

Institution: University of Leicester
Unit of Assessment: UoA4 Psychology, Psychiatry and Neuroscience
1. Unit context and structure, research and impact strategy <u>Unit context and structure</u> The University of Leicester's submission to UoA4 comprises a highly interdisciplinary cohort of researchers seeking to understand the workings of the mind, brain and behaviour, and pathological mechanisms of neurological disease. Our integration of neuroscience, psychology, and clinical research has been made possible by significant strategic investments, prioritising organisational and physical proximity between groups, the provision of state-of-the-art facilities, and strong links between academics and the NHS, which facilitates the application of our research. Our diversity is our strength. The close interface between disciplines enables, for example, psychologists to work with ophthalmologists to investigate eye movements in people with visual impairment, social psychologists to work alongside psychiatrists to understand mental health and well-being in BAME populations (i.e. black, Asian, or minority ethnic groups), and neuroscientists to work with clinicians to understand causes of vertigo in COVID-19 patients. Pulling down interdisciplinary boundaries has led to novel approaches, such as the use of zebrafish as a model for retinal development in humans, and locusts as a model for understanding the basis of tinnitus and concussion. We have invested significantly in state-of the-art facilities, including £42M in the new George Davies Centre for Medicine, which created bespoke laboratory space for human behavioural and neuroscientific research. Here we work alongside colleagues in the School of Medicine and Department of Health Sciences, and teach our students. The Centre is located close to the Leicester Royal Infirmary, facilitating links between fundamental research and frontline clinicians, helping our research to inform practice and achieve translation. This close proximity between fundamental and applied research has helped neuroscientists explore the relationship between cerebrovascular function, stroke and cognition alongside clinical cardiovascular specialists that test these findings. Similarly, it has enabled vision scientists to work with eye specialists, while our approach to facilitating cross-disciplinary interactions and translational research has helped our neuroscientists, psychologists, and research psychiatrists work with specialists in psychiatric services on neurodegenerative conditions such as Huntington's, Alzheimer's and Parkinson's disease. We made significant achievements through 153 external research awards totalling over £20M, including more than £10.5M from UK Research Councils. Additionally, we increased our PGR completions by 64% – from 148 in REF2014 to 242 in REF2021 – and our BAME PGR population increased from 17% to 27% during the REF period, reaching a high of 37% in 2018/19. Parallel investment in people has created 14 new academic posts recruiting nine lecturers and five professors. This REF period also saw us promote 13 people to Associate Professor (6 women) and 5 to Professor (2 women). We also strengthened our early career research by appointing two Royal Society University Fellows, an NIHR Research Fellow, and an ESRC 'Future Research Leaders' Post-doctoral Fellow.

We have returned 50 (47 FTE) staff to this UoA4 submission, representing a significant critical mass of researchers and an increase of 12.6 FTE from REF2014. Forty sit within one department and work closely with 10 key staff from three other departments. As shown in **Figure 1**, our research has embraced two broad themes: (1) Neuroscience & Behaviour and (2) Psychological, Cognitive, and Sensory Sciences. These divide into five research groups, with mechanisms in place to ensure there are flexible interfaces allowing cross-group interactions:

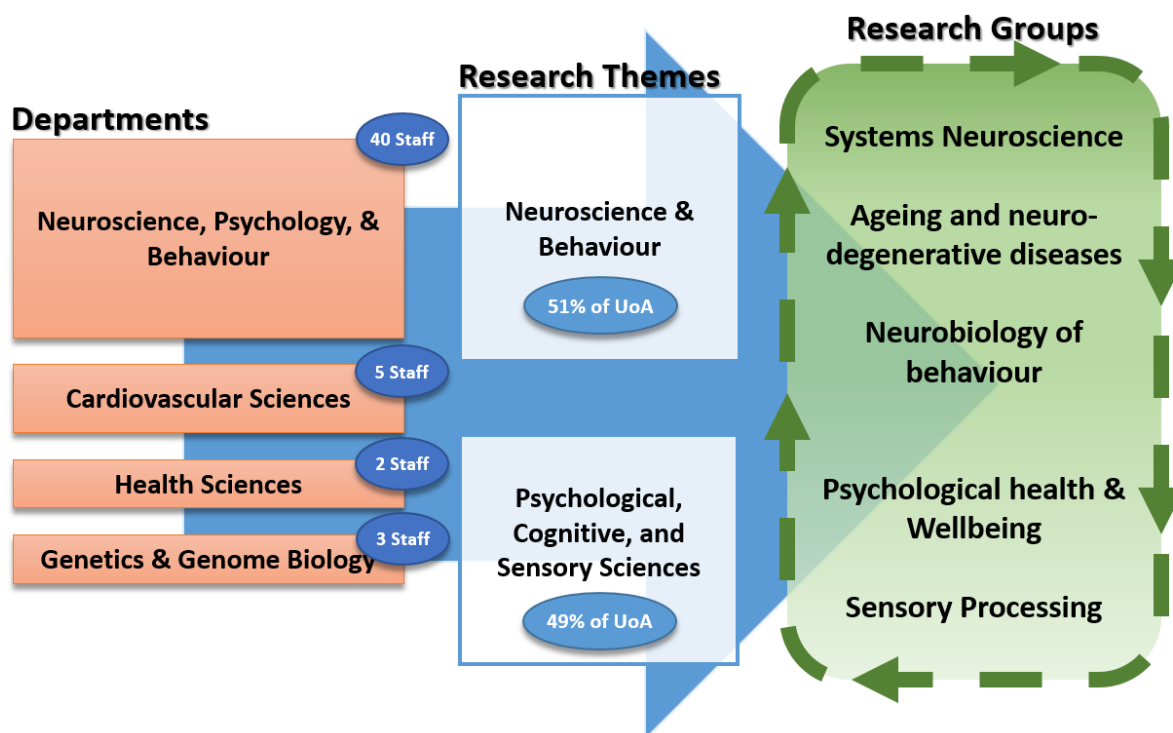


Figure 1: How expertise flows through our research themes into collaborative research groups.

The **Neuroscience and Behaviour** theme focusses on:

- (i) Understanding the **systems neuroscience** underlying the function of cells and cell assemblies, and memory formation in the hippocampus;
- (ii) Revealing the neural basis of normal brain function, **ageing and neurodegenerative disease**, including interventions that benefit patients;
- (iii) Exploring the **neurobiology of behaviour** ranging from *in vivo* and *in vitro* animal models (flatworms, snails, insects and rats) to humans.

The **Psychological, Cognitive, and Sensory Sciences** theme comprises:

- (i) Using epidemiological, quantitative/qualitative, and game-theoretic approaches to address **psychological health and well-being** in diverse populations.
- (ii) Integrating methods from neuroscience, ophthalmology, and psychology to investigate **sensory processing**, from the eye/ear to the brain, in normative and clinical populations.

Research and Impact Strategy

Guided by strategic decisions following from REF2014, and supported by advice from an

external review in 2016, our strategy has been to bring together neuroscience and psychology at Leicester. In REF2014, we described how we restructured to align these areas. We set out to:

- Build on strengths in fundamental neuroscience, cognitive psychology and behaviour,
- Adopt and develop new research methods and,
- Develop cross-disciplinary links, especially between the University and the NHS

To achieve these research aims, an build on our impact strategy in REF2014, we set out to:

- Enhance our culture of promoting and supporting research translation and enterprise,
- Strengthen links between our research and the NHS through new appointments and collaborations,
- Use university funding and support mechanisms to establish industry partnerships, in line with the university enterprise strategy.

We achieved these aims through the following strategies:

- **Integrating neuroscience, ophthalmology, and psychology, along with elements of psychiatry, into a single multi-disciplinary research department** (Neuroscience, Psychology and Behaviour, NPB) in 2015, as part of a College-wide strategic review. This ambitious restructuring brought most UoA4 research into one department, with the aim of facilitating cross-disciplinary interaction around core research themes, with examples including mechanisms and disorders of sensory processing and the neuro-genetic basis of neurodegenerative disease. The 2016 College-wide research review also recommended strengthening links between fundamental and translational research, which resulted in the integration of the previously stand-alone Centre for Systems Neuroscience (**CSN**) into NPB.
- **Inspiring interdisciplinarity and optimising research groupings:** In 2014 our research groups were distributed across departments and spread over the campus. In 2016, we relocated psychology into the new George Davies building, to ensure our researchers are organisationally and physically close, and instituted interdisciplinary research groupings to inspire impactful cross-disciplinary interactions e.g. using fish models to understand neural mechanisms underlying aggression in people and develop therapeutic interventions for conduct disorder. This structure helped UoA4 members engage in interdisciplinary research, for example, around ageing and frailty (**Maltby**) and antibiotic over-prescribing (**Colman, Krockow**). Other initiatives managed by our interdisciplinary Leicester Institute for Advanced Studies (**LIAS**) included UoA4 members leading the cross-university Prison Research Network, focused on health and wellbeing, security and organisational culture in prisons (**Hatcher, Palmer**).
- **Establishing novel research methods and techniques:** through institutional investment in specialist facilities (£90k EEG lab; £50k eye-tracking lab; £50k virtual reality mouse lab), the most significant being £16.5M (£12.6M from UoL, £3.9M from WT) for our Pre-Clinical Research Facility (**PRF**). The PRF underpins UOA4 research based on animal models and has been crucial to the implementation of innovative methods, including use of CRISPR/Cas9 gene-editing to create mouse models of human disease (**Forsythe**). Alongside this, we received £1.5M BBSRC funding for dedicated multiphoton microscopy to support the development of functional super-resolution microscopy for fast, multiphoton imaging in freely moving, living systems (**Hartell**). We also led the application of hand-held OCT for diagnosis of paediatric retinal impairment –

underpinning an impact case study (**Gottlob, Proudlock, Thomas**). These initiatives also generated enterprise opportunities (e.g. IP and patents for advanced microscopy).

