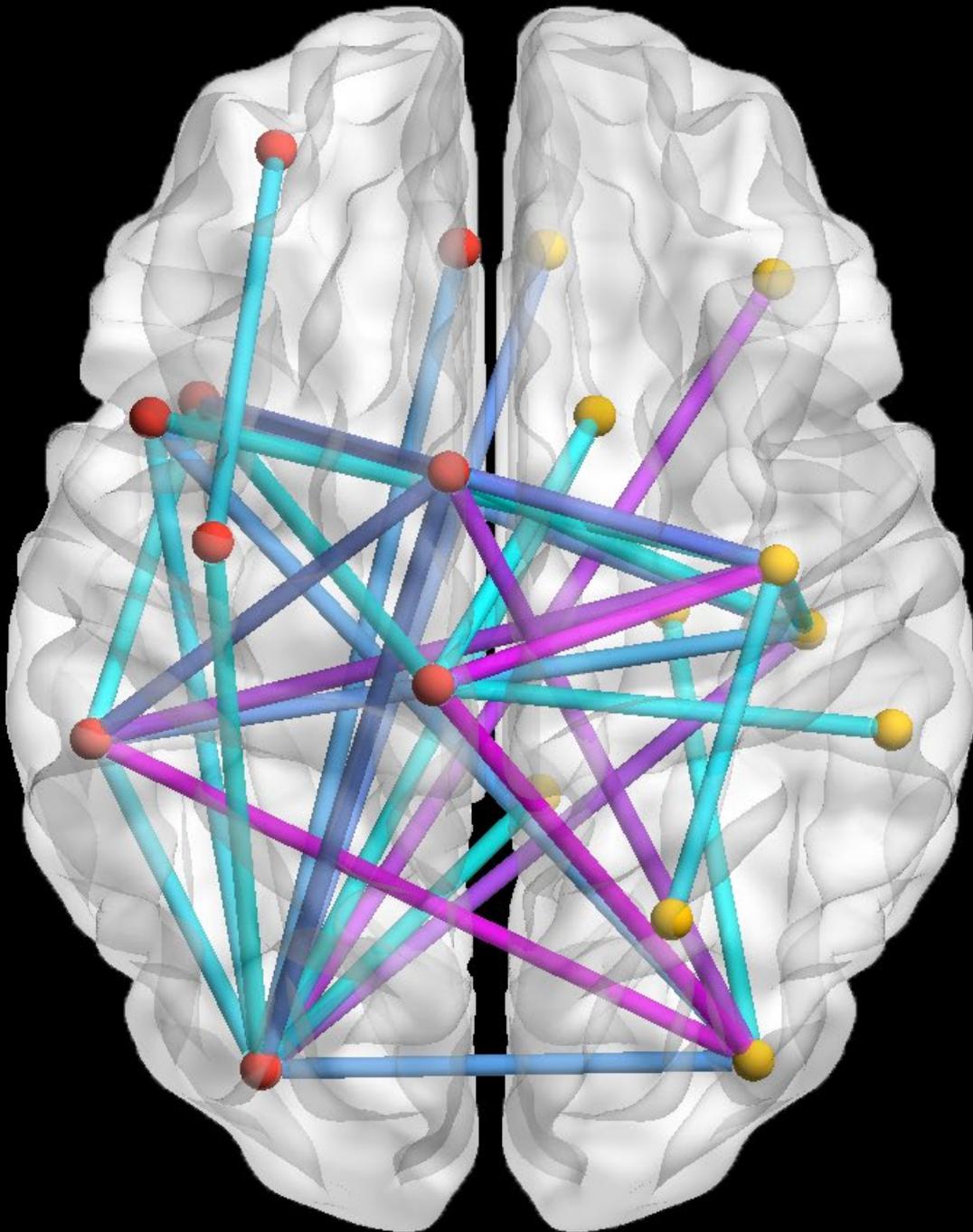


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# National Imaging Facility Quarterly Newsletter Issue Four 2016



