Institution: University of Glasgow
Unit of Assessment: UoA4; Psychology, Psychiatry and Neuroscience
a. Overview

All academic staff reported in UoA4 are members of the **College of Medical, Veterinary and Life Sciences (MVLS)** at the University of Glasgow (UoG). The College of MVLS was founded in 2010 and brings together three former biomedical faculties as a result of major restructuring of UoG to improve interdisciplinary research, which brought significant benefits for both research and enterprise activities with big investments in personnel (67 senior academics and 131 ECRs have been recruited since 2010) as well as infrastructure (£100M has been invested in research infrastructure and facilities). The multi-disciplinary ethos of the MVLS has significantly increased our success rates in national and international funding initiatives with a total extramural support between 2008 and now at over £625M.

As part of this restructuring, the **Institute of Neuroscience and Psychology (INP)** was formed from the former Department of Psychology and part of the Faculty of Biomedical and Life Sciences as one of seven research Institutes in order to facilitate interdisciplinary research, enhance the environment for students, and form an organisation better able to realise the strategic goals of UoG. Research has been reorganised along poles of excellence with staff reprofiling and appointments in strategic areas. The INP includes four Centres, of which three are returned in UoA4 (the fourth one, the Centre for Stroke, being returned to UoA1):

- **the Centre for Cognitive Neuroimaging (CCNi)**
- **the Centre for Social Interactions (CSI)**
- **the Centre for Neuroscience (CN)**

A major driver of research in UoA4 during the REF period has been the development of world-class imaging infrastructure and supporting high-performance computing facilities. This provides strong unifying technological and methodological links across the different Centres of the INP, including a state-of-the-art platform of cognitive imaging in humans, a high-field small bore animal scanner, dedicated confocal and electron microscopy facilities, as well as cutting edge equipment to measure dynamic social signals. Additional significant drivers have been the award of a large ESRC/MRC grant (£5M) that structured research in CSI, a translationally-focussed Pfizer Grand Challenge Award (£1M) and a recent Wellcome Strategic Award (£5M) in CN.

This submission describes the achievements of UoA4 returned staff in the REF period that include:

Vitality

- World-class research in areas ranging from face and voice neuro-cognition, dialogue and communication to cortical oscillations, neural coding, pain and cell signalling
- 700+ publications including in leading generic (Nature and Nature family: 10; PNAS: 19) and specialist (Curr Biol: 20; J Neurosci: 27) journals; 10,000+ citations (Scopus)
- Overall citation count (Scopus) increasing from 4000/yr. in 2008 to 7000/yr. in 2011-12
- Increase in interdisciplinary research in the new structure, e.g. Glasgow Psychosis Research Network, Pfizer Translational Grand Challenge award
- Development and application of innovative computational methods in cognitive neuroimaging and social signalling.

Sustainability

- Strategic staff renewal with 11 recently appointed staff, including 3 early career researchers (*Giordano, Jack, Philiastides*) and 3 Chairs (*Panzeri, Kayser, Jones*) to develop the competitive priorities of the INP
- £20.6M obtained in competitive funding; more than doubling in research awards from £1.5M/yr. in 2008-9 to £ 4M/yr. in 2011-12
- Increase in staff numbers from 26 staff returned in UoA44 (Psychology) at RAE2008 to 34.2

- 50% increase in postgraduate student numbers compared to RAE 2008
- Continuous upgrade of imaging equipment to maintain leading edge, e.g., Helium liquefier for MEG, coil upgrade on 7-T scanner, high-performance computing cluster

INP returns 34.2 FTE in UoA4 named in italics. An asterisk indicates an Early Career Researcher.

b. Research Strategy

The **Institute of Neuroscience and Psychology (INP)** functions as an interactive network that comprises three centres of excellence (CCNi, CSI and CN). Via their interactions, centres of the INP aim to understand brain networks at multiple levels of function, from cells to cognitive, using approaches ranging from molecular, cellular, systems and social level investigations, with a strong emphasis on imaging and computational analyses of each level.

