state-of-the-art technologies (including peripheral physiological assessment, and eye-, body-, and face-tracking technology including eye movement recording, 4D face scanners and social robots). These technologies enable researchers to capture human social signals from facial expressions, morphology, complexion, voice pattern and eye-gaze. The associated, in-house developed image processing and generation software allow them to render sophisticated dynamic faces and bodies that send psychologically validated signals (nonverbal and verbal) for social interactions. *cSCAN* has produced 353 outputs over the current REF-period (cited 4117 times) and hosted leading international conferences, including the Consortium of European Research on Emotion (300+ attendees) and Intelligent Virtual Agents (200+ attendees). *cSCAN* also organized a two-day 'debates' symposium on *How do Online Interactions Shape our Social World* in 2017 (200+ attendees).

Centre for Mental Health and Wellbeing (MHW)

MHW's strategy over the current REF-period has been to consolidate its reputation as a world-class centre for **conducting interdisciplinary research in mental health across the life course**, leading to a comprehensive understanding of the determinants of mental health with a view to improving the health and wellbeing of all and reducing health inequalities. During this REF-period, we have built upon our strengths of applying basic science approaches such as the genetic epidemiology of mood disorders with the development of ground-breaking psychosocial interventions, including smartphone-based interventions to prevent relapse of serious mental health problems and promote wellbeing. MHW has pioneered epidemiological and genetic studies of mood disorders within the landmark UK Biobank cohort of 0.5 million individuals, the global Psychiatric Genomics Consortia (bipolar disorder, major depression, and suicide) and the international Consortium for Lithium Genomics. We have also established the Schools Health and Wellbeing Innovation Network (SHINE) and the Sleep, Circadian Rhythms and Mental Health in Schools (SCRAMS) Network. The MHW Centre has produced 817 outputs, was cited 16,000 times, and has attracted £15.2 million in research funding during the REF period.

We hosted one of nine UK-wide MRC Mental Health Data Pathfinder Awards (Smith) from the government's National Productivity Investment Fund. We are also partners (O'Connor) in the Transdisciplinary Research for the Improvement of Youth Mental Public Health (TRIuMPH) network, one of eight new Mental Health Networks funded by UKRI.

MHW encompasses five specialist groups: (i) the *Mood Disorders Research Group* (led by Smith) focuses on the **genetic epidemiology of mood disorders and related traits** and aims to understand comorbidity between mental and physical health disorders; (ii) The *Glasgow University Centre for Excellence in Developmental Disabilities* (GUCEDD; led by Melville) specialises in research that contributes to a reduction in the **health and social inequalities** experienced by people with developmental disabilities, including the Scottish Learning Disabilities Observatory. Truesdale and Kinnear were strategic appointments to GUCEDD (iii) The Suicidal Behaviour Research Laboratory (SBRL; led by O'Connor) combines novel experimental, naturalistic, and **statistical methods to understand suicide**. It has a worldwide reputation for conducting ground-breaking theoretically grounded basic science and interventions-based research. (iv) The Psychosis Research Group (led by Gumley) has a distinguished track record in the development of complex **psychosocial interventions for those living with psychosis**. (v) The Adverse Childhood

Experiences Centre (led by Minnis) conducts world-leading aetiological and intervention research on the **psychiatric and developmental problems of maltreated children**.

MHW has organised leading international research conferences, such as the World Congress of the International Association for Suicide Prevention (2019, co-led by O'Connor), the largest ever with delegates from 55 countries. Jahoda brought the World Congress of the International Association for The Scientific Study of Intellectual Disabilities, the largest research and practice meeting in the field of intellectual disabilities, to UofG in 2019 (1315 delegates from 50 countries). The Suicidal Behaviour Research Laboratory also runs the annual Suicide and Self-harm Early and Mid-Career Researchers' Forum; this unique global event regularly attracts delegates from across world and supports the next generation of suicide-researchers.

Research Outputs

UoA4 has consistently produced more than 225 outputs per year, averaging 4.61 per author per year for the 53 UoA4 researchers. Our outputs have had a Field-Weighted Citation Impact (excluding self-citations) of 1.97 on average. FWCIs increased over the current REF-period from 1.9 in 2014 to 2.4 in 2020. In terms of international reach, our outputs have been cited in 149/231 countries or regions recognised by Scopus.

For UoA4-relevant subject areas, our mean FWCIs compare favourably to the Russell Group (RG):

Journal Classification Area Subject	RG Mean FWCI	UoA4 Mean FWCI
Cognitive Neuroscience	1.10	1.76
Experimental & Cognitive Psychology	1.21	1.83
Neurology	1.28	1.54
Psychiatry and Mental Health	1.30	2.57

Future Strategic Aims

Each centre within UoA4 has set itself the following ambitious objectives for moving forward. Among these, further development of research synergies and collaborations, both within and across centres, forms a key element in advancing UoA4's research portfolio and creating future opportunities for economic and societal impact.

CCNi: Realizing CCNi's mission critically relies on innovative multidisciplinary research and collaborations. Specific objectives have been set forth to foster these ambitions:

- Developing **new analyses and neuroimaging tools**. CCNi PIs have developed a portfolio of brain imaging methodologies using advanced signal processing, information theory, network theory and computational modelling to map the dynamic neuronal interactions in MEG/EEG source space and fMRI. Major areas of expansion will be in the context of multi-modal data fusion, integrating multimodal neuroimages in analysis space (analytic MEG-EEG-fMRI-DTI data fusion) using cutting-edge information-theoretical approaches (Ince, Schyns), leveraging machine-learning (Philiastides) and MEG-EEG network analysis tools (Satu Palva, Matias Palva). In-silico (computational modelling) and in-vivo (non-invasive) brain stimulation (Hanslmayr, S. Palva, M. Palva, Robertson, Thut) will enable causative inferences.

- **Upgrade our current MEG scanner** to a TRIUX™ neo-MEG system, a whole-head MEG scanner equipped with 306 channels (204 planar gradiometers plus 102 magnetometers) which can be combined with system-integrated high-density EEG recordings. This will allow for considerable expansion of state-of-the-art research in dynamic brain imaging for which CCNi was noted in REF2014. Funding for this development has been secured in Sept 2020 (£1M Wellcome multi-user equipment grant, plus £0.5M funding by UofG) and we expect installation in 2021.