- **Appointing new, and supporting current, staff.** Our approach to making strategic appointments has driven success. For example, in 2016 we appointed **J. Apergis-Schoute** as lecturer to grow our neurobiology group, who subsequently secured Leverhulme Trust and Wellcome Trust funding to apply optogenetics to understanding the role of the hypothalamus in regulating food choice. More recently, we appointed **Arshad** as lecturer in the sensory processing group, following which he obtained an NIH grant (joint with Johns Hopkins University) to study vestibular migraine, and more recent funding to investigate vertigo in long COVID. As described in Section 2, we have a well-developed career progression structure, facilitating the promotion of 18 staff (8 female) in the REF period.
- **Strengthening links with the NHS:** As outlined in Section 3, our College -wide strategy for fostering collaborations between academics and clinicians has helped strengthen links with University Hospitals Leicester (**UHL**) NHS Trust, and support research translation. This is underpinned by joint professorial appointments, which in ophthalmology (**Gottlob**) allow our vision scientists to engage directly with eye-disease specialists, supported by dedicated laboratory space in the Ulverscroft eye clinic at Leicester Royal Infirmary (**LRI**). Specialist cardiovascular laboratories at the LRI also enable our medical physicists to investigate change in cerebrovascular function because of dementia. An appointment in old-age psychiatry (**Mukaetova-Ladinska**) helped establish links with the memory clinic at Leicester General hospital. We also benefit from strong links with specialist psychiatric services at Glenfield Hospital, and work closely with Mill Lodge Huntington's Disease and Community Service (**Giorgini, Maltby**).
- **Promoting research translation and enterprise:** In line with University strategies (described in the IES), UoA4 members established industry partnerships bringing in over £8.7M in the REF period. This includes collaborations with pharmaceutical companies to develop new therapeutic targets for Huntington's Disease (Teva Pharmaceuticals) and to diagnose and treat visual impairment (Allianz Worldwide Care). As described in Section 4, it includes work with third-sector organisations, creation of intellectual property, including development of software and novel patents (e.g. for advanced microscopy, biomarkers of neurodegenerative disease, and technology for developing brain-computer interfaces).
- **Encouraging an open research environment:** In line with the university strategic priority of embedding a culture of open research (Institutional Environment Statement [IES], section 2.6), we encourage open science methods, including promoting use of FigShare (available at Leicester since 2018) as a permanent, open-access repository for research outputs that are citable, shareable and discoverable, adhering to FAIR principles. The CLS FigShare receives >34K views and >25K downloads monthly. UoA4 members are required to deposit their research outputs (as final prepublication versions) on Figshare within three months of acceptance for publication, where they are made available through GREEN OA. The University also administers OA funding from UKRI and WT that supports GOLD OA publication, while numerous UoA4 researchers use arxiv sites to publish pre-prints. UoA4 researchers hold annual workshops to promote

discussion around open science and reproducibility and in 2018, with support from the Wellcome Trust Institutional Strategic Support Fund (WTISSF), UoL hosted a Wellcome Trust open research workshop. During the assessment period, 79% of our outputs were published open access, compared to the Russell Group average of 63% (SciVal).

- **Promoting a culture of research integrity:** The University adheres to DORA principles (IES, 2.7) and is signatory to the Concordat for Research Integrity (renewed in 2019). In 2014, we established a working group to review our research code of conduct and update our research integrity and ethics training – currently mandatory for PhD students and being rolled out to all staff engaged in research.

UoA research activities and achievements

Neuroscience & Behaviour Research Theme

Research in this Theme is conducted in three areas of enquiry:

1. Systems Neuroscience (3FTE, >£1M income, 47 papers, 89% OA):

This research-intensive group led by **Quian Quiroga** conducts research focused on how information is represented in neurons, including the development of novel ‘spike-sorting’ algorithms for analysing complex neural recordings.

Key Achievements: CSN is known internationally for the discovery of ‘concept cells’ – single neurons, primarily in the hippocampus, that fire selectively to stimuli as specific as an individual’s face (e.g. **Quian Quiroga**: *Neuron* 2015, FWCI 2.39; *Curr Biol* 2017, FWCI 3.60; *Curr Biol* 2020, FWCI 3.61). This was achieved by pioneering methods for single-neuron recording in humans, culminating in the hypothesis that concept neurons are a uniquely human, high-level, feature of memory (**Quian Quiroga**, *Trends Cogn Sci* 2020). Work by **Liu**, a strategic appointment in the REF period, has pioneered algorithms underpinning use of synthetic retinal implants for the visually-impaired. **Okun**, another strategic appointment, has driven development of methods for understanding neuron population dynamics in freely-moving animals (e.g. **Okun**, *Nature* 2015, FWCI 6.93).

2. Aging and Neurodegenerative Disease (7.8FTE, >£6.1M income, 181 papers, 73% OA)

This group integrates expertise in genetics, neuroscience and cardiovascular science to conduct fundamental and translational research into the neural basis of normal brain function, stroke and neurodegenerative disease, as well as interventions to benefit patient groups.

Key Achievements: Work by **Giorgini**, **Luthi-Carter**, and **Kronenberg** produced new insights into the neurogenetic basis of Huntington’s and Parkinson’s diseases, improving understanding of specific aetiological and neuroprotective mechanisms, and uncovering new therapeutic targets (**Giorgini**, *Hum Mol Genet* 2015, FWCI 4.33; **Giorgini**, *PNAS* 2016, FWCI 2.81; **Kronenberg**, *Acta Neuropathol* 2018, FWCI 4.33). Other research advanced understanding of the role of sex and steroid hormones in ischaemic stroke/cognitive decline (**Gibson**), autoregulation of cerebral haemodynamics in stroke, cognitive decline and Alzheimer’s Disease (**Chung**, **Panerai**, **Mukaetova-Ladinska**), and blood biomarkers for dementia (**Mukaetova-Ladinska**).

3. Neurobiology of Behaviour (13FTE, >£5M income, 112 papers, 82% OA)

Using state-of-the-art labs, this interdisciplinary team explores how the nervous system controls behaviour in mammalian and insect models. Through these models our neuroscientists,

biologists, and bio-psychologists investigated appetite, food-choice and foraging behaviour, and sensory-motor processing, using these as models for addiction and neurodegenerative disease.

Key Achievements: Work from this group shed new light on use of spatial cues in navigation (**Buckley**), used electrophysiology and optogenetics to reveal the function of the hypothalamus in mediating food choice (**J. Apergis-Schoute**, *J Neurosci* 2015, FWCI 3.48; **J. Apergis-Schoute**, *Cell Rep* 2014, FWCI 4.56), and used functional neuroimaging to understand the neural basis of obsessive-compulsive disorder (**Urcelay**, *Am J Psychiatry* 2015, FWCI 7.34). Other work with transgenic rat models helped understand how the mesolimbic system motivates behaviour relevant to models of addiction, schizophrenia and psychosis (**Gerdjikov**, *Nat Neurosci* 2016, FWCI 4.02; **Gerdjikov**, *J Neurosci* 2014, FWCI 6.93). Work with zebrafish and mouse models helped understand mechanisms mediating motor learning, coordination and aggressive behaviour, with translational relevance to conduct disorder in humans (**Norton**, *Nat Struct Mol Biol* 2018, FWCI 5.16). Research with sponges and comb jellies provided additional insights into evolutionary processes, including those underpinning vision (**Feuda**, *Curr Biol* 2017, FWCI 10.98); while work with locusts provided insights into mechanisms of sensory-motor processing and associative learning (**Mathieson**, **Ott**, **Warren**).

Psychological, Cognitive, and Sensory Sciences Research Theme

Research in this Theme is conducted in two areas of enquiry:

4. Psychological Health & Wellbeing (11.8FTE, >£2.3M income, 281 papers, 76% OA)

This group integrates social, cognitive and developmental psychologists and psychiatrists, using epidemiological, quantitative/qualitative, and game-theoretic methods to address psychological health and well-being in diverse populations. It also fosters relationships with NICE (**Johnson**), and overseas NGOs (**Vostanis**; 18 Government and NGO managers in the Middle East, Africa, and South America).

Key Achievements: The group provided trailblazing insights into social/cognitive development of children born preterm (ICS 3, **Johnson**: *Psychol Sci* 2015, FWCI 2.4; *Arch Dis Child* 2018, FWCI 15.49; *J Pediatr* 2015, FWCI 3.95), and advanced understanding of the neuro-cognitive basis of obsessive-compulsive disorder (**A. Apergis-Schoute**, *Biol Psychiatry* 2017, FWCI 6.66; *Biol Psychiatry* 2019, FWCI 6.44). Our epidemiological research identified higher prevalence of autism in adults which, in turn, has improved services and changed attitudes (ICS 1, **Brugha**; *Psychol Med* 2015, FWCI 18.82; *Br J Psychiatry* 2016, FWCI 5.09). A further ICS (4, **Vostanis**) describes how our research improved the mental health of children experiencing trauma through training programmes for health professional and NGOs in LMICS. Other studies produced ground-breaking insights into confidence, co-operation and trust in human decision-making (**Colman**, **Pulford**), achieved timely impact by applying game-theoretic approaches to understanding antibiotic over-prescribing (**Krockow**), and used big data to gain insights into mental health and neurodegenerative disease (**Maltby** and **McElroy**, *J Child Psychol Psychiatry* 2018, FWCI 4.35).