- **Centre for Cognitive Neuroimaging (CCNi)**

CCNi was created as part of significant UoG, Scottish Research Infrastructure Fund (SRIF) and Wolfson investment in state-of-the-art, multi-modal neuroimaging technologies to support research in cognitive neuroscience. CCNi is already an established, world-renowned centre of excellence for the understanding of the complex relationships between brain, cognition and behaviour at multiple levels of analysis. CCNi returns 10 staff: *Grosbras*, *Gross*, *Harvey*, *Kayser*, *Muckli*, *Panzeri*, *Rousselet*, *Sereno*, *Thut* and *Uhlhaas*.

Key strengths include:

- *Wide research interests*: Application of non-invasive multi-modal brain imaging using fMRI, MEG, TMS and EEG in the domains of fundamental perception (particularly vision and auditory processing), attention, cognition (particularly face, object and scene recognition and voice) and decision, language and social interactions, with a special emphasis on dynamic oscillatory signals, network reconstruction, interactions in brain networks and neural coding.

- *Wide range of approaches*: Extensive imaging facilities; extensive knowledge of formal methods for analysis of functional imaging data, pioneering applications of Information Theory.

Achievements Our RAE2008 submission identified the development of excellence in cognitive neuroimaging as the main strategic objective. Thanks to the high quality of the existing and newly appointed staff as well as significant resource investment we have established CCNi as a world-level neuroimaging centre. Achievements in the REF period include:

- *Competitive awards*: £7.6M has been obtained in competitive funding (BBSRC, Wellcome, MRC) including an ERC Consolidator Award (*Muckli*, 2012, €1.5M) and a joint Wellcome Trust Senior Investigator Award (*Thut* and *Gross*, 2012, £2M), an award supporting "exceptional, world-class researchers…who are leaders in their fields."

- *Large number of publications* (235 in REF period), cited 4500 times (including 20 publications already cited more than 50 times), including in leading journals: *Panzeri* and *Kayser*'s use of information theoretic analyses in single-trial analyses of cell recordings have been described in two *Nat Rev Neurosci* (IF: 31) and a *Trends Neurosci* papers having received 250 combined citations since 2009; *Gross* and *Thut*'s work on cortical oscillations using a combination of MEG and high-frequency TMS has appeared in *PLoS Biol* and *Curr Biol*; *Thut*'s review on TMS-EEG studies in *Trends Cogn Sci* has been cited more than 100 times since 2009. *Uhlhaas*' work on cortical oscillations in schizophrenia has been described in a *Nat Rev Neurosci* article cited 238 times since 2010. (All citation counts from Scopus.)

- *Strategic recruitment of three internationally leading researchers*, each previously Max-Planck Institute Group Leader, complementing and expanding existing research excellence: *Panzeri* is a leading expert in Computational Neuroscience, with a world-leading specialisation in powerful, model-free, applications of Information Theory to behavioural and brain data. *Kayser* has a unique research profile with expertise in animal and human electrophysiology in visual and auditory perception. *Uhlhaas* is internationally recognised for his neuroimaging research in schizophrenia.

Future objectives We will foster and facilitate research and staff intake (at the postgraduate and postdoctoral level) for the areas of Computational Neuroscience, Clinical Neurophysiology and animal/human Neurophysiology. Specific objectives are:

- *Developing further information theoretic approaches to brain imaging*: we have pioneered this approach by combining carefully controlled information content in presented visual stimuli with information theoretic data analysis of MEG/EEG data. This approach is currently expanded to several sensory and imaging modalities to result in the first method that can track (in space and time) details of information transmission in the human brain. The first publication in *PLoS Biol* (*Schyns* et al., 2011) received more than 8000 article views and extensive media coverage (e.g. BBC interview and newspaper articles).

- *Developing clinical applications of our advanced brain imaging methods*: a first step in this direction was a recently awarded MRC grant where a novel combination of TMS and MEG (*Thut* et al., *Curr Biol* 2011) is now applied to obsessive-compulsive disorder patients. In addition, *Uhlhaas* is one of three leaders of the Glasgow Psychosis Research Network promoting clinical research, ideally placing him to initiate and oversee methodological knowledge transfer from CCNi into clinical applications. Furthermore, the recently awarded 5-year joint Wellcome Trust Investigator Award (*Gross & Thut*) has a clinical strand that will build on collaborations in UoG with Prof Muir (Stroke research) and Dr Cavanagh (Mental Health Disorders) (UoA1).