*Network of dominant post-DBS-surgery changes in whole brain functional connectivity in patients with Obsessive Compulsive Disorder - Magnetoencephalography (MEG) imaging*

*Dr. Will Woods - Swinburne Neuroimaging, Swinburne University of Technology*



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## IN THIS ISSUE

### DIRECTOR'S MESSAGE

### INDUSTRY PROJECT

- OIL AND GAS INDUSTRY BORROWS MAGNETIC RESONANCE IMAGING

### INTERNATIONAL COLLABORATIONS

- INSIGHT INTO MYOCARDIAL INFARCTION A LEADING CAUSE OF HEART FAILURE
- INTRODUCING PHYSIO – A NEW OPEN-SOURCE TOOLBOX FOR MODELLING PHYSIOLOGICAL NOISE IN FUNCTIONAL MRI

### RESEARCH PROJECT

- DETECTING BRAIN CONNECTIVITY CHANGES IN PATIENTS WITH OBSESSIVE COMPULSIVE DISORDER

### NEWS

- OUTREACH & ENGAGEMENT
- HEALTH MINISTER VISITS UQ NODE OF NIF



# DIRECTOR'S MESSAGE

Is NIF relevant to my research? Imaging is not traditionally used in my field, why should I bother? If you are not sure, then have a look in this newsletter. Maybe you identify NIF solely with biomedical research. Well, there is more! You are only limited by your imagination, so read on and get inspired.

The lead article, from University of Western Australia, has zero biomedical content, the anaesthetic machine has been replaced by a model pumping station, and the medical researchers by hydraulic engineers. This is industrial engineering at its most innovative, with the project originating from the ARC Industrial Transformation Training Centre in Liquefied Natural Gas Futures.

Biomedical is indeed the biggest area of research, and it is obviously important, but it comes in lots of flavours. Whether it be discovery research, aiming to understand basic physiology or translational research, or providing important information to change patient management, imaging has a significant role. An international collaboration at UniSA is using the Large Animal Research and Imaging Facility in Adelaide, to study myocardial infarcts in animal models, while at Swinburne, MEG is being used to identify the effects of Deep Brain Stimulation, as a treatment for OCD. And through another international collaboration (Switzerland, UK and Germany) with the University of Queensland, better tools are being developed to support researchers in getting the most from their data.

Add to this the stories about engagement with academia, industry and politicians, and you will see that NIF has been busy, delivering, developing and promoting world-leading research infrastructure.

The NIF team looks forward to the new opportunities in 2017, but in the meantime, we wish all our colleagues and their families a very blessed holiday season, a time of relaxation and renewal, and we will be here to help you achieve your scientific goals in 2017.

**PROFESSOR GRAHAM GALLOWAY**  
DIRECTOR OF OPERATIONS



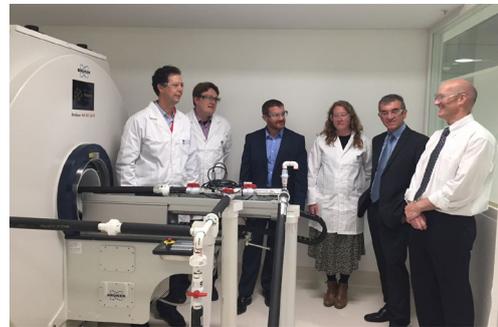


# OIL AND GAS INDUSTRY BORROWS MAGNETIC RESONANCE IMAGING

INDUSTRY PROJECT



Sean Salter, VP Technology of Woodside Energy and researcher Dr. Sarah Vogt discussing MRI aspects of the hydrate research project



From left: Prof. Eric May, UWA, Dr. Einar Fridjonsson, UWA, Dr. Paul Pickering, Woodside, Dr. Sarah Vogt, UWA, Nino Fogliani, Woodside & Sean Salter, Woodside in the MRI magnet room with the hydrates flow loop

In what is believed to be a world first, researchers are using medical Magnetic Resonance Imaging (MRI) to get a view inside oil & gas pipelines; specifically to study the behavior of hydrate particles and hydrate agglomerates as they are transported in water and oil.