5. Sensory Processing (11.4FTE, >£5.5M income, 167 papers, 79% OA)

This group combines electrophysiological, ophthalmological, and psychological approaches to improve understanding of human sensory function and visual and auditory impairment, including the impact on activities of daily life, benefitting from close links with local NHS hospitals, charities focused on improving treatment for, and supporting individuals with, visual impairment, as well as significant international collaborations.

Key Achievements: This group has driven understanding of genetic and structural causes, and functional consequences, of visual impairment. It pioneered the use of handheld optical coherence tomography (OCT) in infants to retinal development normatively and in paediatric visual impairment, to improve diagnosis, management, and treatment of disease (ICS 2 **Gottlob, Proudlock, Thomas**; e.g. *Brain* 2019 and *Eur J Hum Genet* 2017). The group also furthered understanding of ageing and reading strategy effects on mechanisms of eye movement control through international collaborations, and pioneering use of co-registration of eye movements and EEG to understand the neural basis of these effects (**McGowan, Paterson and White, J Gerontol B Psychol Sci Soc Sci 2018, FWCI 3.19). They also improved understanding of visual changes in Alzheimer's disease and chronic fatigue syndrome (**Hutchinson**), provided insights into vestibular dysfunction and disorders of sensory processing following brain damage and disease (**Arshad, Lancet 2016, FWCI 5.96), and investigated mechanisms of attention and oculomotor control, including for fingerprint recognition and driving (**Souto, Barrett**). Auditory researchers within the group explored the ionic and synaptic basis of information processing in the brainstem auditory pathway, advancing understanding of mechanisms of hearing loss and tinnitus (**Forsythe, Hamann**; e.g. *J Neurosci* 2014).****

UoA future research and impact strategy

Our future plan is to build on our achievements, in alignment with university and college strategies, by **focussing on research excellence** and strengthening **synergies between fundamental and translational research**, to ensure we achieve economic and societal impact from a larger proportion of our excellent research. Specifically, we aim to:

- **Focus our research endeavour** in key areas of inter-disciplinary enquiry to tackle topics that are important to society, including in relation to ageing and neurodegeneration, functional vision and sensory impairment, and the psychology of health and wellbeing.
- **Achieve greater research translation and societal impact** by strengthening our links with academic clinicians and the NHS, including in areas of cardiovascular science, ophthalmology, and mental health, education services, and relevant third-sector organisations (e.g. Ulverscroft Foundation) and industry and to widen our access to patient / participant groups to increase our impact.
- **Engage pro-actively with issues surrounding equality, diversity and inclusion**, by mentoring and supporting members of under-represented groups (female, BAME, and those who intersect these characteristics) to conduct world-class research and take research leadership positions.
- **Build on our approach to open science and research integrity**, by creating an environment that prizes openness and transparency in scientific enquiry, supports the discoverability and availability of research findings, and makes available software and data for sharing and re-use.

2. People

Staffing strategy and staff development

In line with the university's major strategic initiative of Discovering People (described in the IES), our strategy is to attract, retain and develop the best researchers by celebrating and recognising success while valuing equality and advancing diversity, by:

- **Recruiting** academic staff who fit strategically within priority areas, with the highest potential to achieve research excellence;
- **Retaining** excellent staff by supporting ECRs to obtain permanent academic positions and making emeritus appointments to retain expertise;
- **Supporting** new and existing staff to realise their potential, through individual mentoring, recognising excellence, and supporting career progression;
- **Increasing diversity** by ensuring appointment and promotion procedures are fair and equitable, affording opportunity to under-represented groups.

UoA4 currently comprises 50 staff (47 FTE): 16 professors (25% female), 4 Readers (25% female), 13 Associate Professors (40% female), 14 Lecturers (38% female), and 3 Research Fellow ECRs (all male).

Recruitment strategy

In line with our staffing strategy, we enhanced our staff by:

- **New appointments.** We made 14 appointments in the REF period, all leading to productive research programmes. For example, although junior appointments, **Buckley, J. Apergis-Schoute, McCutcheon**, and **Urcelay** obtained funds totalling over £675k to research the neurobiology of behaviour.
- **Internal appointment of ECRs to permanent academic posts** to attract and retain talented staff. This includes the appointment of an ESRC postdoctoral fellowship to a permanent academic position (**McGowan**), award of an internally-funded fellowship, and subsequent appointment to a permanent position, of a talented ECR (**Okun**); and the commitment of permanent positions to three current ECRs (**Feuda, Thomas, Warren**).
- **Recruiting senior academics to strengthen NHS links.** We appointed **Kronenberg** and **Mukaetova-Ladinska** at professorial level to strengthen links with NHS psychiatric services and build research capacity in ageing, neurodegeneration, and dementia. We also appointed an NIHR Academic Clinical Lecturer (**Thomas**) to investigate the genetic basis of nystagmus, leading to a further £58k in research awards, and our NIHR Doctoral Fellow **Rufai** (joint with Great Ormond Street Hospital) was awarded £345k to investigate retinal development.

Staff development and retention

We support staff across all career stages through a well-established mentoring system and encourage staff to engage in the **Coaching and Mentoring Academy** (described in the IES) to facilitate career development. There is a thriving informal mentoring system within UoA4. For example, **Krockow** (mentored by **McCutcheon**) says, *'He was extremely engaged and encouraging, and looked over my CVs and applications... I always felt very well supported in the Department and I'm sure this has enabled me to progress in my academic career.'*

Our specific staff development strategies are to:

- **Support Early Career Researchers (ECRs)** through a dedicated academic lead on Early Career Development who reports to CSL Research and Enterprise Committees. This lead works closely with Doctoral College and PGR leadership team to organise mentorship and training for ECRs and research staff, supporting the implementation of the Concordat for Researchers at College-level, and engaging with EDI initiatives. ECRs

present their work regularly at monthly research group meetings, and receive constructive feedback from peers and senior academics. Bespoke grant writing courses and departmentally-run grant development meetings serve to help develop funding applications.

- **Provide internal seed-corn funding opportunities** to support the exploration of new ideas and collaborations. This includes dedicated ECR funding via WTISSE and Doctoral College ECR fund. ECRs have used this funding to leverage follow-up support from, e.g., Parkinson's UK (**Moisoi**) and Daphne-Jackson Trust (**Asif-Malik**). WTISSE funding (2017-21) also provided one-year ECR fellowships to **Krockow** (applying decision-making research to antibiotic over-prescribing) and **Warren** (investigating the molecular basis of hearing in locusts).
- **Facilitating career progression:** Effective staff development is key to our success, and achieved through support mechanisms including a buddy system for orienting new staff members, and our mentorship scheme. Mentors function independently of line managers, advising on research and funding strategy, grant applications, publications, and career development, including applying for promotion and engaging in cross-disciplinary research. This has supported early-career staff in achieving promotion, e.g. **Hutchinson**, *'My mentor helped me reflect on how I might use my research in more applied areas. This led to my work on to visual ageing and resulted in several well-cited, high-impact papers and the successful completion of my first PhD student. These outcomes formed a key part of my successful promotion application.'*

We encourage staff to make use of university initiatives, e.g. future leaders training, coaching and mentorship, including schemes specifically for women, such as Aurora, Calibre programme, and Women Leading with a Purpose (WLP). The VITAL Leadership Programme (VLP), designed to equip academics with skills to operate and lead strategically and successfully in a competitive environment. For example, Gibson, **Luthi-Carter**, and **Maltby's** participation in university Future Leadership Programme equipped them to take on leadership roles: Gibson as head of NPB, **Luthi-Carter** as College ECR lead and departmental lead for Athena SWAN; **Maltby** as departmental research director.

We encourage ECRs to access the University's Academic Practice Unit, which provides research development training including induction, mentoring, and workshops on research leadership and management.

We provide a phased route to retirement, helping staff to continue working with a reduced workload before transitioning from full-time work to full-time retirement. Staff wishing to work beyond the conventional retirement age continue to make significant contributions to research and teaching in an agreed role or emeritus capacity (e.g. **Colman**, **Panerai**).

- **Developing research excellence:** All staff create a Personal Research Strategy (**PRS**) and participate in Personal Development Discussions (**PDDs**) annually. These assess research and impact activities for the past year, and plans and training needs for the coming year, helping staff to formulate targets and assess these relative to their performance. PDDs are undertaken with the departmental head or nominated

representative, and clinical academics have joint NHS/University PDDs. We facilitate career growth through grant application development and review procedures that assess applications >£50k.

- Our promotion structure **recognises success and rewards staff** for conducting high-quality research and achieving impact. To support career development, the University launched a Coaching and Mentoring Academy in 2017, and the Academic Career Map designed to harmonise and support promotion processes, and narrow gender and BAME pay and promotion gaps, by valuing achievements across a range of activities, including impact and knowledge exchange, and citizenship. Achievements are celebrated through weekly newsletters and all-staff emails, and staff are recommended for awards that recognise their contribution to research impact. Our approach to recognising and rewarding success was commended in the response to our 2017 Athena SWAN application.
- **Stimulating Exchange with Business and Enterprise** by advertising internal research and impact funding schemes via flyers and a weekly newsletter. An excellent example from UoA4 was a seed-corn internal award focused on ageing and dementia (**Maltby, Mukaetova-Ladinska**), which facilitated an industrial collaboration with Cerebrum Matters Ltd. and a subsequent MRC iCASE studentship to assess benefits of brain-training in healthy ageing and dementia.
- **Supporting our Technical staff:** The university is a signatory to the Technician Commitment (2017), indicating the value it gives to ensuring visibility, recognition, career development and sustainability for technicians across disciplines. A Steering Group and action plan to implement the commitment was established in 2018, to develop professional registration pathways for technicians, promote CPD opportunities, and implement a mentoring scheme for technical staff. We also participate in the College Technician's Forum, which provides a focus for discussions around career development and training. Since 2019 a 'Technician of the Year' category is included in the University Discovering Excellence Staff Awards to celebrate the contributions of our technical staff.