- **Centre for Social Interactions (CSI)**

CSI was created following the award of an ESRC/MRC large grant "Social Interactions: a cognitive neurosciences approach" to PIs *Garrod*, *Belin* and *Schyns* which structured much of its research over the REF period. In particular the grant supported 15 postdoctoral RAs and the purchase of state of the art equipment for capturing social signals (a Vicom motion capture system and a 4-D facial capture system). CSI performs excellent research related to human social signal processing, interactive communication and cultural and biological influences on social perception. CSI returns 13 staff: *Barr*, *Belin*, *DeBruine*, *Garrod*, *Giordano**, *Jack**, *Jones*, *Moxey*, *Philiastides**, *Pollick*, *Scheepers*, *Schyns* and *Simmons*.

Key strengths include:

- *Novel stimulus imaging and generation techniques*: CSI pioneered state of the art visual and auditory imaging, analysis and morphing techniques for analysing and manipulating social signals from voice, body and dynamic facial expressions in controlled experiments.

- *Online platforms for collecting large datasets*: CSI has pioneered the use of online experiments as an extremely efficient alternative to testing subjects in the lab, with little loss in reliability and much larger sample sizes. Typical experiments now routinely include participants in the hundreds, and millions of trials have been collected. *Jones* and *DeBruine*'s online experiments have been access by more than 4.3M unique visitors in the REF period.

Achievements in the REF period include:

- *Competitive awards*: £3.3M has been obtained in competitive funding (BBSRC, ESRC, MRC) including an ERC Starting Grant (Jones, €1.4M). This is in addition to the large ESRC/MRC grant (£5M) awarded in 2007 but spent during the REF period.

- *Large number of publications* (300 in REF period), cited 3200 times (Scopus, including 9 already cited more than 50 times each), including in leading journals: *Belin*'s work on voice neuro-cognition appeared in two *Curr Biol* and was described in two *Trends Cogn Sci* papers. *Schyns'* and *Jack*'s work on cross-cultural differences in processing emotional facial expressions appeared in *PNAS*; *Garrod*'s work on interactive communication appeared in *Trends Cogn Sci* and *Behav Brain Sci*; *Jones* and *DeBruine*'s work on individual differences in social perception appeared in *PNAS* and *Proc Roy Soc B*. *Simmons*' review paper on vision in autism spectrum disorders has been cited 86 times since 2009 (Scopus) and has received an Elsevier award as the top-cited article in *Vis Res* 2009-11.

- *Strategic recruitment of outstanding researchers*: CSI has recruited five new staff in the REF period including three ECRs and one Chair in areas complementing and extending existing expertise: *Jack** (ESRC Future Leader) performs pioneering work on cultural differences in emotion processing using the advanced methods developed by *Schyns*; *Giordano** (Marie-Curie Fellow) applies multivariate and information theoretic analyses to cerebral sound and voice processing; *Jones* (Chair) investigates how people respond to social cues particularly in faces; *DeBruine*'s research is on kin recognition, facial resemblance and face processing; *Philiastides** examines the neural correlates of perceptual and value-based decision making in humans. All

these appointments enrich and renew the research dynamic in CSI by bringing complementary themes and methods.

Future objectives CSI's great strength is in using neuroimaging methods to determine how aspects of social interaction influence brain activity. We plan to retain this basic objective over the next REF period. However, we also plan to extend the work in the directions of comparative and evolutionary approaches to social interactions, more specifically to integrate understanding of micro level influences on social interactions (e.g., neuroendocrine effects) to macro level influences of institutions and culture. This aspect of CSI's future work will be supported by on-going grants from the ERC (*Jones* 'neuroendocrine effects on social judgements') and ESRC (*Jack*, *DeBruine* 'cultural effects on social judgements'). This strategy recognises the increasing importance of cultural/ biological evolutionary theory to understanding human social interaction. In addition to this we plan to examine the life-long development of social interactions in infancy and aging (*Belin*, MRC), social learning (*DeBruine*, *Jones* & *Garrod*) and decision-making (*Philiastides*, BBSRC).