- **Develop collaborative flagship research themes** within UoA4. With cSCAN, we are ideally poised to integrate research on cognition: social signalling/sensing (within the remit of ESRC), neuroimaging (BBSRC) and artificial intelligence and digital humans (EPSRC) to develop realistic artificial companion robots with a wide range of applications including health interventions, and social skill training (MRC). Some research already interfaces CCNi with cSCAN on this theme (Schyns from CCNi, Jack and Cross from cSCAN). With CforNS, we plan to build on existing ties for cross-scale, cross-species studies, with many opportunities for synergies, for example with a theme on pain and leveraging respective expertise in electrophysiology of spinal circuits (e.g., Riddell for CforNS) and cortical signal processing (e.g., Rousselet for CCNi). With ICE, we will further develop themes with translational potential. Recently received awards under this remit are from MRC to Uhlhaas (joint MEG and 7T-fMRI) and from VersusArthritis to Basu (Institute of Infection, Immunity and Inflammation, UofG) in collaboration with Thut from CCNi (joint Brain Stimulation and 7T-fMRI).

- Further enhance our research potential and multidisciplinary thinking by developing a **comprehensive human and animal translational imaging** platform, bringing together neuroimaging across research Centres and Institutes; ideally under one roof and/or by eliminating communication barriers via bespoke initiatives (topical lab meetings across structures, common seminars etc.).

- Recent initiatives which may lead to potential impact include reaching out to **epilepsy groups** (e.g. at the William Quarrier Scottish Epilepsy Centre, Glasgow) for integration of human electrophysiological data from the single neuron level (via invasive recordings in epilepsy patients) to the macroscopic scale (i.e. MEG/EEG recordings in healthy subjects); PIs Hansmayr and Wimber add substantial expertise in this area. Moreover, PI Hanslmayr is currently advising a start-up company that intends to build **neuro-prosthetics** to improve cognitive performance in patients with memory deficits. The company will draw on the knowledge generated from our basic research on how brain oscillations mediate memory and other cognitive processes, to develop electrical stimulation regimes that boost cognitive performance.

- CCNi's collaboration with Radio Frequency Engineering at ICE (PIs Philiastides and Gunnamony) has led to a recently awarded Innovate UK grant of £663,609 (PI Gunnamony), which will be used to **commercialize the 7T-MR compatible headcoil** that was developed as part of this collaboration. Project partners on this grant are UofG, NHS, MR CoilTech and Wideblue.

CforNS: Building on its current strengths, CforNS will further develop cutting-edge research that provides mechanistic explanation in two main areas (i) spinal circuits processing of pain and itch and (ii) brain circuits underlying cognition. Specifically,

- We will foster within-Centre interactions between the Spinal Cord and Brain Circuit groups, utilising shared technologies and approaches. For example, we will explore the use of 2-P and chronic electrophysiology in the context of pain.

- We will proactively explore strategic collaborations with CCNi and key groups in other Institutes. For example, a new collaboration between Riddell and the Tobin/Bradley (UoA5) group will investigate **brain mechanisms in models of neurodegeneration and the action of disease modifying drugs** supported by a £40K investment in wireless electrophysiological equipment for chronic brain recording in behaving animals. We aim to develop further infrastructural capacity e.g. for multimodal animal brain imaging and behavioural testing to support wider collaboration.

- **Pain** is a theme with particular potential for cross-disciplinary development, from the study of animal circuits and mechanisms, through clinical mechanisms underlying chronic pain in patients, to mood disorders and impact on mental health. We will pursue the opportunities that exist for cross-animal and human MR imaging (Riddell, Goense, Basu). A strategic objective is to develop novel ways of controlling and treating pain. We aim to identify potential

targets for **pain modulation and control by** building on new collaborative links (Milligan, Tobin; UoA5) to exploit local expertise on the molecular pharmacology of GPCRs.

- Our general strategy aims at a mechanistic understanding of neurological disorders, dementia/mental health, control of pain, and recovery of function after injury. In collaboration with the NHS, molecular biologists, and industry, we expect our research to identify opportunities for managing or treating these conditions more effectively and will exploit these to maximise the longer-term socio-economic impact of our work.

cSCAN is pursuing the following key initiatives designed to broaden its national and international standing, expand its funding base, and create opportunities for future impact:

- There has been a rapidly growing international research and industrial focus on the development of **Artificial Social Intelligence** (ASI) that can effectively interact with people. Further, many of the byproducts of artificial intelligence such as machine learning and the design of virtual humans have become increasingly relevant methods to enable research in psychology. In light of these international developments, cSCAN will pursue a strategy of bringing expertise in psychology and neuroscience to ASI. cSCAN has already put together an interdisciplinary *Social Robotics* initiative with Computing Sciences, leading to the Centre for Doctoral Training in Socially Intelligent Artificial Agents. This initiative was further supported with the key hires of Cross (chair in Social Robotics) and Marsella (chair of Excellence) and opened new research collaborations and funding doors. For example, cSCAN's efforts in Social Robotics and associated work on ASI has provided new funding streams (such as DARPA and EPSRC) that are typically unavailable to traditional Psychology departments.

- We will further foster and strengthen our synergies with the *Mental Health* research theme (MHW), with the goal of generating future impact. For example, we see potential for our expertise in the fields of face/gesture/emotion processing and social avatars to be developed into applications for the remote delivery of mental health assessments and interventions. Moreover, existing collaborations in ecological sustainability (Papis, Pell) have the potential to inform policy makers and create behavioural change.

- To consolidate our strengths in Psycholinguistics and Communication research, we recently appointed Ostarek (Lecturer in Social Cognitive Neuroscience) and Raviv (Lecturer in Cultural Evolution of Languages), both confirmed to start in early 2021. The appointment of Ostarek will further collaboration between cSCAN and CCNi, and the appointment of Raviv will create closer links to *Social Sciences*.

- Another key future initiative is cSCAN's effort to a launch an interdisciplinary *Modeling and Methods* research centre. There have been growing concerns across the empirical sciences about the lack of reproducibility, replicability, or generalisability. cSCAN researchers have been at the forefront of research on best practices in this area, and already contribute to leading activities within the *Methods and Statistics* support group (Section 2). The next step in this process will be the establishment of a research centre, provisionally titled the *Modeling and Methods Centre* (MMC), which will lead efforts in advancing methods for empirical sciences. Our goal is an internationally recognised effort that will impact on the University, provide workshops, tutorials and materials internationally, and make novel contributions to methods development and statistical modelling.

MHW: Strategically, our future programme of research dovetails with the IHW's three research themes on *data science*, *solution-focussed research* and *determinants of health and health inequality.* We will build upon our existing strengths in data science and complex psychological interventions. Our strategy is to further develop high quality research collaborations in four areas:

- Using new digital technologies to develop therapeutic and complex interventions for individuals with mental health problems, including research dedicated to understanding the psychological, social, interpersonal, and biological mechanisms of change (Gumley, Evans,

O'Connor). This will include building new collaborations with cSCAN, Computing Science colleagues as well as the IHW's Solutions-Focused Research Theme.