The Research is funded by Australian Oil & Gas company Woodside Energy Ltd and the Australian Research Council (ARC) under the 2015 Linkage Projects Scheme. The linkage project is titled "Controlling Hydrate Slurry Flow to enable deepwater oil and gas production" and investigates the poorly understood flow behavior of hydrate slurries to determine under which circumstances they will flow satisfactorily.

Gas hydrates are water-methane ice-like structures that can form in production piping. Hydrate formation may result in blockages that cause safety issues and loss of production. Current operating practice in industry is to prevent hydrates from forming through the injection of hydrate inhibition chemicals. By better understanding the behavior of hydrate slurries in pipelines, the industry may be able to tolerate some hydrate formation and hence drastically reduce the amount of chemical usage.

The research is a great example of multi-discipline expertise from the LNG Futures and Fluid Science & Resources groups

at UWA and uses the 9.4 T Bruker MRI, the National Imaging Facility's flagship instrument located at the UWA Harry Perkins Institute of Medical Research at the QEII Medical Centre in Nedlands. It is operated by the UWA Centre for Microscopy, Characterisation and Analysis (CMCA).

In the coming months the team will continue to improve the experimental set up and value of the acquired MRI data, extending to rapid imaging techniques and PFG displacement propagator measurements to facilitate studies on more transient hydrate blockages.

For more information on this project, contact Prof. Michael Johns ([michael.johns@uwa.edu.au](mailto:michael.johns@uwa.edu.au)) and for details about the 9.4 T MRI at UWA node, contact Dr. Kirk Feindel ([kirk.feindel@uwa.edu.au](mailto:kirk.feindel@uwa.edu.au)).

The ARC ITTC for LNG Futures is an Australian Research Council Industrial Transformation Training Centre based at UWA. The Training Centre is funded for five years with \$5 million from the Australian Research Council and \$4 million from nine major oil and gas companies. Research partners include the CSIRO, Curtin University and the Universities of Queensland, Adelaide and Melbourne ([www.lngfutures.edu.au](http://www.lngfutures.edu.au)).





# INSIGHT INTO MYOCARDIAL INFARCTION A LEADING CAUSE OF HEART FAILURE

INTERNATIONAL  
COLLABORATION

**M**yocardial infarction is a leading cause of heart failure. Despite modern reperfusion and drug therapies, the five year post-infarction mortality remains over 20%, contributing to a millions of deaths every year. In the past few decades, the development of the late gadolinium enhancement cardiovascular magnetic resonance imaging (LGE CMR) technique has allowed for the accurate and reproducible non-invasive assessment of the infarct in adults. LGE imaging, which uses a gadolinium chelate as a contrast agent to shorten myocardial T1 time, has allowed clinicians to accurately diagnose and assess myocardial infarction.

Despite these recent advances in imaging, assessing myocardial injury with LGE CMR in the fetus has not been achieved. Although not currently applicable to humans, visualizing infarct in the fetus in animal research could be particularly beneficial to understanding the physiological response to myocardial infarction and testing the efficacy of mechanical and pharmaceutical interventions.

A project at Large Animal Research and Imaging Facility (LARIF) node of National Imaging Facility explored the application of LGE CMR in the infarcted fetus. With the collaborative effort of Dr. Mike Seed's MRI team from the Hospital for Sick Children in Canada and Prof. Janna Morrison's Early Origins of Adult Health Research Group from the Sansom Institute of Health Research at the University of South Australia, the feasibility of using LGE CMR to detect myocardial infarction in the sheep fetus was investigated. The collaborative team performed surgery on 2 sham sheep fetuses and 6 infarction fetuses to ligate the left anterior descending coronary artery and thereby trigger an infarction. These fetuses then underwent LGE CMR. LGE CMR was shown to

be able to accurately detect the infarct site three days after the artery ligation, by revealing a clear hyper-enhancement in the infarcted area.