- **Centre for Neuroscience (CN)**

The CN was formed in 2010, together with the INP, to provide a focus for preclinical and translational neuroscience, and hence to exploit the evolving opportunities for translational and inter-disciplinary research within INP. CN returns 12 staff: *Riddell*, *Maxwell*, *Todd* (Spinal Cord Group), *Baillie*, *Cobb*, *Houslay*, *McKay*, *Morris*, *Stone* and *Surget* (Synaptic Plasticity and Neuro-degeneration), *Biello*, *Goense* (Physiology of Cognitive Processes).

Key strengths include:

- *Research interests focused on topical translational themes*: Spinal cord and brainstem circuits that underlie pain, motor control and breathing; psychiatric and neuro-developmental conditions such as schizophrenia, stress and Rett syndrome; molecular mechanisms of synaptic transmission and plasticity; circadian rhythms; visual perception; cyclic nucleotide signal transduction.

- *Application of cutting edge approaches*: Anatomical (e.g. immunocytochemistry, tract-tracing, confocal/electron microscopy), electrophysiological (in vivo and in vitro recording, patch-clamp, optogenetics), molecular biological (molecular genetics, functional genomics), behavioural (cognition, pain, respiration, stress), and imaging (high resolution fMRI, FRET) techniques, peptide array technology and xCELLigence real-time cell monitoring.

Achievements in the REF period include:

- *Competitive awards*: £9.6M has been obtained in competitive funding (Wellcome, BBSRC, MRC, Pfizer, Scottish enterprise) including an MRC Programme Grant on cAMP Phospho-diesterases to *Houslay* (£2M/5yr.); a Scottish Enterprise translational proof of concept award on protein-protein interaction disruptors as therapeutics to *Baillie* (£600k); two recent project grants (BBSRC, MRC) and a Wellcome Strategic Award on spinal pain pathways to *Todd* (£5.8M).

- *Large number of publications* (220 in REF period), cited 3300 times (including 16 publications already cited more than 50 times) including in leading journals. *Morris*' work on rodent models in translational research has been published in a *Nat Rev Drug Discov* article (IF 29). *Baillie*'s *Nature* publication on the effects of sleep deprivation on cAMP signalling has been cited 78 times since 2009. *Todd*'s 2010 review on neuronal organisation of spinal pain pathways in *Nat Rev Neurosci* has been cited 75 times in less than 3 years. (All citation counts from Scopus.)

- *Research on neural function and dysfunction extended*: New appointments of outstanding researchers extend disease area expertise to include depression and stress, broadening underlying molecular and cellular skills (*Surget*), and introduce expertise in the study of cognitive processes in animal models (*Goense*).

- *Translational technologies developed*: *Baillie*, *Houslay* and *Morris* played a pivotal role in helping to establish the Pfizer / Wyeth Grand Challenge in Psychosis Initiative aimed at providing novel therapies. This also involved close interactions with consultant psychiatrists and clinical imagers at the University of Edinburgh.

- *Links with CCNi developed*: the Glasgow-wide Psychosis Research Network led by *Uhlhaas* (CCNi) provides a dynamic new forum for preclinical-clinical interaction. Links are

strengthened by recent CCNi appointments (*Kayser*, *Panzeri*) bridging psychology and neuroscience.