- Developing new collaborative partnerships to study the impact of, and contribute to the development and evaluation of, policies and interventions which target: i) social and environmental determinants of health; ii) primary care; iii) secondary care; and iv) social care interventions and service models. Our aim is to work closely with national and international partners to develop an optimal impact implementation framework.

- Harnessing the expertise within the Mood Disorders Research Group (Smith), the Suicidal Behaviour Research Lab (O'Connor), the Adverse Childhood Experiences Centre (Minnis), the Psychosis Research Group (Gumley), to develop a themed programme of mental health research focused on children, young people, and their families. This research programme specifically addresses the marked increase in health problems among young people in recent years, and will exploit existing resources (e.g., Schools Health and Wellbeing Innovation Network) and collaborations as well as developing and consolidating health and social care partnerships. Adopting a precision medicine approach, the goal will be to use basic science to inform the development of tailored interventions for specific populations and physical/mental health conditions (Smith, Cullen, Gumley, Evans).

- Consolidating and extend our genetic epidemiology of mood disorders and related traits research to new at-risk groups and populations (Cullen, Smith).

Addressing inequalities is one of the six University Research Beacons and it underpins all our basic science and interventions-based work. Post-COVID-19, reducing inequalities in mental health outcomes will be one of our research priorities. For example, we will focus on two groups in particular: young people and people with developmental disabilities, as both of those groups have been particularly affected by COVID-19. Our *Centre for Excellence in Developmental Disabilities* research will lead on the latter (Melville, Jahoda, Kinnear, Robb, Truesdale).

2.People

Staffing Strategy and Development

We returned 96% of eligible staff in REF2014 and have expanded our unit considerably in the current REF-submission (from previously 36.2FTE to 49.5FTE). This growth is primarily due to key appointments (e.g., to develop Social Robotics within *cSCAN*) and the inclusion of the MHW centre into UoA4. This development has added considerable expertise, skills, breadth, and depth to the composition of our unit, while also maintaining critical mass in key areas of strength, such as Neuroscience and Cognitive Neuroscience.

The following staff recruitments have taken place per centre over the current REF period:

- *CCNi:* To support and strengthen the three key areas of CCNi specialization (Computational Cognitive Neuroimaging, High-Precision Neuroimaging, Neuroimaging-Guided Brain Stimulation), and their integration, CCNi has made the following new appointments: Porter (Chair in High Field MRI, moving from Siemens to UofG), Ince (for Information-Theoretical Models), S. Palva and M. Palva (Chairs in MEG), Fracasso (Lecturer, specialising in 7T Cognitive Neuroimaging), Robertson (Chair, MEG), Hanslmayr (Brain Oscillations and Multimodal Brain Imaging across scales), Wimber (for Memory and Neuroimaging) and Goense (Senior Research Fellow, High-Field MRI). These appointments are closely linked to our strategic goal of developing dynamic information processing with MEG and high resolution, cortical layer-specific 7T fMRI (see also Section 3). Moreover, Uhlhaas and Philiastides have both been promoted to Professor in the current REF period.

- *CforNS* has made several strategic appointments of strong early career scientists. The Spinal Cord Group is bolstered by the appointment of Hachisuka (who brings new in vitro approaches for investigating spinal cord function that have been applied, for example to investigation of ascending pain pathways, as reported recently in Nature. Weir holds a

competitively awarded MRC Fellowship and a UofG LKAS fellowship and will transition into a permanent appointment. He brings expertise in technologies for manipulating the excitability of sensory neurons which may have utility in pain control as well as tools for probing the role of afferent input in chronic pain mechanisms. The appointments of Kohl, Craig and Sampaio-Baptista underpin our aim to build excellence in brain circuits and cognitive function, and brings new approaches for interrogating brain function (Kohl, 2-photon microscopy in head fixed animals and miniscopes in awake behaving animals; Craig, slice electrophysiology and wireless chronic electrophysiology in awake behaving animals; Sampaio-Baptista, MRI techniques to measure brain changes at functional, structural and neurochemical levels). These appointments also underscore our aim to maximise interactions between groups using animal and human based approaches as well as neuroscience groups housed in other areas of specialisation e.g. molecular pharmacology or neuroimmunology.

- *cSCAN* has made substantial new appointments to support the development of *Social Robotics*, including Marsella (Chair of Excellence, UofG), Cross (Chair in Social Robotics), Barsalou (Chair in Social Cognition), and Papies (Senior Lecturer in Behaviour Change). These appointments are closely linked to our strategic goal of developing social robotics for its applied (Marsella), foundational (Barsalou) and health psychology (Papies) dimensions. Moreover, Jack and DeBruine have both been promoted to Professor within the current REF-period. The unique dimension of cSCAN is to enable the testing of social signalling theories in "micro-Turing tests" that use in-house-developed dynamic 3D renderings of digital avatars and social robots. In turn, these applications will ask new theoretical challenges for social interactions. Very recent new recruitments (September 2020) include Ostarek (Lecturer in Social Cognitive Neuroscience and Embodied Cognition) and Raviv (Lecturer in Cultural Evolution of Languages). Both are first-time lecturer appointments (expected to start in early 2021) and will not only create new synergies between cSCAN and CCNi /cSCAN and Social Sciences, but also further enhance and expand our portfolio in language-related research.

- *MHW:* Kinnear alongside Truesdale (Senior Lectureships in Learning Disabilities) were both appointed in 2019 to support MHW's strategic investment in research on learning disabilities. The two senior lecturer appointments were to consolidate the position of the Glasgow University Centre for Excellence in Developmental Disabilities (UCEDD) as the world leading centre for trials of complex interventions to improve the health and wellbeing of individuals with intellectual disabilities. We also have three clinical lecturers in psychiatry and a clinical senior lecturer in psychiatry (Langan Martin), appointed in 2018. In total, 19 research fellowships (e.g., Royal Society, Wellcome Trust, MRC, Marie Skłodowska-Curie Actions) with a total value of £2M have been held in our unit during the current REF-period, including Strawbridge (HDR-UK Innovation Fellowship). In addition, Melville (Learning Disabilities) Minnis (Child & Adolescent Psychiatry) and Smith (Psychiatry) were promoted to personal chairs in this period. Cullen (Senior Lecturer) and Robb (Reader) have each been promoted since 2014.