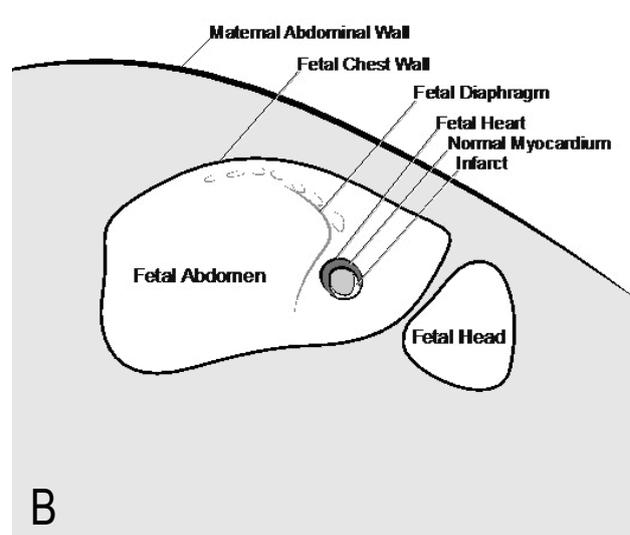
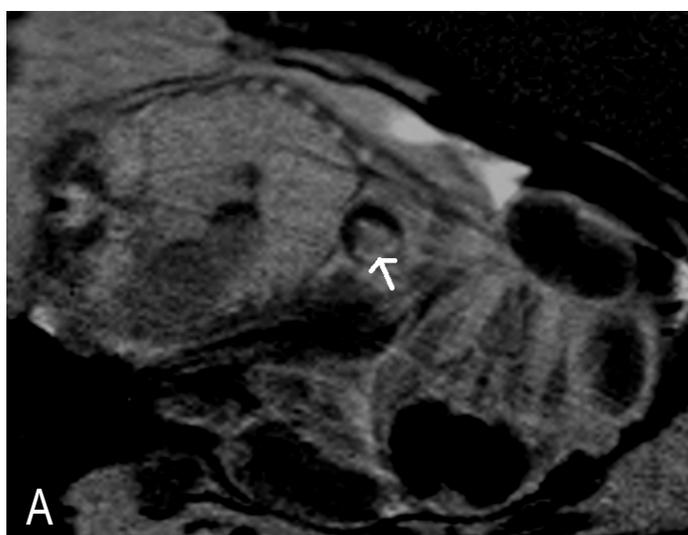
This study provides evidence for a tool to monitor the progression of cardiac repair and damage in fetuses with myocardial infarction. Besides LGE CMR, the team also tested the feasibility of cine CMR, which is a common clinical tool for visualising the beating fetal heart. They were able to quantify the ventricular function with cine CMR and visualized regional wall motion abnormality in 2 of the infarcted fetal hearts. The team proposes that in future fetal CMR can provide comprehensive fetal cardiovascular assessment in the fetal infarction model and enable us to study fetal cardiac regeneration in more depth.

For more information, please contact Angela Duan ([angela.duan@sickkids.ca](mailto:angela.duan@sickkids.ca)).

#### Collaborators

Members of Early Origins of Adult Health Research Group - Sansom Institute of Health Research at the University of South Australia (Mitchell Lock, Jack Darby, Jia Yin Soo, Stacey Holman and Erin McGillick)  
South Australian Health and Medical Research Institute (Raj Perumal, Tim Kuchel, Robb Muirhead, Loren Mathews and Daniel John)  
University of Toronto and Hospital for Sick Children (Chris MacGowan)

This work was funded by a Research Themes Investment Scheme from the University of South Australia (JLM). This team has been awarded a Canadian Institutes of Health Research grant (MS & JLM) to continue work in this area.



(A) An example LGE image of an infarcted fetal heart. The arrow indicates the infarct site. (B) An illustration of the LGE image with maternal and fetal structures labeled.



# DETECTING BRAIN CONNECTIVITY CHANGES IN PATIENTS WITH OBSESSIVE COMPULSIVE DISORDER

Obsessive Compulsive Disorder (OCD) is a relatively common anxiety disorder, affecting around 2-3% of Australians at some point in their life. The standard treatments are either psychological, such as cognitive behaviour therapy, or through medication. However, for those patients who do not respond to traditional treatment the effect on their quality of life can be considerable, resulting in severe social disability.