Future objectives Future strategy focuses on expanding expertise underpinning molecular and functional aspects of the research, and growing/exploiting our reputation for high-quality translational research in these areas. Recent appointments in INP provide additional skills at the forefront of translational psychiatric research (in vivo oscillatory activity). The strategy is to expand academic and commercially-funded research, combining analogous clinical and pre-clinical techniques, and harness the power of studying patient populations and rodent models in parallel. The aim is to advance understanding of the molecular pharmacology of psychiatric diseases and explore novel therapeutic approaches for cognitive disorders and schizophrenia (*Baillie*, *Houslay*, *Morris*, *Goense**, with *Uhlhaas*, *Kayser* (CCNi)), stress (*Surget*) sleep apnoea (*McKay*) and autism-spectrum disorders, including Rett syndrome (*Cobb*). A major goal for the Spinal Cord Group is to determine the role of dorsal horn interneurons in pain and itch perception by targeted activation/ ablation. Assessment of therapies for spinal injury will focus on manipulation of plasticity in spared systems, and cell-based therapies. The contribution of novel inputs from descending systems to spinal neurons will be assessed in a rodent stroke model to determine whether stem cell implantation enhances recovery.

c. People, including:

I. Staffing strategy and staff development

The staff returned for UoA4 has increased to 34.2 FTE compared to the 26 returned in UoA44 (Psychology) at RAE2008. These numbers reflect dynamic renewal and strategic reorganisation of staff into coherent research units. Eight staff members previously returned in UoA44 have retired or moved (Jones, Burton, Jenkins, Kessler, Hillis, Leuthold, Sanford and Caldara). Nine staff in other UoG units joined the INP to form the core of CN: *Baillie, Cobb, Houslay, Maxwell, McKay, Morris, Riddell, Stone, Todd*.

In parallel we were successful in recruiting top international researchers to strengthen existing research excellence and develop new avenues. Over the REF period, **eleven new staff members** with outstanding records were appointed across the three INP centres including 3 ECR and 3 chairs: *Barr (SL), DeBruine* (R)*, Giordano** (Marie-Curie Fellow)*, Goense* (Lord Kelvin-Adam Smith Fellow), *Jack** (L), *Jones* (P), *Kayser* (P), *Panzeri* (P), *Philiastides** (SL), *Surget* (Lord-Kelvin Adam-Smith fellow)*, Uhlhaas* (R). Both *Kayser* and *Panzeri* were previously Group Leaders at the Max Planck Institute for Biological Cybernetics, Tübingen, Germany.

Staff strategy All recently-appointed staff (11 of 35) have been selected on the basis of excellence in research, as well as in teaching. Further criteria were applied: for example we actively targeted suitable candidates while avoiding overlap, we developed strategic new areas (e.g. computational neuroscience) while encouraging connections to existing PIs. In all cases we targeted candidates with a strong international profile in a field of research sufficiently different from the existing topical strengths of the INP, but with sufficient overlap (e.g. methodological) to foster innovative collaborations with other members of INP.

INP runs an explicit work-allocation model, including teaching, research and administration. New staff are given a small teaching and administration load in their first years, ramping up to a full load in year 3, in order to allow them to establish their research. All newly appointed staff are given dedicated (single-occupancy) laboratory space, provided by INP on arrival. Furthermore, new staff are favoured in resource allocation by INP management, particularly with a view to conducting pilot studies prior to applications for external research funds. For example, access to imaging facilities is free for all to develop pilot studies, with the proviso that they apply for a grant within 6 months following the start of the pilot study.

c. II. Research students

ESRC Doctoral Training Centre Glasgow Psychology was instrumental in the successful Scottish ESRC DTC bid (value £20M) for both a *Psychology Pathway* and *Language Science Pathway*. This was an interdisciplinary bid that involved all Scottish Social Science Departments that met a certain RAE threshold. We provided input into the general training framework document that now applies to all social science PGR students in Scotland and wrote (UoG as elected ESRC

representative, with input from three other Psychology Institutions) the training framework for all Psychology ESRC PGR and PGT students, that will now be implemented over the next 5 years. As part of the Pathway DTC we offer established high-quality ESRC-accredited Masters in Research programmes in Psychology (GLW07001). Doctoral students in their second year and beyond will participate in relevant workshops from the Scottish Universities Psychology Postgraduate Research Training (SUPPORT) to gain advanced disciplinary training.