Across the four Centres, there were 33 promotion requests over the current REF-period; 27 (82%) were successful (10 male, 17 female staff) and 6 were not (3 male, 3 female).

Cross-Centre Support Groups

To enhance synergies and to facilitate sharing of best practices across research centres, we established three support groups within the current REF-period which thematically cut across all four centres. These groups include the *Grant Writing* group, the *Paper Writing* group, and the *Methods and Statistics* group. Each group is led by a prominent academic with a strong track record in the relevant topic, and further comprises members from each Centre, plus teaching and support staff. Including teaching and support staff ensures that teaching and administrative support are fully integrated and optimised to meet these goals, and to support research culture within our unit. The groups ensure dissemination of best practices across the full academic spectrum, as well as adjustment of support to the needs of a genuine culture of excellence in research. More specifically:

- The **Grant Writing** group proactively matches staff to funding schemes and opportunities that are directly relevant to their specific research strengths, and provides practical support for applications (e.g., idea development, internal peer review, costings). One research administrator (Gallagher) from outside of the research institute is part of the group to ensure that opportunities to take advantage of central resources and expertise are not being missed. The group is an important contributor to our successes in research income in the current REF-period (Section 3), and through its support, has helped to sustain a steady stream of grant submissions over the past 7 years (242 grants of more than £200K/FTE, and with at least 50% UoA4 PI ownership, have been submitted to various funders). The group also arranges workshops for staff and students on topics such as utilising funder feedback on applications. The effectiveness of the Grant Writing group is further evidenced by the fact that within this REF-period, UoA4 has surpassed the number of large awards (e.g., Wellcome Investigator, ERC) that were obtained in the previous REF-cycle, and that 75% of staff held an award on average per year (min. 67%, max. 88%).

- The **Paper Writing** group's primary role is to increase the number of manuscripts that are reviewed by competitive journals (with rejection rates >80%). Among other activities, the group achieves this through regular (1-2 per year) workshops that are focused on publication criteria and theoretical remits of various journals (e.g., the Editor of Nature Human Behavior visited in December 2017, and the Editor of Lancet Psychiatry spoke at an Early & Mid-Career Researchers' event in UofG in 2019). More importantly, individuals can also submit their work to the group for timely and constructive feedback, thereby improving their chances of being reviewed. There has been sustained enthusiasm for this group, with strongly positive comments from early adopters. A good example of the group's work (in collaboration with the Grant Writing group) was a *Resilience, Rejection and Peer Review* workshop, which was open to all staff and students in the unit and highlighted good practice for handling peer review and criticism of manuscripts as well as funding applications. The paper writing group clearly contributed to the unit's publication successes over the current REF-period (for instance, 98 of our outputs appeared in journals with a SNIP >4).

- The **Methods and Statistics** group promotes best practices in advanced quantitative methods and open science, organising weekly talks and workshops on modern statistical modelling techniques, open science, data archiving, data visualisation, reproducibility/replication, and data analysis software. These weekly events are very well attended by staff and postgraduate (PG) students of all levels and have hosted speakers from other UK, European and US institutions who made important contributions to open science and best practises in quantitative methods (e.g., Dorothy Bishop, Richard Morey, Tal Yarkoni, Daniel Lakens). Weekly events typically have 40+ attendees (with substantially larger audiences for external speakers) and are particularly well attended by ECRs and Postgraduate Researchers (PGRs). PGRs are especially encouraged to present and discuss analytical modelling problems they have encountered in their own work, to receive feedback and advice from a larger expert audience. Members of the Methods and Statistics group (most notably, Barr and DeBruine) have also been instrumental in helping to integrate best open science practises for reproducible data analysis into the undergraduate and postgraduate teaching curriculum in Psychology (including training for teaching staff); statistics teaching at all levels is now based on the open-access programming platform *R*.

Training and Supervision of PGR students

Doctoral Degree Student numbers have been consistent over the current REF-period, with an annual average of 134.3 students (3.9 students / FTE) registered to UoA4. The number of International PhD students, in particular, has seen significant and steady growth, from 33 in 2013/14 to 54 in 2019/20 – an increase by 64% over a 7-year period. A noteworthy 48 nationalities (excluding UK) are represented within the UoA4 PhD student population, with students from China forming the largest international cohort.

We had a high number of **Doctoral Degrees Awarded** (DDA) per FTE over the current REF period:

	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019-20	**Total**
DDA	38.7	62.95	14.68	33.78	39.75	46	38.05	**273.91**
DDA / FTE	0.80	1.30	0.30	0.70	0.82	0.95	0.78	**5.65**

Indeed, UofG is ranked first when compared with other Russell Group Universities for Doctoral Degrees Awarded per FTE per annum (for UoA4 averaged over the current REF-period; from HESA Doctoral Degrees Awarded returns 2013/14 to 2018/19).

With the new UKRI Centre for Doctoral Training**,** we anticipate further growth in terms of student numbers and DDA over the coming years. As stated in Section 1, this Centre is unique in its decidedly **interdisciplinary** approach to doctoral training (each PhD is supervised by a team of supervisors from different disciplines) and aims to **foster closer links to business and industry** by actively integrating industry partners into the funding, mentoring, and supervision of PhD projects.

In addition to allowing best practices to be shared among PIs, our cross-centre *Support Groups* provide training for postgraduate and postdoctoral researchers within our unit, e.g., through workshops that are specifically aimed at earlier career researchers. This training is demonstrably effective. For example, 29 of these researchers have taken up permanent or tenure track faculty positions during the current REF-period.

Apart from receiving support and feedback in annual progression meetings, PGRs in our unit are engaged in a wide range of activities, such as Research Open Days, in which they present posters or short talks and receive feedback from staff as well as peers. They are also strongly encouraged to take part in our weekly seminars (presentations by external speakers) and activities organised by our three support groups. Also worth mentioning are the *CCNi* and *cSCAN Debates*, where we invite leading scientists representing a diversity of viewpoints to discuss hotly debated topics relating to scientific practise in or societal impacts of our key areas of research; over several weeks leading to these debates, PGRs and post-docs, together with PIs, prepare themselves by reading and discussing key papers related to the upcoming debate, thereby ensuring lively participation and informed engagement from all parties involved.