Research Students

UoA4 awarded 242 PhDs in the REF period, supervised by 54 staff (including teaching-focused staff), averaging 4.48 students per staff member. Over the REF period, we averaged 63% female, and 31% BAME, students. Postgraduate research was supported by regional BBSRC and MRC doctoral training programmes (DTP), and collaborative studentships through the Midlands ESRC DTP. Our NHS-funded Doctorate in Clinical Psychology (D.Clin.Psy) provided clinical and research training to ~14 students per year, with research supervision provided by UoA4 members and clinical teaching staff. Since 2013/14, we have offered competitive department and college studentships annually to outstanding candidates, and funded doctoral research by graduate teaching assistants in the School of Psychology, achieving 22 doctoral awards from university funding in the REF period. We also attracted international applicants funded by their university or government education departments, with other UK Government (e.g. Home Office, NHS), charity and EU (e.g. Marie Curie training networks) funded studentships. Figure 2 show the distribution of doctoral completions across funding sources.

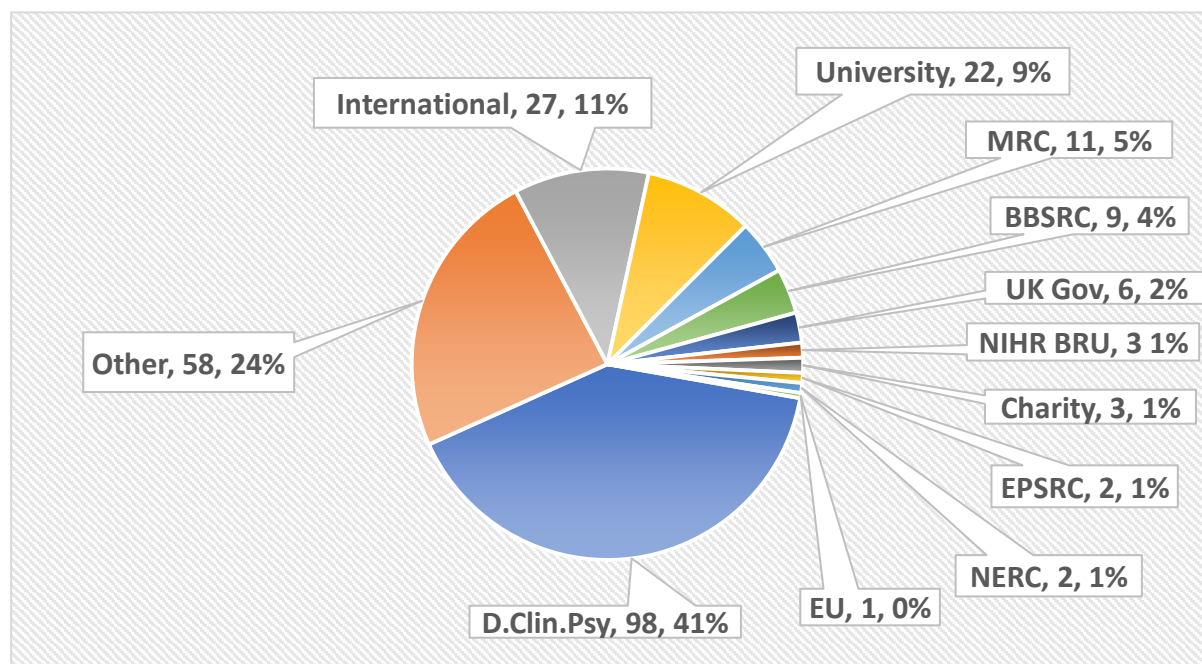


Figure 2: Doctoral awards in UoA4 over the REF period.

Recruitment & funding: Our recruitment process ensures applicants receive fair and equitable opportunities. RCUK, charity and College studentships are advertised via University webpages, FindaPhD.com, and social media to reach large and diverse audiences. Prospective students outline their academic background, intended topic, and potential supervisor. Relevant staff discuss proposals informally with applicants to help shape projects, followed by a formal interview with a potential supervisor and other staff to mitigate bias. Interviews have gender-balanced panels, are held within core hours (10am–4pm), with accessibility arrangements to fit applicant needs. Part-time registration is welcomed, in recognition that individuals may have commitments that preclude full-time study.

For studentships awarded through the regional DTPs (described below) BBSRC Midlands Integrative Biosciences Training Partnership (MIBTP), and the DTPs, potential supervisor-proposed projects are assessed for fit with the DTP remit and advertised via DTP webpages and online. Applicants are shortlisted and invited for interview by panels comprising staff from across member universities.

BBSRC Midlands Integrative Biosciences Training Partnership (MIBTP): This 4-year programme established in 2015 and renewed in 2020 (£20M, 52 students/year), provides broad experience of life sciences research, by rotating students across short-duration (12-week) projects on different topics in year one, before focusing on the PhD project in years two to four. This DTP supported 9 UoA4 projects in the REF period.

MRC Integrated Midlands Partnership for Biomedical Training (IMPACT): Established in 2016, this midlands DTP (£3.5M, 14 students/year), supports research around the theme of complex disease, including nine UoA4 projects in the REF period.

Central England NERC Training Alliance (CENTA): This consortium, led by the University of Leicester and established in 2013 and renewed in 2019 (£4.9M; 24 students/year), supports

research around environment and earth science, including genetics and genomic science, supporting two UoA4 projects in the REF period.

ESRC: This consortium of midlands institutions, was established in 2016, and supported two collaborative UoA4 research projects in the REF period.

UoA4 researchers participated in three **EU Initial Training Networks (ITNs)** during the REF period, CINCHRON (Comparative INsect CHRONobiology: €547M to Leicester, which was the co-ordinating institution; **Rosato** as co-lead), LISTEN (Liaison in Scientific Training for European auditory Neuroscience: €273K to Leicester), and INTREPID Forensics (Interdisciplinary Training and Research Programme for Innovative Doctorates in Forensic Science: €2.9M, with Leicester as co-ordinating institution). These ITNs supported studentships supervised by **Rosato**, **Forsythe** and **Barrett**, respectively.

Support, Training, and Supervision of PGR students: PGR support and training is overseen by the Doctoral College (IES, 3.3). PGR progress is monitored using an online system (MyPGR) to record monthly supervisory meetings and other milestones. Academic and pastoral support is provided by departmental postgraduate research tutors. Students are registered initially for one year as an advanced postgraduate, after which they can proceed to full PhD status dependent on the outcome of a formal probationary review. At the start of their studies, students are assigned a supervisory team comprising at least two supervisors, and an independent progress review panel (PRP) which reviews progress at the end of years 1 and 2 (of full-time study, with equivalent part-time milestones). During the first year (full-time, with part-time equivalent), students meet with their supervisors at least monthly, to develop research and training plans. Students record these meetings, including content and goals, using MyPGR.

Within 10 months, the student submits a report including a literature review and research plan, having given a seminar outlining their progress and future research plans, and attend a probationary review meeting with their PRP. This is a key decision point where the PRP recommends progression to a PhD degree, revision and resubmission of the research plan, or termination of studies. Full-time students must complete their research within 3 years of registration and submit their thesis within 4 years. This structure allows PGRs freedom to explore their research interests while simultaneously being supported by their supervisory panel and Department.

DTPs have their own generic training programmes but all students benefit from a broad range of training delivered at UoL and partner organisations. Within UoL, the Doctoral College provides a comprehensive research skills and career development programme for doctoral and postdoctoral researchers. Library services also provide workshops and online training in bibliographic methods. For all our research areas, adjacent high-quality office space is provided for PhD students and postdoctoral researchers. The timeline for students, regardless of funding body, is shown in **Figure 3**.

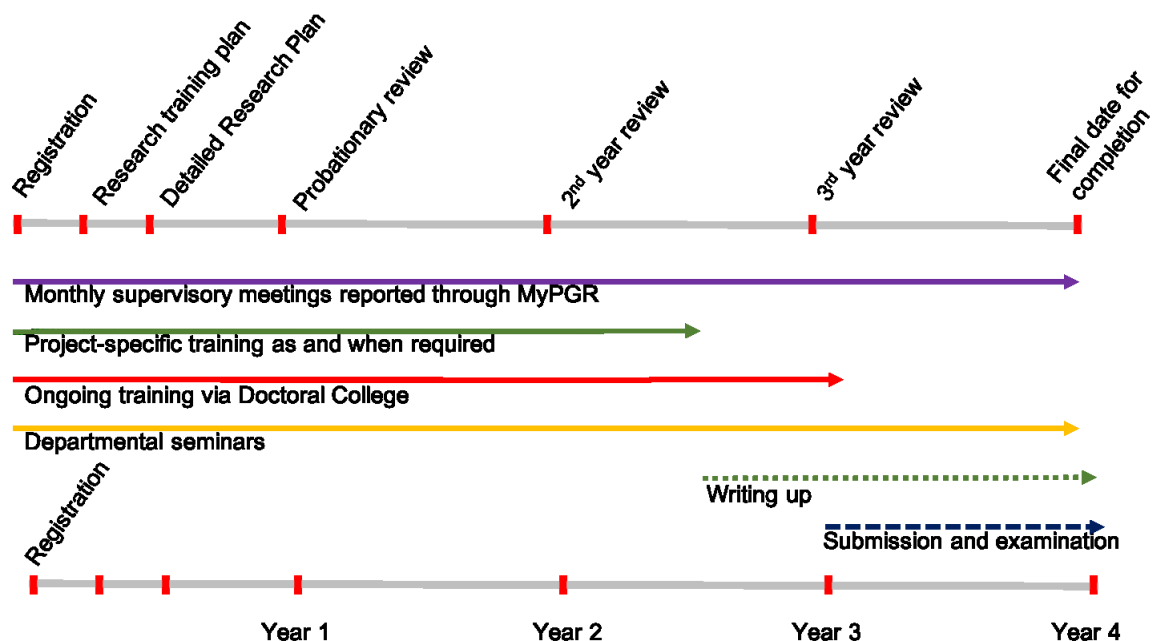


Figure 3: The PGR training timeline for all students regardless of funding body.