Recently a radical surgical procedure has been proposed for these treatment resistant patients in the form of deep brain stimulation (DBS), where electrodes are surgically implanted in the striatum and stimulated at around 130Hz. More commonly used in the treatment of Parkinson's disease, it has been applied with some success in a variety of other disorders, including depression.

After DBS surgery, the presence of the electrodes precludes any further examination of brain structure or function using MRI. Until recently the only direct measures of changes in brain function induced by DBS have been made using PET, but this requires a group of patients to be studied before statistically significant effects can be seen.

At Swinburne University of Technology we are working with surgeons and other clinicians from St Vincent's Hospital, Melbourne on a study using Magnetoencephalography (MEG) to measure the changes in whole brain functional connectivity by recording resting state data both before and after surgery. Unlike PET, statistically significant differences can be observed in individual patients.

MEG is an entirely passive procedure, involving no external magnetic fields or radiation, designed to measure the extremely small magnetic field oscillations generated by the brain's electrical activity. Measuring these same oscillations in the presence of magnetic field noise generated by the DBS device, which is several orders of magnitude larger than the brain oscillations of interest, poses a severe technical challenge. By using a number of spatial filtering techniques it has been possible to overcome this hurdle and generate reproducible estimates of neural activity in response to the patient viewing a series of human faces. The same reconstruction method was then applied to eyes-closed resting state data from recordings made both before and after surgery.

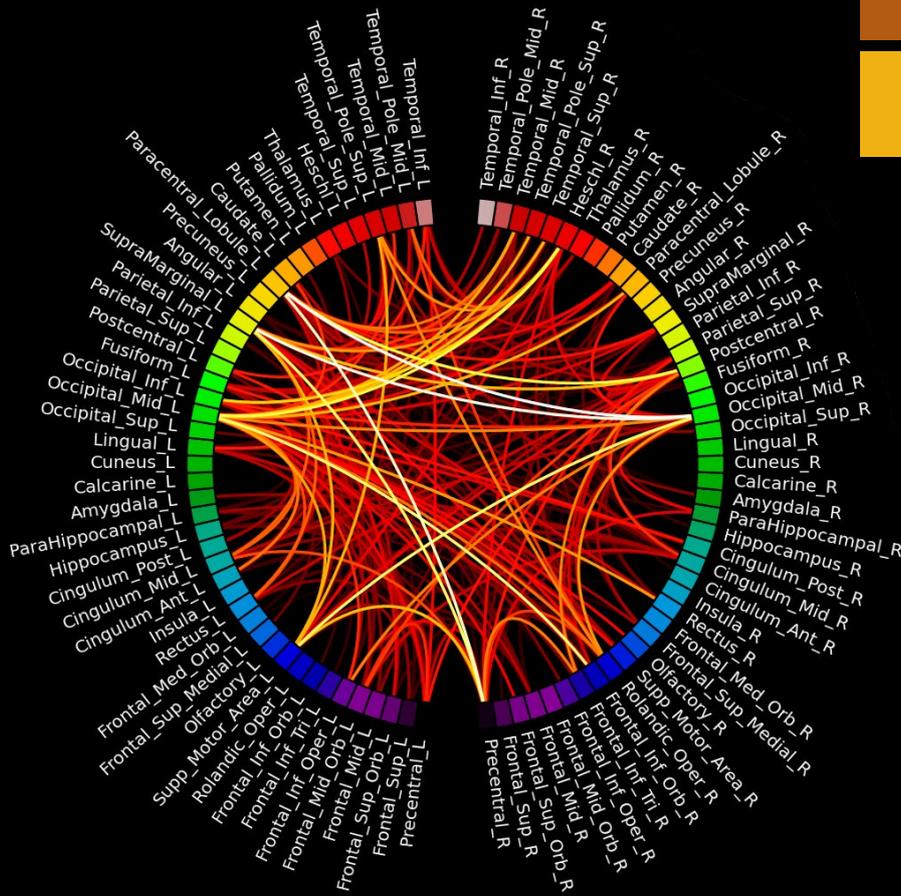
The brain was divided into a number of different regions based on anatomy, and time series estimates of the neural activation in each region made using a spatial filter. A proxy for functional connectivity, in the form of phase synchronisation measures between every pair of regions, was used to construct a weighted graph representing the network of connections within the brain. By comparing the networks from the pre- and post- surgery recordings it was possible to find connections between regions which had increased or decreased significantly after surgery.