Early Career Researchers (ECRs)

ECRs featured strongly on UoA4's recruitment strategy for the current REF-period, as reflected in the appointments of Gunamony (from the Max-Planck Institute in Tuebingen and now Senior Research Fellow at UofG), Ince (Junior Research Fellow at UofG), Fracasso and Sampaio-Baptista (both first-time lectureships), Strawbridge (HDR-UK Innovation Fellowship), Kinnear (moved from research post to Senior Lecturer in Learning Disabilities), and Cullen (moved from research post to Lecturer in Mental Health to Senior Lecturer in Clinical Psychology). Other ECRs who joined us on individual Fellowships are Learmonth (Sir Henry Wellcome Fellowship), Recasens and Ruzzoli (both with Marie-Curie Fellowships), Queirazza (JMAS Sim Fellowship Royal College of Physicians of Edinburgh), van Kemenade (DFG Research Fellowship), and Weir (MRC/LKAS Fellow). Two recent lecturer appointments for cSCAN, Ostarek and Raviv, are first-time independent researcher appointments, and the Senior Lectureships of Kohl, Hachisuka, and Craig (all CforNS) are first-time permanent academic appointments. ECRs are generally given light or no teaching duties over the first couple of years, to enable them to develop their research portfolios.

There is also cross-unit innovation in supporting ECRs. For instance, within IHW, the *Suicidal Behaviour Research Laboratory* is at the forefront of supporting the next generation of suicide research scientists, by hosting the annual Early and Mid-Career Researchers' Forum on Suicide and Self-harm, which aims to foster networking and research mentorship and collaboration attracting a global audience. The *Psychosis Research Group* has established the Psychosis ECR network, hosting a national conference for psychosis ECRs and lead a Reproducibility Journal Club for PGR students. The *Adverse Childhood Experiences* centre is also developing young scientists by consulting with children about the research approaches for undertaking a large-scale medical study

to explore why abused and neglected children are at higher risk of health problems. To our knowledge, this is the first time that children as young as eight have been included as equal partners in research practice, collaborating on development of appropriate research questions, design of studies and the appropriateness of research assessments.

Equality and Diversity

IHW holds **Athena Swan Gold** award and INP **Athena Swan Silver**. INP is also represented on IHW's Athena Swan Self-Assessment Team.

We embedded several key features into our working environment and culture that specifically promote equality, diversity and inclusivity for all staff and research students. These include:

- Embedding of Athena Swan activities into the workload model for all staff.
- Establishment of a staff and student Athena Swan Team with 4 working groups, focusing on staff career development, student development, flexible working, and culture development.
- Establishing Personal Development Plans for all staff (reviewed annually).
- Embedding career development into annual PDR-meetings.
- Wide-scale promotion of flexible working.
- Mentoring groups available to all staff to develop professional skills.
- Social and professional events within core hours.
- Identifying a Parental as well as a Professional & Support Staff Champion.
- Regular Student Mentoring Circles, and 'Meet the Role Model' events.
- Annual Promotion Workshops for all staff.
- Mandatory Equality, Diversity & Inclusivity training (all staff); mandatory Unconscious Bias training for interview panels.
- Gender representation on interview panels.
- Bespoke support before, during and after maternity, paternity, and adoption leave.
- Keeping In Touch days for staff on parental leave.
- Carers Conference Fund; Academic Returners Fund.
- Annual EDI-focused talks/workshops.

Together, these measures help in fostering an inclusive, sustainable, engaged, and diverse working culture within our unit.

All UoA4 staff involved in REF-processes (including output review and selection) undertook mandatory training including ED&I principles, unconscious bias, and sensitive data handling. In accordance with the University's Code of Practice, outputs were selected and allocated to authors to maximise the UoA's GPA. An interim equality impact assessment of our methodology indicated no significant bias against any protected characteristic.

Research Integrity

The proportion of open access outputs within UoA4 has steadily increased, being more than twice as high in 2020 (~88%) as in 2014 (~40%). This reflects open science featuring increasingly strongly in our research culture and is also made possible through institutional support in terms of covering publication fees.

Many staff and students preregister experiments, make data and analysis pipelines public, and post preprints online. An informal survey among CCNi and cSCAN PIs indicated that between 01/2018 and 09/2020, ~15% of their outputs reported preregistered studies and ~60% were published with open access to data and code.

UoA4 staff and students are highly engaged in activities related to research integrity and best scientific practices. Such activities are salient and widely applied in our research culture, as well as our teaching: Across all levels of our undergraduate and postgraduate programs, students receive core instruction in issues related to open science, research ethics, reproducibility, and best practices;

starting in the first year of our undergraduate program, open science practises are infused into the curriculum as students learn the principles of reproducible data analysis in open-access statistics platform *R*.

The *Methods and Statistics* support group plays a particularly important role in organising regular talks, seminars, and workshops (e.g., *Methodology and Metascience seminar series* https://www.psy.gla.ac.uk/events/?sub=12) on issues relating to best practises in scientific research and keeping track of recent methodological developments and debates. Moreover, junior researchers within our unit actively take part in the *ReproducibiliTea* journal club initiative (https://reproducibilitea.org/).
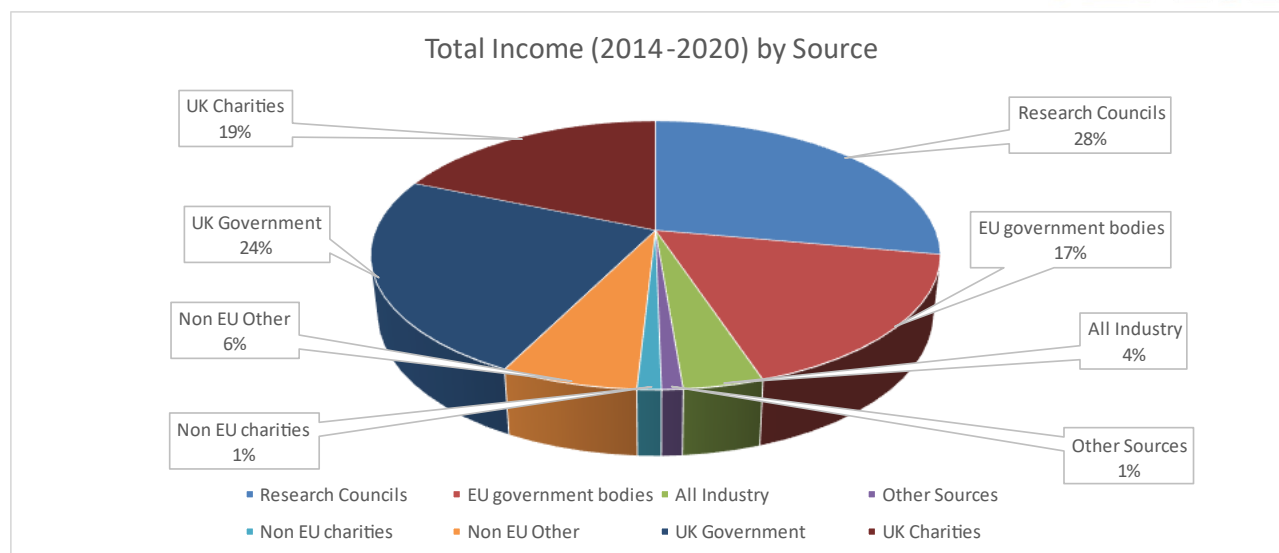

3.Income, infrastructure and facilities

Income and Awards

Within this REF-period, UoA4 has performed well in terms of annual research income, specifically:

- We have maintained a position among the **top five institutions in the Russell Group for income/FTE in Psychology & Behavioural Sciences**, with a median ranking of 4th.