INP has a healthy population of postgraduate research students (n=189 over REF period), with funding mostly from ESRC (n=54), BBSRC (n=20) and UoG (n=44). **Student numbers have strongly increased during the REF period** compared to RAE2008 during which 128 PGR students were supervised. Enthusiasm for student research in general is high within INP. In the REF period a total of 126 vacation scholarships (£162k, mostly from the Wellcome Trust and the Nuffield Foundation). This is more than double the corresponding numbers over the RAE2008 period (53 for UoA44).

INP has further developed PGR training by creating three **Masters Programmes**: *MSc in Brain Imaging*, *MSc in Research Methods*, and *MRes in Brain Sciences*. All include a significant research component for which students perform a project linked to on-going research in one of the Unit's laboratories. Students in our programmes thus have the opportunity to study a broad spectrum of interdisciplinary research using state of the art equipment for investigation of human and both in vivo and in vitro model systems. In addition to their involvement in research in laboratories of international standing, drawn from all three Research Centres, students receive training in research methods, statistics and professional skills. Since their creation, student uptake has grown steadily from around 5 students per year in 2008 to around 20/yr. 2011-12.

d. Income, infrastructure and facilities

Income

UoA4 staff obtained £19.8M in competitive funding during the REF period. The award rate has more than doubled from £1.5M/yr. in 2008-9 to £4M/yr. in 2011-12. Awards are from a wide range of funders from Charity (e.g., Wellcome Trust, Leverhulme Trust), Industry (e.g., Pfizer and Wyeth), Scottish Government, RCUK (mostly BBSRC and ESRC), EU, translational funding and also include international funding e.g., NIH.

Noteworthy awards include:

- ERC Starting Grant (*Jones*, €1.4M);
- ERC Consolidator Grant (*Muckli*, €1.5M);
- Wellcome Trust Senior Investigator Award (joint award to *Gross & Thut*, £2M);
- ESRC/MRC large grant (*Garrod and co-Is*, £4.5M) which although awarded in 2007 spanned years 2008-2011;
- MRC Programme Grant on cAMP Phosphodiesterases (*Houslay,* £2M/5yr.);
- Scottish Enterprise translational proof of concept award on protein-protein interaction disruptors as therapeutics (*Baillie,* £600k);
- MRC Award (*Uhlhaas*, £800k) on oscillations and schizophrenia;
- ESRC awards to *Jack** (£490k) on culture and face emotion processing;
- Wellcome Strategic Award (*Todd*, £5M*)* on spinal pain pathways.

Infrastructure and facilities

The research infrastructure in the INP is excellent. Most significant is the platform for neuroimaging installed in CCNI with funding from UoG, SRIF and the Wolfson Foundation (£5.7M). The platform, entirely dedicated to INP research, is the top scanning facility in Scotland offering staff access to a 3-Tesla MRI scanner (Siemens) equipped with a 32-channel head coil and a 248-channel whole-head MEG system (WH-3600, 4D-Neuroimaging) both equipped with top-end stimulation and recording equipment including eye-tracker. Two specialised NeuroCognitive Stimulation labs are equipped with state-of-the-art 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, simultaneous

EEG acquisition, MEP recordings and Eye tracking. Five EEG labs and a dedicated Eye-tracking lab complement the Neuroimaging equipment.

The computing facilities are outstanding, featuring ~1200 Terabytes of storage and computing clusters (including dedicated parallel Matlab clusters) with about 1900 computing cores. Many testing rooms for behavioural studies are available. Further specialised labs include a 3D motion capture system and a '4D face capture system' allowing capture of 3D face meshes at a frame rate comparable to that of videos making the installation unique in the UK.

INP also features 3 dedicated confocal microscopes and a transmission EM, with core support for immuno-cytochemistry, histology, electron microscopy and neuronal tracing studies, augmented by image analysis and neuronal reconstruction workstations. There are numerous electrophysiology setups (for in vivo and in vitro recording), with capability for imaging and optogenetic experiments, and there is access to two 7 Tesla preclinical MR scanners equipped for anatomical and functional imaging in rodents. Extensive facilities are available for cellular neurobiology studies including cell culture suites and there is provision for molecular biology studies and the manufacture of viral vectors for CNS studies. Additional infrastructure available to UoA4 staff include state-of-the-art facilities for genetic, genomic, molecular and cellular studies, refurbished and equipped through international pharmaceutical company funding, two peptide array robots, three advanced xCELLigence real-time cell monitoring rigs, Licor Odyssey and Bio-Rad gel imaging equipment, a Berthold Mithras multi-function plate reader and FRET imaging microscopes.