Integration into the research environment is achieved through departmental seminars, with dedicated time for students to interact with speakers, and monthly journal clubs. Independently, UoA4 students created a 'Reproducibilitea Journal Club' in association with the reproducibilitea.org network, hosting discussions of reproducibility in science. Our students regularly present work within their research groups, gaining constructive feedback from peers and senior staff. Departmental and Graduate school funds are available to support conference attendance in addition to studentship funding.

As described in the IES, **postgraduate student satisfaction** is high, with Leicester scoring higher than sector and Russell group averages in almost all sections of PRES. UoA4 satisfaction is especially high (>80%) in relation to **quality of supervision** and **resources**.

Equality, Diversity & Inclusion (EDI)

EDI and the provision of high quality staff support is central to the University's Strategic Plan (IES, 3.1). UoA4 benefits from institutional policies including: **Flexible Working policy** to support staff, including staff with care responsibilities, ill-health or disability, or working towards retirement. We offer enhanced schemes for parental leave, regardless of sex or length of service, and compassionate leave. We have zero tolerance of bullying or harassment and operate a Dignity at Work code of practice to ensure staff are treated with dignity irrespective of age, disability, gender or gender reassignment, marriage or civil partnership, race, religion or belief, sex, or sexual orientation.

The University has an Equal Opportunities (**EO**) Policy, an Equalities Unit (with an EO and Athena SWAN coordinator), and an EO Committee at which gender equality and EO issues are under continual review. In line with this, our on-boarding process for new staff mandates training in EDI and unconscious bias at induction, with refresher courses at least every 24 months. UoA4 has three Diversity champions, who play a vital role in leading and advertising diversity initiatives, e.g. in relation to International Women's day and Black History month. CLS holds a silver Athena Swan award, reflecting our commitment to equality. We are proud that

UoL is signed up to the Race Equality Charter and the only UK University partner in the United Nations' 'HeforShe' campaign. However, we are not complacent about the need to improve gender parity and BAME representation, especially at senior grades. Within UoA4, 32% of staff are women, 8% identify as BAME, and 6% are both female and identify as BAME. We recognise female, BAME, and those who intersect these characteristics, historically have achieved lower levels of research income. To combat this, we provide grant development meetings to support idea development, constructive peer review from experienced academics on funder committees (BBSRC, ESRC, MRC, Leverhulme Trust), supplemented by expert support from the RED team in preparing and costing applications. Our most recent Athena SWAN application (2017) was commended for the support for early career research and in aiding staff to develop grant applications.

We are committed to ensuring all staff are fully supported in undertaking research, including providing access to facilities by staff with physical disabilities (e.g., lifts and wheelchair access) in all research and teaching buildings. Staff are also provided with specialist equipment (e.g. standing desks, high-resolution monitors, ergonomic chairs) to support a healthy working environment. The university provides support in relation to mental health and wellbeing via a 24/7 telephone counselling service and face-to-face counselling, and comprehensive occupational health provision, including an employee assistance programme (validium.com).

3. Income, infrastructure and facilities

Research Income

Research income over the REF period totals >£20M, equating to £64k per FTE per annum. The major sources of this income are summarised in Figure 4.

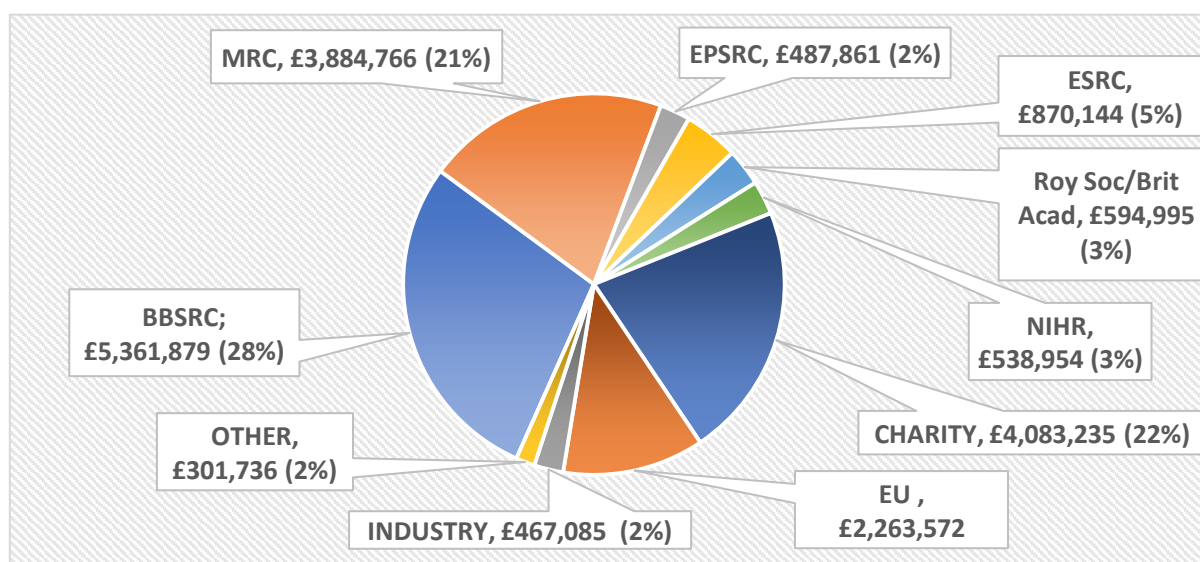


Figure 4: UoA4 research income from external sources over REF period.

This included more than £10.5M from RCUK and significant NIHR funding, supplemented by funding from major UK Charities (e.g. Wellcome Trust, Leverhulme Trust; £3.8M). We also benefit from support from smaller charities, including The British Tinnitus Association (£40k), Rosetrees Trust (£50k), and Ulverscroft Foundation (>£650k). Overseas funding streams

included £130k from National Institutes of Mental Health (NIMH), and £180k from Visterra Inc. to develop innovative antibody-based therapies for patients with hard-to-treat diseases, reflecting continuing efforts to diversify our research income streams.

We attained 153 awards by 54 (49 current at REF return) PIs totalling more than £20M over the REF period. Noteworthy awards went to **Johnson**: >£600k UKRI funding, £200k of EU funding, and £280k from Action Medical Research that led to studies into educational achievement following premature birth and interventions to support school learning by children born pre-term, with results the subject of an ICS (3) and flagship publications (**Johnson**: *Psychol Sci* 2015; *NEJM* 2019; *Lancet Child Adolesc Health*, 2019).

Gottlob received £770k from UKRI and £700k from UK charities, including ongoing support from the Ulverscroft Foundation to facilitate ground-breaking work into the genetics of visual disorders, and the novel application of handheld optical coherence tomography to study paediatric retinal development, (ICS 2), and published in leading journals in ophthalmology (*Ophthalmology* 2016) neurology (*Neurology* 2018) and genetics (*Hum Mol Genet* 2017).

Projects by **Giorgini** and **Luthi-Carter** investigated the genetic, genomic and neural basis of degenerative brain disease, including Huntington's, Alzheimer's and Parkinson's diseases and schizophrenia, aimed at developing novel therapeutic interventions. **Giorgini's** research is supported by large-scale MRC funding (totalling >£2M between Leicester and UCL), NIMH (\$1.1M), and charity funding from Parkinson's UK and CHDI Foundation (~£370k), facilitating understanding of kynurenine pathway metabolism and RAB GTPases in neurodegenerative disorders (**Giorgini**: *Nat Commun* 2018; *Brain* 2017; and *PNAS* 2016). **Luthi-Carter's** work benefited > £1M EUFP7 funding as part of a major inter-disciplinary consortium (NEUROACT), and industry funding (TEVA Pharmaceuticals), producing highly-cited outputs (**Luthi-Carter**: *Brain* 2014 and *Hum Mol Genet* 2014).

Strategies for generating income

Mechanisms for attracting research income are structured around annual targets set for the Colleges by the University Research & Enterprise Committee (**REC**). Based on this, each College Research & Enterprise Committee (**CREC**), led by a Dean of Research and including departmental research leads, sets departmental targets and reviews performance annually. CREC also leads on initiatives to enhance research infrastructure.

UoA4 employs a range of mechanisms to support staff in developing high-quality grant applications. These include **Grant Development Meetings**, where PIs present funding ideas to colleagues for constructive feedback. Alongside this, regular targeted emails from the RED team inform staff of opportunities and deadlines. We run regular writing workshops (e.g. 'WriteNow') and writing 'boot camps' to encourage application writing in a collegiate setting, with informal feedback from peers and RED staff. RED staff also provide expert support for grant writing, MTAs and collaboration agreements.