- **Total research income** has steadily increased, from ca. £5M in 2013/14 to over £6.7M in 2018/19 (an increase by more than 30%) and totalling £41.7M over the entire period. Meanwhile, **income/FTE** remained steady, averaging ~£120K/FTE per annum.

- UoA4 has a balanced income portfolio, with no individual income stream providing over 28% of income.

- Income from **UK Charities** has more than doubled, from under £0.75M in 2013/14 to £1.6M 2018/19.

- Income from the **EU Government** increased by 230%, from under £0.6M in 2013/14 to over £1.3M in 2018/19.

- In terms of **Awards**, UoA4 has secured over £45M in external research funding. This is part of an overall research portfolio worth over £60M; 2019/20 has seen a particularly strong increase, by 39% compared to the median across the previous years.

The above successes are largely driven by our increased strategic focus on large individual awards and implementation of the Grant Writing group to maximise submission and success rates. Large awards for the current REF include three Wellcome Investigator awards (Thut, Gross, Schyns), six 5-year ERC awards (Cross, DeBruine, Jack, Jones, Kayser, Muckli) and a Lister Institute Prize Fellowship (Smith). Hanslmayr and Wimber (very recently appointed by CCNi) hold ERC grants worth €1.9M and €1.5M, respectively.

Total Income (2014-2020) by Source

- UK Charities 19%
- UK Government 24%
- Non EU Other 6%
- Non EU charities 1%
- Research Councils 28%
- EU government bodies 17%
- All Industry 4%
- Other Sources 1%

Legend: Research Councils · EU government bodies · All Industry · Other Sources · Non EU charities · Non EU Other · UK Government · UK Charities

Another positive trend is that an apparent gender gap in staff holding an award has closed in recent years. The most salient difference was in Q4 of 2015/16 (45% female vs. 82% male staff held an award), but there was practically no gender difference in Q1 (both equal at 57%) and Q2 (female:64%, male:63%) of 2018/19.

Research Infrastructure and Facilities

Apart from being pivotal to support our research, state-of-the-art facilities and infrastructure are an important contributor to our successes in securing external funding and play an important role in attracting leading international researchers in our staff recruitment strategy. The sections below give an overview of our research facilities per Centre.

Cognitive Neuroscience (CCNi)

Most significant in terms of investment is the research infrastructure as part of *CCNi*, with funding from UofG, Science Research Investment Fund, and the Wolfson Foundation (£5.7M). The platform, entirely dedicated to research at UoA4, is the premier cognitive brain scanning facility in Scotland, offering staff within our unit access to a **3-Tesla MRI scanner (Siemens)** equipped with a 32-channel head coil, as well as to **248-channel whole-head MEG system** (WH-3600, 4D-Neuroimaging). Both scanners are equipped with top-end visual, auditory, and tactile stimulation and behavioural recording equipment, including suitable eye-tracking devices. Very recently (Sept-2020), we secured funding to upgrade our MEG facilities to a TRIUX™ neo MEG system (£1M Wellcome multi-user equipment grant, +0.5M funded by UofG), with installation expected in 2021. Moreover, CCNi comprises two specialised **NeuroCognitive Brain Stimulation labs** that are equipped with state-of-the-art transcranial magnetic stimulation (TMS), transcranial alternative current stimulation (tACS) and transcranial direct current stimulation (tDCS) systems, featuring devices for anatomical MRI-based neuro-navigation, single pulse, paired-pulse, double-coil and repetitive stimulation, electrical current modelling, simultaneous TMS-compatible EEG acquisition (Brain Product, 64-channels), MEP recordings and concurrent eye-tracking. Three **EEG labs with multichannel EEG systems** (Biosemi, 128 channels), also with concurrent eye tracking facilities, complement the neuroimaging equipment. Several dedicated, "floating" EEG-systems (Brain Product, 64 channel) allow EEG recordings at bedside in affiliated hospitals, and in the MR scanner for combined EEG-fMRI studies. For EEG recordings in the 7T MRI, we have developed a bespoke EEG-MRI-coil. ICE houses a state-of-the-art **7-Tesla Siemens Magnatom Terra MRI system**, allowing acquisition of high-resolution functional MRI. The system is capable of switching between a clinically (CE and FDA-) approved single transmit system and a research-dedicated parallel transmit system that is highly flexible for RF-specific applications. The MRI suite is equipped with audio and visual stimulation capabilities, and with a real-time analysis system using Turbo-BrainVoyager software. ICE is currently developing specialised coils for simultaneous EEG-acquisition and for visual cortex studies. The vision coil will increase spatial resolution in visual cortex by increasing homogeneity and

sensitivity in the occipital lobe of the brain and will increase participants' experimental visual field via an open-face design. 3T and high resolution 7T MRI analysis is supported by a High Performance Computing grid system installed at the INP (Networking via 10G Ethernet core network, 5Pb of data storage and 3500 compute cores with access to 25 Tesla GPU devices and 16Tb of Ram).

Neuroscience (CforNS)

CforNS has excellent facilities for modern multidisciplinary and multilevel animal neuroscience, and the University has committed £1.3M for the refurbishment of new labs to Home Office standards for animal work. There are facilities for cell culture, genotyping, molecular biology, immunocytochemistry/EM processing, confocal microscopy, and transmission EM. Functional studies of brain and spinal cord circuits are supported by in vivo and in vitro electrophysiology labs, a 2-photon microscope and mini-scopes for imaging in awake behaving animals, as well as wireless electrophysiology equipment. The nearby animal facilities have operating theatres that we have equipped for surgical implantation of recording and stimulating devices, injections of recombinant viruses into brain and spinal cord, setting up nerve and spinal cord injury models and behavioural testing rooms equipped for a range of sensory, motor, and cognitive behavioural tests. At GEMRIC and the Wellcome Surgical Institute there are two 7T animal scanners, a Brucker Biospec and Brucker Pharmascan for animal MRI, together with surgical and behavioural facilities.