A high quality animal facility offers a wide range of technical services including timed mating, embryo transplantation and surgical suites, and facilities for cognitive testing in rodents. There is also provision for cognitive, loco motor and neurophysiological phenotyping, long-term recording of circadian activity and telemetry, as well as stereotaxic surgical facilities for CNS studies.

e. Collaboration and contribution to the discipline or research base

Collaboration with external bodies

INP staff maintain a large network of collaborations nationally and internationally. Noteworthy international collaborators include:

- Prof Ralph Adolphs at Caltech (USA) on dynamic mental representations of facial expressions of emotion in Autism Spectrum Disorder (*Schyns, Jack**) having resulted in several publications including in *Nature*
- Prof Charles Schroeder (Columbia University, NY, USA) & Troy Hackett (Vanderbilt, USA) on the neurophysiology and anatomy of multisensory processing in auditory cortex, funded by NIH (*Kayser*)
- Dr David Feinberg (McMaster University, Canada) investigating with *Jones* and *DeBruine* differences and similarities in social perceptions of faces and voices – a collaboration having produced 40 papers in peer-reviewed journals in the REF period, including in *Psych Sci* and *Proc Roy Soc B*
- Prof Ted Abel (University of Pennsylvania, USA), on cAMP signalling pathway in memory consolidation (*Baillie*) resulting in recent papers in *J Neurosci* and *Nature*
- Dr Nick Fay (University of Western Australia) on dialogue with *Garrod* resulting in a Distinguished Visiting Professorship and a Partner Investigator (PI) position on an Australian Research Council
- Prof Paul Sadja (Columbia University, USA) on perceptual decision making and simultaneous EEG/fMRI (*Philiastides**) leading to publications including in *PNAS*
- Prof Elzbieta Jankowska (University of Gothenburg, Sweden), with joint NIH funding and *Maxwell* on pre-motor neuronal networks
- Prof Bob Turner (Max-Planck Institute for Human and Cognitive Brain Sciences; Leipzig, Germany) on BOLD and CBV fMRI in human visual cortex at 7Tesla (*Goense**).

The PsyRING project (*Morris*) brought in £6M funding over the period 1997-2007. Although this funding was outside the REF period, the novel targets for schizophrenia drug development identified by our work are currently being developed by the Japanese pharmaceutical company who funded the project. The expertise built up over this period, and the close interaction of clinical

and preclinical staff, has enabled a strong collaboration to be developed (PsyRING), initially with Wyeth and the TMRI, and currently with Pfizer. This has so far resulted in funding of ~£1.1M (TMRI) and £1.2M (Pfizer).

Participation in peer-review process, fellowships, journal editorships All staff returned in UoA4 regularly perform reviewing and editorial activities as part of their research. Noteworthy reviewing and editorial responsibilities include:

- Editor-in-Chief: Channel and Ligand Research (*Stone*); Frontiers in Perception (*Schyns*); Cellular Signalling Journal (*Baillie*, co-editor).
- Editorial board: Psychological Science (*Schyns*); Journal of Neuroscience (*Kayser)*; Neuroimage (*Gross*); British Journal of Psychology (*Jones*); Frontiers in Auditory Cognitive Neuroscience (*Belin*), Frontiers in Emotion (*Belin*); Neuropsychologia (*Harvey*);

Several UoA4 staff belong or have participated to review boards examining grant proposals and institutions in different countries: AERES committees (France; *Schyns*, *Belin*, *Todd*); European Open Research Area panel (*Schyns*); EU FP7-ICT, 2011 (*Kayser*); ESRC Professorial Fellowship Panel, 2011; Netherlands QUANU panel, 2011 (*Garrod*).