ECRs receive specific support in grant and fellowship writing from the Doctoral College and RED-run workshops. Success is reflected in nine fellowship award to UoA4 members, including NIHR fellowships (**Rufai, Patel, Thomas**), Royal Society University Fellowships (**Warren, Feuda**), and an ESRC postdoctoral fellowship (**McGowan**).

All new appointees receive start-up funding, are prioritised for internal funding, and have a reduced teaching load during their probation period. UoL recognises that women receive

disproportionately less research funding because of structural imbalances in HE. This is addressed by providing female staff with targeted support by senior female colleagues, grant development staff in RED, and the Senior Women's Network and Aurora scheme support women into leadership roles.

At University level, **key funder working groups** are academic-led, centrally-supported groups dedicated to each research council, plus Wellcome Trust, Leverhulme Trust and NIHR. They build relationships with funders, publicise funding schemes, review applications and support fellowship candidates.

Internal funding opportunities

Our robust internal peer-reviewed funding mechanisms provided ~£1.46M for UoA4 in the REF period, summarised in **Figure 5**.

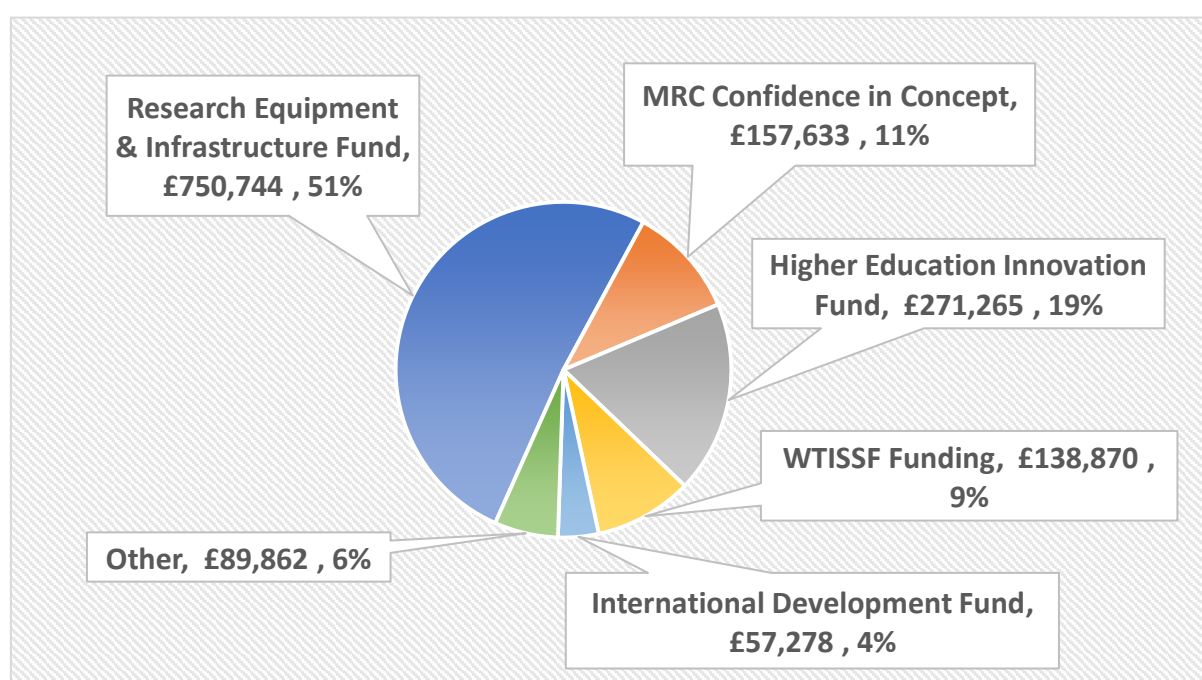


Figure 5: Breakdown of UOA4 research income from internal sources over REF period.

Our **WTISF** award supported three fellowships in the REF period (**Repici**, **Krockow**, **Warren**). **Repici** investigated cellular functions of DJ-1 – a protein linked to rare forms of Parkinson's disease; **Krockow** examined health-related decision-making, using 'Wisdom of Crowds' to reduce diagnostic uncertainty and antibiotic over-prescribing; **Warren** used electrophysiology and gene-editing to identify sound transduction mechanisms in insect auditory neurons, with a translational focus on improving understanding of mechanisms of hearing loss across species – including humans. WT-ISSF funding supported these fellows to progress their careers: **Repici** to a lectureship (Aston University), **Krockow** to a lectureship (UoL), and **Warren** in achieving a Royal Society University Research Fellowship at UoL.

Our research translation is underpinned by interactions with industry. This is supported by the Leicester Innovation Hub (a £5.1M programme supported by HEIF, University, and European Regional Development Fund; IES, 2.5). Work by **Hartell** is an exemplar of seed-corn funding leading to significant scientific developments. He received £30k from the HEIF-supported Proof

of Concept Fund to develop methods for brain-imaging in freely-moving animals, leading to ~£200k equipment funding through REIF, which provided a foundation for a >£1.1M award from the BBSRC (2013-18) to establish this technique.

Internal funding supports interdisciplinary Tiger Teams (£37k), Networks (£105k), 10x10 Challenge Fund projects (£100K), and interdisciplinary visiting fellowships. These are managed by the Leicester Institute for Advanced Studies (**LIAS**, IES 2.2), which was formed to promote and enhance interdisciplinary working. Tiger teams are short-duration, interdisciplinary research teams designed to tackle a specific research issue, intended to lead to ongoing collaborations and funding applications. As an example, **Maltby** was awarded Tiger Team and LIAS visiting fellowship funding to explore multi-cultural and multi-disciplinary perspectives on adolescent mental health, leading to £250k further funding from UK charities to advance these ideas. Networks support longer-term interdisciplinary groups, including the Prisons Research Network - a cross-college team led by UoA4 members (**Hatcher**, **Palmer**, described in section1). Starting in 2020, the University 10x10 Challenge fund provided start-up for innovative interdisciplinary projects. Uo4 members led two successful applications in this first round of awards to investigate ethnic and cultural determinants of healthy cognitive ageing (**Maltby**, **Mukatova-Ladinska**), and cardiovascular health and cognitive wellbeing (**Panerai**, **Paterson**).

The ESRC awarded UoL a £1M Impact Accelerator Account (IAA) from 2019-2023 to support the development of social science impact. This provides small (£2.5k) and larger (£7.5k) grants to kickstart impact activities, and other funding to create sustainable partnerships with stakeholders. This allowed **White** and Warrington to assess the impact of speed-reading training in education, and **Vostanis** to improve mental health provision for child refugees and develop digital tools to support mental health services in LMICS. It also funded strategic partnerships around the protection and care of vulnerable children (**Vostanis**) and health and wellbeing in prisons (**Hatcher**).

Research Infrastructure & Facilities

We benefited from significant institutional investment in infrastructure and facilities to support research and scholarship, including ~£28M investment in the David Wilson Library (as described in the IES) Completion of the **£42M George Davies Centre for Medicine (GDC; IES, 4.2)** benefited UoA4 directly, by bringing together previously scattered groups as part of a strategic plan to strengthen collaborations within and between neuroscience and psychology. This ensured none of our researchers is more than a 10-minute walk away from each other. Proximity to the **Leicester Royal Infirmary (LRI)** and **specialist state-of-the art, centrally resourced facilities** in the neighbouring Maurice Shock Building (MSB), **Adrian Building**, and **£12M purpose-built Pre-Clinical Research Facility (PRF; IES, 4.3)**, jointly funded by the Wellcome Trust and the University and opened in 2012, provides access for our neuroscience researchers to **specialist, centrally resourced facilities**.

The **PRF** provides modern facilities for animal husbandry, state-of-the-art transgenic facilities for CRISPR/Cas9 gene-editing, surgical and animal behaviour facilities, including for *in vivo* recording, multi-electrode array recording, calcium imaging and multiphoton imaging from anaesthetized and awake animals. It supports methods development, such as a novel laboratory where mice running on a spherical treadmill perform behavioural tasks in a 360° computer-generated, virtual environment while neural activity is recorded in high-resolution using *in vivo* electrophysiological recording and optical imaging (**Quian Quiroga**). PRF houses containment and cryogenic facilities, while staff provide advice and evaluation of animal research ethics. The University is committed to 3Rs, employing a stringent local ethical review process, with oversight

from local and government bodies, to ensure good practice and cost-benefit analysis in research with animals.

Following REF2014, the **CSN**, led by **Quian Quiroga** was established as one of 6 University-wide research centres to attract world-class researchers. Within the current REF period, we made the strategic decision to incorporate CSN into NPB. This helped support the growth of CSN (through 2 ECR appointments) and development of ground-breaking research on human memory formation, measurement of single-neural responses in the human brain, and novel approaches to studying neuronal population dynamics in freely-moving animals. The group benefits from laboratory space in the **GDC**, including high-performance computing, eye-tracking, electroencephalography (EEG), and neuro-prosthetics, as well as specialist facilities in the PRF. This group has attracted significant funding from The Royal Society and BBSRC (>£400k), producing ~50 publications in world-leading journals during the REF period.

Research in Sensory Processing benefits from specialist infrastructure in the **GDC** including bespoke laboratory space for human behavioural research, and laboratories equipped with purpose-built Faraday cages incorporated into the fabric of the building to support EEG research. Washroom and shower facilities for human participants are located nearby the EEG labs, with adjacent washroom facilities for cleaning apparatus. This laboratory space includes an eye-tracking suite and facilities for visual and auditory psychophysics, and a dedicated laboratory for co-registration of eye movements and EEG (**Barratt, Hutchinson, McGowan, Paterson, White, Souto**). Equipment and infrastructure was supported by competitive internal funding and local charity funding, and underpinned awards from the ESRC and Leverhulme Trust (totalling >£1M) during the REF period. This equipment facilitates joint research with a brain-training company (Cerebrum Matter Ltd). Another laboratory interfacing EEG and transcranial magnetic stimulation was supported by £220k from NIH funding shared with Johns Hopkins University to investigate neural mechanisms of spatial disorientation in vestibular migraine (**Arshad**).