Social, Cognitive and Affective Neuroscience (cSCAN)

cSCAN comprises its own suite of state-of-the-art technologies (including peripheral physiological assessment, and eye-, body-, and face-tracking technology, 4D face scanners and social robots). Specific facilities include:

- Vicon-based motion capture lab
- Qualisys Motion Capture lab
- Xsens motion capture suit for portable motion capture
- VR labs with Vive Pro Eye and Oculus Quest headsets
- Character animation system for fully-articulated, interactive characters
- DI3D face capture system with software to analyse images
- Di4D stereo photogrammetry and facial motion capture system, real-time 3D facial animation and rendering system
- A 3D facial identity database and synthetic facial identity generation system
- A suite of humanoid and non-humanoid social robots
- Several desk-mounted (EyeLink 1000) and head-mounted (EyeLink II) eye-tracking systems, the latter with real-world scene tracking facility

These technologies enable researchers to capture human social signals from facial expressions, morphology, complexion, voice pattern and eye-gaze. Associated image processing software allows them to render sophisticated dynamic stimuli to be used in behavioural and brain imaging studies.

Mental Health and Wellbeing (MHW)

We have dedicated **laboratory facilities** to conduct mental health research, including the SBRL's Health Laboratory and the ACE's laboratory for observational work and interviews with children and families. The SBRL comprises three experimental testing suites, equipped with bespoke psychophysiological equipment (electrodermal reactivity kit), mood and stress-induction equipment (including algometer and cold pressor). The ACE laboratory is a dedicated set of rooms in which to conduct interviews as well as observations. Facilities also include access to **very large datasets** for work on the genetic epidemiology of mental illness, including data from UK Biobank, the global Psychiatric Genomics Consortia (bipolar disorder, major depression, and suicide), and the international Consortium for Lithium Genomics. There are also mental health data science resources that are part of the Mental Health Data Pathfinder Award (e.g., the Schools Health and Wellbeing Innovation Network, SHINE), large-scale routine data linkage projects (e.g., prescribing in bipolar disorder, antihypertensives as repurposed treatments for depression, etc.), plus the Sleep, Circadian Rhythms and Mental Health in Schools (SCRAMS) Network, and finally, the Glasgow Psychosis

Information System (PsyCIS) which is a linked clinical dataset of over 10,000 patients with schizophrenia and bipolar disorder.

4.Collaboration and contribution to the research base, economy and society

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International Collaboration

Over the current REF-period, we have actively encouraged international collaboration through participation in national and international scientific networks and partnerships (see below). This has driven an increase in the percentage of outputs with international collaborating institutions, from 44.7% in 2014 to 56.3% in 2020.

In addition, our Unit has been involved in many national and international scientific networks and partnerships. For example:

CCNi

- Muckli leads a work-package of the prestigious Human Brain Project leading to further international collaborations.

- Palva, Gross, and Uhlhaas are involved in the MEG-UK network and the National Dementia Network (both MRC funded).

- Thut has been a member of the Wellcome Trust Expert Review Group *Cognitive Neuroscience* and Mental Health (2013-2017)

- Robertson is a member of the MRC *Neuroscience & Mental Health Board*, 2019-today).

CforNS

- Todd is part of a Wellcome Trust strategic award with King's College London, University College London, University of Oxford, and University of California San Francisco.

- Kohl collaborates with colleagues at Seoul University on the role of inhibitory interneurons in memory processes and related dementia-treatments. This work is co-funded funded by MRC and the Korea Health Industry Development Institute.

cSCAN

- Marsella and Roberts hold several NSF- and DARPA-funded joint projects with researchers at US universities. Specifically, Marsella holds two DARPA grants, one in collaboration with the Psychology Department at University of Southern California (USC), Annenberg Center, and the Institute of Creative Technologies (USC/ICT), the other involving USC/ICT, SRI Research, and Raytheon/UTC.

- Several other staff are involved in collaborations with researchers at University of Wisconsin–Madison, University of Michigan, McGill University, University of Madrid, and KU Leuven that have been published in leading journals (e.g., Psychological Science, PNAS, Nature Human Behaviour).

MHW

- Cullen is a member of the NIHR Mental Health Translational Research Collaboration Treatment Resistant Depression working group.

- Evans is on the Board of Governors of the International Neuropsychology Society (INS) and Chair of the INS International Liaison Committee and Executive Committee of the World Federation for NeuroRehabilitation Special Interest Group in Neuropsychological Rehabilitation.

- O'Connor is a Vice President of the International Association for Suicide Prevention and a past President (during REF period) of the International Academy of Suicide Research.

- Gumley is Chair of Scottish Government COVID-19 Mental Health Research Advisory Group.

- O'Connor is joint first author of the Academy of Medical Sciences and MQ Research charity coordinated Position Paper on Multidisciplinary research priorities for the COVID-19 pandemic: a call for action for mental health science (published in Lancet Psychiatry in April 2020, already cited 600+ times on google scholar).

- O'Connor is also a core member of the COVID-19 Suicide Prevention Research Collaboration which published a strategic priorities paper in Lancet Psychiatry: Suicide risk and prevention during the COVID-19 pandemic.

Industrial/Corporate Partnerships

Our industrial collaborations within the current REF-period included the following:

- Funding from pharmaceutical companies, e.g. Hughes (Grunenthal GmbH), Morris (Servier), and Uhlhaas (Eli Lilly, Lundbeck), and Riddel (IPSEN Bioinnervation).

- Funding medical imaging companies, e.g., Gross (BESA), and Gunamnoy (Siemens).

- Funding from companies in the area of digital technology, e.g. Jack (DI4D, Furhat Robotics), DeBruine (DI4D), Pollick (Qumodo, Jaguar-Land Rover).

- Papies has funding from food companies (Unilever R&D, Danone).

- Philiastides collaborates with MR Coiltech Ltd (embedded in the University's Clinical Innovation Zone) on 7T-headcoil development.

Internal Collaborations

Interdisciplinary synergies across centres, as well as with other units across UofG, is an integral part of our research activities and is key to our strengths as a research unit. Examples of such internal collaborations over the current REF-period include:

- The recently established *UKRI Centre for Doctoral Training in Socially Intelligent Artificial Agents* (£4.8M funding for 50 PhD UofG studentships, 2020-2025) will further enhance our collaborative links with Computing Science over the coming years, through joint interdisciplinary supervision of PhD projects.