Mechanisms promoting collaborative research include:

- **INP Seminar series** The INP's highly attended seminar series features invited talks from distinguished national and international speakers. During the REF period the INP Seminar series has hosted more than a hundred selected speakers: 53 speakers from other UK institutions, and 53 speakers from overseas institutions.

- **CCNi debates** Since 2009 CCNi has been organising on a near yearly basis debates around hot research topics where 3-5 international experts discuss current relevant controversies:

  - 2009: Gamma activity
  - 2010: Does BOLD fMRI reveal pseudo neuronal activity?
  - 2012: The meaning of Mirror Neurons' (appearing in a special issue of *Cortex)*
  - 2013: Studies of large-scale brain networks: Saviour or Hype?

These events have been very successful and regularly attracted more than 100 participants.

- **Workshops, conferences, summer schools** A number of workshops and conferences have been organised by UoA4 staff to promote their research and network with researchers from other institutions: "Voice and speech processing in social interaction" (2011, *Belin*); Public symposium on 'The New Science of Social Interaction' (British Association, 2011); PsyRING Inaugural Symposium (2008, 100 delegates, *Morris*); National MEG UK conference in 2010 with 150 participants (*Gross*); Workshop on multivariate analysis of fMRI data (*Belin*, 2012); Workshop on analysis of diffusion tensor imaging data (*Belin*, 2013); Summer school in in-vivo neuroscience techniques (since 2009, now with BPS funding (*McKay*); "Not idle at all: Scrutinizing the functional relevance of cortical alpha oscillations" (2009, *Thut*); 'Cortico-cortical connectivity studied by TMS-EEG' (2009, *Thut*). 'Entraining the Brain? Effects of rhythmic brain stimulation protocols on oscillatory brain activity and behaviour" (2011, *Thut*); Yearly Glasgow Neuroscience day regrouping neuroscientists across several Scottish universities *(McKay)*.

Indicators of influence include:

- News, Views and Profile articles in *Nature, Neuron, Curr Biol (Kayser, Belin, Schyns)*;
- Highly cited papers and reviews written in REF period: 45 publications already cited more than 50 times;
- Fellowships of the Royal Society of Edinburgh: *Schyns, Garrod, Houslay*;
- Awards and distinctions;
  - *Gross & Thut*: joint Wellcome Senior Investigator award
  - *Jack**: ESRC Future Research Leaders awarded (2012), American Psychological Association (APA) New Investigator award (2013)
  - *Garrod*: Distinguished Scientist award from Society of Text and Discourse (2012)
  - *DeBruine:* Association for Psychological Science Rising Star Award (2011)

- *DeBruine:* co-chair of the Royal Society of Edinburgh's Young Academy of Scotland
- *Jones:* ERC Starting Grant
- *Muckli*: ERC Consolidator Grant

- Membership, Wellcome Trust expert review group/panel: Cognitive neuroscience and mental health, 2013-15 (*Thut*);
- Editorship of main International MEG mailing list (*Gross*);
- Provision of evidence to House of Lords Science & Technology Committee on Behavioural Change (2010) as part of RCUK response (*Garrod*);
- Organisation of special topics/issues: "Integrating TMS with EEG" for journal Brain Topography (2009, *Thut*); "Lower frequency brain oscillations in perception" for journal Frontiers in Psychology (2011, *Thut*); Philosophical Transactions of the Royal Society of London B (*Jones, DeBruine)* "The Meaning of Mirror Neurons" for the journal Cortex *(Garrod)*; 'Neurodevelopmental disorders' in Neuropharmacology (*Cobb*);
- Membership, Safety of Transcranial Magnetic Stimulation (TMS) consensus board commissioned by the International Federation of Clinical Neurophysiology to revise and update guidelines for Safety, Ethical Considerations, and Application of TMS in Clinical Practice and Research (2008-09) Influential output document cited 400 times since publication in 2009 (*Thut*);.

Finally, UoA4 staff delivered more than 80 Keynote Lectures in national and international institutions during the REF period.