The Ulverscroft Eye Unit, based at the LRI, houses laboratories funded by the Ulverscroft Foundation, for eye-tracking, posturography, and ocular coherence tomography in adults and children (**Gottlob, Proudlock, Thomas**). This underpins our interdisciplinary vision science research. Other laboratory space at the LRI houses functional transcranial Doppler sonography (fTDS) to investigate cerebrovascular function in individuals with Alzheimer's disease and establish new biomarkers for neurodegeneration, supported most recently by Dunhill funding (**Chung, Mukatova-Ladinska, Panerai**).

Laboratory-based neurophysiology is housed within MSB, with dedicated laboratories for cellular and molecular neuroscience (**J. Apergis-Schoute, Forsythe, Gerjikov, Hamann, Hartell, Luthi-Carter**). Shared facilities provide advanced imaging, immunohistochemistry, fluorescence imaging and PALM laser microdissection, and facilities for preparation of *in vitro* brain slices, primary tissue culture and cell cultures. **Forsythe** and **Warren** laboratories use CRISPR/Cas9 gene editing in mice and locusts, supporting research into potassium channel function and mechano-electrical transducer channels in hearing, supported by BBSRC and Royal Society. **J. Apergis-Schoute, Okun** and **Gerjikov** laboratories use *in vivo* optogenetic methods and high-density silicon probe electrophysiology (Neuropixel) from cortical structures in studies of striatum, cognition, motivation, cortical state-change and appetite, supported by Academy of Medical Sciences, BBSRC, Leverhulme Trust, and Wellcome Trust. The MSB includes a brain tissue bank for dementia research (**Mukatova-Ladinska**).

Facilities for studying genetics, movement, behaviour and electrophysiology in non-vertebrate animal models (*Drosophila*, locusts, planaria, zebrafish) are located in the **Adrian Building**. *Drosophila* and mammalian cell models underpin our world-class research into molecular mechanisms in neurodegeneration (**Giorgini**). The *Drosophila* lab also supports world-leading research on circadian behaviour (**Rosato**), in collaboration with Biological Sciences (Kyriacou). Specialist facilities support research in insect behaviour (**Ott, Mathieson, Warren**) and use of zebrafish and sticklebacks as models of the genetics of aggressive behaviour, with relevance to human psychiatric disorders (**McDearmid, Norton**).

Laboratory research is supported by centrally-resourced Core Biotechnology Services (CBS), which provides access to technical support and state-of-the-art imaging, electron microscopy, genomics, proteomics, flow cytometry, histology and preclinical imaging. CBS supports the Midlands Innovation group of Universities, members of which can access the Kit Catalogue of available equipment. CBS receives institutional support of ~£1.3M per annum and invested a similar amount on new equipment over REF period.

Technician Support

Research in the GDC and LRI is supported by centrally-funded specialist technicians with expertise in electronics, computer hardware and interfaces and programming, and knowledge of eye-tracking and EEG hardware and software. We recognise and value the contribution of our **technician support** and understand the importance of their career development (IES, 4.2). In November 2016, a College-wide review highlighted the importance of career development to ensure a sustainable workforce, leading to work with the Science Council to support the accreditation of research staff.

The PRF is staffed by centrally-funded, trained animal care technicians focused on providing effective husbandry, compassion and care for animals, while enabling high quality research outcomes. These staff are essential to laboratory operation and integral to the development of specialist facilities. Managerial and administrative staff ensure the PRF operates smoothly and research is conducted ethically and fulfils regulatory requirements.

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

UoA4 makes a significant contribution to UK and international science, exemplified by the recognition given to **Quian Quiroga** during the REF period. **Quian Quiroga** was selected as one of 10 UK RISE Leaders in Science and Engineering (2014), and subsequently elected Fellow of the Academy of Medical Sciences (AMS, 2019), reflecting his world-leading role in the discovery of 'Concept Cells' or 'Jennifer Aniston neurons' - neurons in the human brain that play a key role in memory formation.

We are a highly collaborative unit, as demonstrated by 1108 total outputs in the REF period, 48% involving international co-authors, and an increasing number with industry co-authors (4% average). Our collaborative research led to £3.4M of HEBCI income.

UoA4 led seven national and five international collaborations in the REF period. Highlights include collaborations led by **Gottlob**, with Harvard and Philadelphia Universities to investigate paediatric visual impairment, and a longstanding collaboration, led by **Paterson**, with Tianjin

Normal University (China) to investigate ageing effects on Chinese reading. **Paterson** receiving a Haihe friendship award in recognition of this work.

During the REF period, UoA4 members were involved in major EU Framework 7 projects to understand synaptic function and treat diseases of the nervous system (NEUROACT, **Luthi-Carter**) and to improve insight and treatment in psychiatric disorders (Aggressotype, **Norton**) and as detailed in section 2 UoA4 members participated in **three** EU ITNs: CINCHRON, LISTEN and INTREPID Forensics.

Collaboration with and contribution to the research base

Collaboration is vital for interdisciplinarity, and is a core strength of UoA4. We ensure that staff are aware of internal funds to facilitate collaborations through regular newsletters. For example, four UoA4 members applied successfully for over £57k of competitive International Research Development funds (IDF) during this REF period. Funding to **Vostanis** to work with partners in Kenya and South Africa on the resilience of children experiencing trauma, led to collaborations with UCL and NHS England to research children's mental health.

Other examples include **Norton's** contribution to a major multi-site European project ('Aggressotype'), which led to improved treatment for people with ADHD and conduct disorder. **Norton** also collaborated with Radboud University, using zebrafish models to reveal how caffeine and sildenafil can selectively reduce aggression, establishing zebrafish as a model for drug screening, and identifying signalling pathways that mediate aggression.

Brugha received >£4M in external funding and built on networks created in REF2014 to undertake surveys of adult mental health jointly with the National Centre for Social Research (reported as an ICS). **Brugha** also led a multi-centre investigation of autism prevalence, having conducted the first ever large-scale epidemiological survey of adult autism in the UK, leading to his appointment to the board of the Department of Health's National Autism Strategy Implementation Team.

Sustainability

Sustainability is demonstrated by the ongoing nature of these collaborations, with 29 awards continuing beyond 2021. A multi-site collaboration (including Birmingham Children's and Great Ormond Street hospitals) led by **Gottlob** to understand retinal development is a strong example of this sustainability, with ongoing support from the Ulverscroft Foundation, National Eye Research Centre, and Academy of Medical Sciences to continue this research for another 24 months.

Impact, engagement, and contributions to society

UoA4 worked collaboratively with numerous industrial partners, including pharmaceutical and bio-technology companies (e.g. Calliditas Therapeutics, Teva Pharmaceutical, Allianz Worldwide Care) to identify therapeutic targets to combat neurodegenerative disease, and new diagnostic methods for paediatric visual impairment. We supported external organisations through contract research and IP-licensing, including software development and smart phone applications. We developed patents around novel technology and potential therapeutic discoveries, including advanced microscopy, portable devices for deep-brain neural recording in patients, brain-computer interfaces, ultra-low power wireless technology, blood biomarkers for neurodegenerative disease, and adherence to optical treatments for visual impairment. This translates as £8.7M to UoA4 through HEBCI, including collaborative research (£3.4M), consultancy (£2.8M), contract research (£1.9M), and IP (£43k) in the REF period.

We also provided training for research users, including annual courses in OCT use and data interpretation run by our ophthalmologists to encourage its uptake by clinicians, and conducted Patient and Public Involvement (PPI) activities aimed at improving assessment, diagnosis and patient outcomes. Our Sensory Processing group also hosted PPI meetings with third-sector organisations and older people to facilitate the co-production of ageing research, and our forensic psychologists held knowledge exchange events with Her Majesty's Inspectorate of Prisons (**Hatcher, Palmer**).

We fully engaged with the agenda around global research challenges. Our World Awareness for Children in Trauma project (WACIT) focused on raising awareness of child mental health worldwide and establishing a sustainable model of helping children suffering from trauma.

Vostanis' work with aid agencies such as Youth Refugee Service (France), Hussaini Foundation (Pakistan), and Gallagher Trust (Rwanda) led to long-term positive outcomes for children, communities, and economies, informing global policies such as The World Health Organization's 2018 care guidance for asylum-seeking children in the EU. The work resulted in Wellcome Trust funding to explore perspectives on anxiety and depression in LMICS, in line with their global mental health strategy.

Public outreach

UoA4 was a longstanding participant in annual Brain Awareness events, supported by the Dana Foundation and British Neuroscience Association. We provided talks and demonstrations on brain research to A-Level students and the general public, with over 450 participants annually, with highly positive feedback. We contributed to the ESRC Festival of Social Science (**McGowan, Vostanis**), and 'Pint of Science' events were organised within UoA4 (**Urcelay**), featuring numerous talks by UoA4 members.

UoA4 members contributed to public discussion and dissemination of science via local and national media. **Colman** was consultant for BBC4's 'The Joy of Winning' (2018), interviewed on Sky One's 'Duck Quacks Don't Echo' and the Voice of Islam radio about 'Trust' (2019), an expert witness on Radio 4's 'The Moral Maze', and participated in a panel discussion at the Cheltenham Science Festival (2016). **Krockow** writes a regular blog on decision-making for Psychology Today, published numerous media articles (e.g. *Leicester Mercury*, 2020; *The Psychologist*, 2019; *Healthy Magazine*, 2019), and gave radio interviews (e.g. ABC Radio Melbourne, 2019; BBC Radio 4, 2019) on human decision-making. Staff also contributed articles to the 'The Conversation'.