- Infrastructure development within CCNi/ICE included the construction of a bespoke 7T-MR compatible headcoil for concurrent EEG recordings, combining dynamic with anatomical neuroimaging in the high field environment (e.g. for EEG-informed subcortical and laminar 7TMR imaging). This resulted from collaboration between CCNi and Radio Frequency Engineering at ICE (PIs Philiastides and Gunamony).

- Philiastides (CCNi, cSCAN) and Cavanagh (MHW) collaborate on developing behavioural phenotypes and neural markers for predicting treatment response in psychiatry.

- Papies (cSCAN) and Pell (MHW) have an ongoing research collaboration on recycling behaviours.

- Pollik (cSCAN) and Brewster (Computing Science) collaborate on ViAjeRo Project *improving passenger experience with XR* (2019-2022, £401K ERC Advanced Award with Brewster as lead PI).

Wider Activities and Contributions to the Research Base

Staff from our unit are editors at many prominent journals (e.g., *Journal of Experimental Psychology: General*, *Current Biology*, *Journal of Experimental Social Psychology*, *Cognition*, *Psychological Science*, *PLOS Biology, European Neuropsychopharmacology*) and have edited special issues of *Phil Trans B*. Some staff members have won prominent prizes, such as the BPS Spearman's Medal, the ECVP Rank Prize Lecture and the Evans Forrest Medal for Cancer research.

UoA4 staff are also represented on various **Funding Review Panels**, including Gumley (Health Research Board Ireland and Bamford Northern Ireland), Jahoda (Carnegie Trust, ESRC, and NIHR), Morris (EC/Horizon2020), Smith (Health Research Board Ireland), Robertson (MRC), Cross, Jack, and Scheepers (for ESRC), Thut (UKRI and Wellcome Trust), McLeod (NIHR, Sheikh Hamdan Awards for Medical Sciences, and The Netherlands organisation for Health Research and Development), Gross (BBSRC and Norway Research Council), DeBruine (Carnegie Trust), Uhlhaas (French National Research Agency), O'Connor (American Foundation for Suicide Prevention and Chief Scientist Office), and Cooper (Baily Thomas Trust and Chief Scientist Office).

Staff from our unit have also led adoption of Registered Reports at several specialist journals and/or edited special journal issues of Registered Reports. Rousselet has recently been appointed Senior Editor for Registered Reports in *Brain and Neuroscience Advances*, the recently created official journal of the British Neuroscience Association.

Reproducible research practices are actively promoted in our unit through our *Methods and Metascience* seminar and workshop series (https://www.psy.gla.ac.uk/events/?sub=12), which is organised by members of the Methods and Statistics support group.

Reproducible science is firmly embedded in our teaching at all levels (e.g., R-coding for reproducible analyses is taught from Level 1 undergraduate level through to postgraduate students, postdoctoral researchers, and other staff, as well as academic staff). Notably, many of these initiatives are led by PhD students, such as the *ESRC-funded workshop on data visualisation* (in which our PhD students taught such skills to arts and social science students) or active participation in the *ReproducibiliTea* journal club initiative.

Staff from our unit have led several large-scale global replication efforts. Most notably, they led the first study selected to be run via the Psychological Science Accelerator (a distributed network of 400+ laboratories from across the world who conduct democratically selected large-scale studies). This work has been accepted in principle as a Registered Report at Nature Human Behavior. Moreover, staff from our unit have published large-scale replication studies in leading international journals (e.g., Elife, Psychological Science).

Our staff has given keynotes and invited talks on reproducibility at key meetings (e.g., University of Cambridge's and University of Oxford's Annual Reproducibility Meetings), as well as led symposia on teaching reproducible science (e.g., led symposium at International Congress of Psychological Science), and are well represented on the UK Reproducibility Network. Our teaching staff have also delivered a series of workshops aimed at those looking to place a greater emphasis on teaching reproducible analysis at their own institutions (100+ attendees) and led a workshop on this topic at the annual meeting of the Society for Improvements of Psychological Science. In her role as Chair of the British Psychological Society's Undergraduate Education Committee, our Deputy Head of Psychology oversaw key changes to accreditation standards that facilitate innovation in models of empirical project supervision, meaning that students can undertake projects that better educate them in reproducible, strong science.

Societal Impact and Outreach

Our research has made considerable societal impact. Indeed, maximizing the societal impact of our research is embedded in everything we do. In addition to our impact case studies, our research regularly informs government policy nationally and internationally. For example:

- Research within MHW has influenced national and international policy and clinical practice in suicide prevention. Indeed, O'Connor's IMV model of suicide (http://www.suicideresearch.info/the-imv) is guiding the Scottish government's national suicide prevention action plan.
- Minnis' early years' work has led directly to the Scottish Government pledging more than £3million for new Infant Mental Health Clinical "Hubs" in Scotland, based on the model we are testing within our BeST Services Trial.

- The work of Scottish Learning Disabilities Observatory (Melville) is improving the lives of those with disabilities.

- We are partners in the Scottish Government's flagship Distress Brief Intervention (DBI; dbi.scot) programme, a world's first in providing inter-agency problem solving support to individuals in distress. DBI won the Care for Mental Health award at the Scottish Health Awards in 2019. It has already helped more than 5,000 people in distress. SBRL developed all intervention and training materials and our research is embedded throughout.

- Staff from *cSCAN* and *CCNi* presented an interactive exhibit of their work on cultural differences in perceptions of social signals at the *Royal Society Summer Science Exhibition*. This exhibit was one of three that was highlighted by the Royal Society as being of particularly broad interest. Analysis of attendee feedback showed that our interactive exhibit increased attendees' understanding of the interdisciplinary nature of psychological research, by highlighting links to other disciplines, such as computer science, biology, neuroscience, and anthropology.

We are actively engaged in a wide variety of **mentoring, outreach, and public engagement activities** to promote wider participation in the discipline from people of all backgrounds. These activities include providing annual Nuffield Research Placements (UK), Robertson Trust Mentors (UK), Society of Personality and Social Psychology Summer Program for Undergraduate Research (SPUR, SPSP; USA), "Pint of Science" public presentation/discussion evenings, online seminars with primary and secondary schools, campus visits and shadowing. We also participate in the Festival of Science and regularly hold public demonstrations and exhibitions at the Glasgow Science Centre.

To support staff in establishing and maintaining collaborations, networks, and partnerships within and outside of academia, we developed and implemented several practices and facilities to meet the diverse needs of all staff. These include promoting and providing flexible working options, bespoke support before, during and after leave, annual discussions (as part of PDR) and support from line managers to establish and maintain research collaborations and pursue membership of influential external boards, networking opportunities and related workshops during core hours.