Influence and esteem

Prizes, Awards and Fellowships

Nine UoA4 members received 10 accolades from learned societies and research councils over the REF period, including **Quian Quiroga's** selection as a UK RISE Leaders and election as Fellow of the AMS.

Nine research fellowships were awarded to UoA4 member. As described in Section 2, these include two Royal Society University Fellowships (**Feuda, Warren**), ESRC 'Future Research Leaders' postdoctoral Fellowship (**McGowan**), NIHR Postdoctoral Fellowship (**Thomas**). It also includes a Dorothy Hodgkin Royal Society Fellowship (**J. Apergis-Schoute**), and an NIHR Fellowship awarded to **Jones** to develop mechanisms for improving healthcare management.

Gottlob was awarded the Roger Trimble Medal for distinction in the field of strabismus (2017), and an UHL Educator Award (2018). **Paterson** was awarded a 1000 Talents visiting professorship (Tianjin, 2017-2020), and appointed Haihe invited professor (2020). **Lambert** is visiting professor at Kufa University, Iraq, and honorary professor at Hubei University of Medicine, China. **Quian Quiroga** is visiting professor at Peking University.

Roles in Learned Societies, Government Agencies, Advisory Boards

Brugha has been the Chair of the WHO Advisory Committee, Schedules for Clinical Assessment in Neuropsychiatry (SCAN) since 1998. In 2010, he became Board Member of the National Autism Strategy Implementation within the Department of Health.

Johnson is an expert adviser for the National Institute of Health and Clinical Excellence (NICE) Centre for Guidelines, and member of the NICE Quality Standard Advisory Committee (QSAC) for children and young people born preterm (2015-2018). Her input has influenced clinical guidelines, including NICE guidelines on developmental surveillance. She is a member of the European Foundation for Care of Newborn Infants expert group, which used evidence from her work to develop recommendations for follow-up care of preterm children.

Jones is member of East Midlands Leadership Academy organisational development network (2008-2016), expert advisor to the Health Education England patient safety group (2013-2016) and member of East Midlands Learning from Incidents Group (2013-2017). **Jones** chairs the Health Education East Midlands Patient Safety & Human Factors Exchange steering group (2017-2018) and is member of the Leicester Improvement and Innovation Patient Safety Unit (2015-17). Other significant roles include **Gottlob's** position as NIHR lead for Ophthalmology in the East Midlands and Medical Advisor for Nystagmus UK, while **Hatcher** is a member of the Ministry of Justice Experts Network.

Five members of UoA4 contributed to activities of learned societies during the REF period. This including appointments to leading roles, such as **Giorgini's** position as Chair of the Scientific and Bioethics Advisory Committee for the European Huntington's Disease Network (2016–2017). **Arshad** was council member for the Institute for Quantum Social and Cognitive Science (2014-2018). **Paterson** was conference secretary for the Experimental Psychology Society (2015-2018)

Conference organisation

During the REF period, UoA4 members organised annual meetings of the WHO Schedules for Clinical Assessment in Neuropsychiatry (**Brugha**) and a meeting of the Experimental Psychology Society (EPS) in 2018 (**Paterson, White**). They organised symposia at national and international conferences, including the EPS (**de Lillo**, 2016; **Paterson, White**, 2018), Physiological Society (**Forsythe**, 2015), Molecular Biology and Evolution annual meeting (**Feuda**, 2019), and Festival of Neurosciences (**Hamann**, 2019). **Young** was an organising committee member for the International Conference on Monitoring Molecules in Neuroscience (2018), and **Paterson** a member of the international programme committee for the ACM Symposium on Eye Tracking Research and Applications (2020), and co-organiser of a British Council 'Researcher Links' conference in China (2016). **Hatcher** hosted a British Psychological Society seminar series (2018–2019).

Twenty UoA4 staff gave more than 120 invited conference talks, and a similar number of invited seminars, equating to ~2.5 invited talks per FTE over the REF period, indicating our engagement with our disciplines. As a flavour of the contributions, **J. Apergis-Schoute** gave an invited talk at a Royal Society conference (London, 2019), **Arshad** gave a keynote to the Meniere's Society

(2020), and **Brugha** gave a keynote to the European Association of Psychiatry conference (Vienna, 2018). **Forsythe** gave keynotes at the Winter Conference on Brain Research (Steamboat, 2015), a Society for Neuroscience meeting (Bethesda, 2014) and a meeting of the German Neuroscience Association (Goettingen, 2015). **Panerai** was an invited speaker at the European Society of Microcirculation conference (Maastricht, 2019), while **Proudlock** gave invited talks at meetings of the American Nystagmus Network (New Orleans, 2015; Washington DC, 2019), and **Paterson** gave invited talks at the biennial China International Conference on Eye Movements (2014, 2016, 2018), and a Rank Symposium on visual processing (Grasmere, 2015).

Grant review panels

Sixteen members of UoA4 contributed to funding bodies as panel chairs or members. **Hartell** was BBSRC Committee A Deputy Chair (2011-12) and Chair (2012-16), BBSRC Committee A Co-Chair (2016-17), ALERT 13, 15, 16 Committee Member, and Strategic Lola Committee Member (2011-16). **Forsythe** was an Action on Hearing Loss grant panel member (2018-present), and member of a DFG review panel. **Matheson** was a panel member for NC3Rs (2016-current), the Expert Working Group for Impact (2017-current), Training Fellowships (2016-current), BBSRC 18ALERT mid-range equipment (2018-current), and BBSRC Panel A (2017-current). Previously, **Matheson** was part of the BBSRC Pool of Experts (2015-2016). **Chung** was a panel member for the British Medical Ultrasound Society Pump Priming award (2018).

Paterson was a member of the ESRC Peer Review College (2009-2015), and one of only two psychologists appointed as a Fellow of the ESRC Peer Review College (2015-2019). He was a panel member for ESRC studentship competition in Artificial Intelligence (2018) and panel reviewer for the Research Grants Council of Hong Kong (2017-current). Other significant contributions include Gibson as an N3CRs panel member, **Giorgini** as panel member for Parkinson's UK, **Gottlob** as board member for the Swedish Research Council, and **Johnson** as member of the Scientific Advisory Panel for Action Medical Research UK.

Over 77% of staff reviewed grant applications for national and international research councils and charities, which is high given the large number of ECRs in this submission, underlining the contribution of UoA4 to UK and international science.

Contributions to journals, books and public understanding of science

Seven staff were editors and 29 associate editors for journals during the REF period. This includes deputy editor-in-chief for *The Journal of Physiology* and associate editor for *Hearing Research* (**Forsythe**), and editor for *Counselling and Psychotherapy Research* (**Vostanis**). Associate editor positions are held by **Brugha**, **Lambert**, and **Pulford** for *Psychological Medicine*, *British Journal of Anaesthesia*, and *Judgment and Decision Making*, respectively. **Mukaetova-Ladinska** was associate editor for *Age and Ageing*, *Journal of Alzheimer's Disease*, *Frontiers of Aging Neuroscience*, and *European Journal of Medicinal Plants*. **Paterson** was associate editor for *The Quarterly Journal of Experimental Psychology*, *Journal of Research in Reading*, *PLOS ONE*, and *Frontiers in Psychology*.

UoA4 is represented on editorial boards of multiple peer-reviewed journals, including *Journal of Huntington's Disease* (**Giorgini**), *British Journal of Ophthalmology* (**Gottlob**), *Trends in Anaesthesia and Critical Care* (**Lambert**), *Psychology and Aging* (**Paterson**), and *Journal of Traumatic Stress* (**McElroy**). **Matheson** was review editor for *Frontiers in Invertebrate Physiology*. UoA members contribute substantially to the peer review process, reviewing more than 320 manuscripts per year; approximately seven manuscripts per FTE per year, which is

again high given the large number of ECRs. Additionally, **Brugha** is author of *The Psychiatry of Adult Autism and Asperger Syndrome* (Oxford University Press, 2018).

Contribution to PhD student and ECR training

Twenty-six staff were external examiners for 55 PhDs in the UK and 46 internationally, including The Champalimaud Centre, Lisbon (**Okun**), University of Karachi, Pakistan (**Vostanis**), and Murdoch University, Australia (**Palmer**).

UoA4 contributed to ECR research training internationally. Highlights include a UK-China 'Researcher Links' Workshop, funded by the British Council/Newton Fund (**Paterson**, 2016), that brought together keynote speakers and ECRs from both countries, and included mentoring and networking sessions. We also contributed to the international summer school in cognitive science at the New Bulgarian University, Sofia (**Colman**, 2019).

Statement Summary

This statement describes the breadth and close integration of neuroscience, psychology and psychiatry within our unit, highlighting the diversity and inter-disciplinarity of this work, our success in attracting research funding, producing high-quality outputs and achieving economic and societal impact, and our commitment to training the next generation of researchers. Our research endeavours have benefitted significantly from the institutional provision of new, key infrastructure, especially the new GDC building and the PRF, and from targeted internally-administered funding in promoting inter-disciplinarity and collaboration with industry. Our research benefits from local, national and international collaborations, engagement with industrial partners, and the involvement of general public, while our members play important roles in maintaining and developing our disciplines in the UK and internationally. We have demonstrated the excellence of our research through our publications and societal impact, and our strategies for ensuring the sustainability and future success of these endeavours.