While the current study is designed only to detect changes in network connections caused by DBS, there is the potential to use this method as a form of feedback to inform the tuning of the stimulation parameters in a principled way to achieve a network structure closer to that found in the healthy population, with the expectation that this will also correspond to a consequent reduction of symptoms.

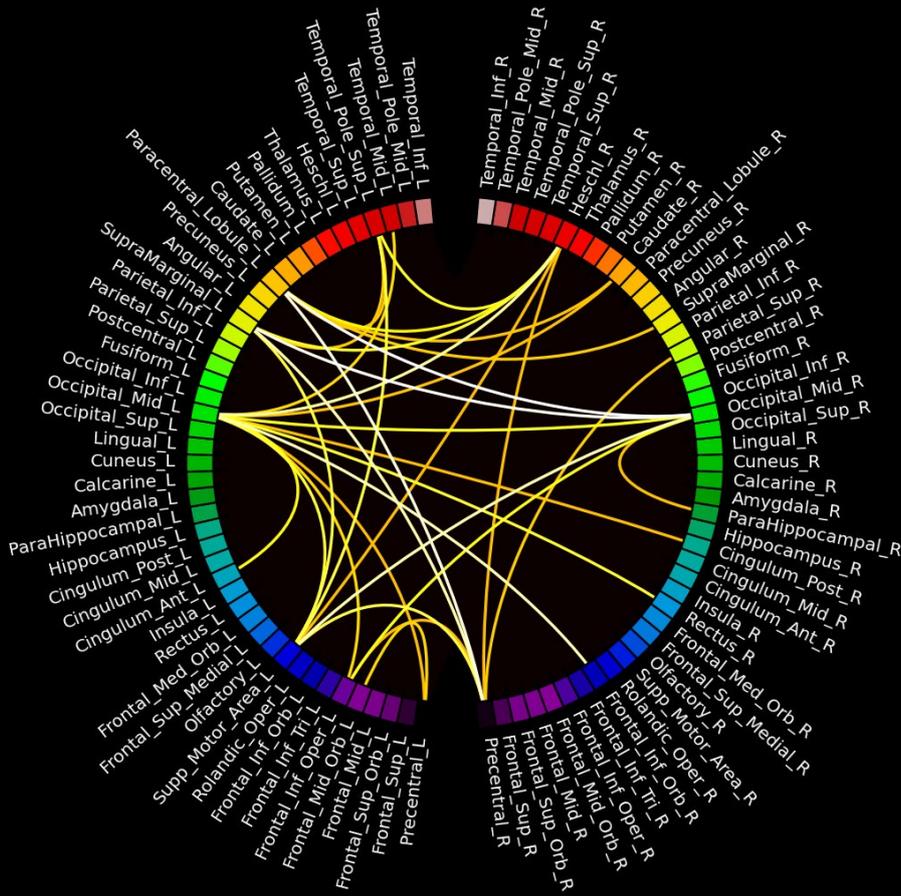
For more information on this project, contact Dr. Will Woods ([wwoods@swin.edu.au](mailto:wwoods@swin.edu.au)).

#### Collaborators

Swinburne Neuroimaging, Swinburne University of Technology  
St Vincent's Hospital, Melbourne



Regional connections with largest change in strength from pre- to post-DBS surgery



# INTRODUCING PHYSIO – A NEW OPEN-SOURCE TOOLBOX FOR MODELLING PHYSIOLOGICAL NOISE IN FUNCTIONAL MRI

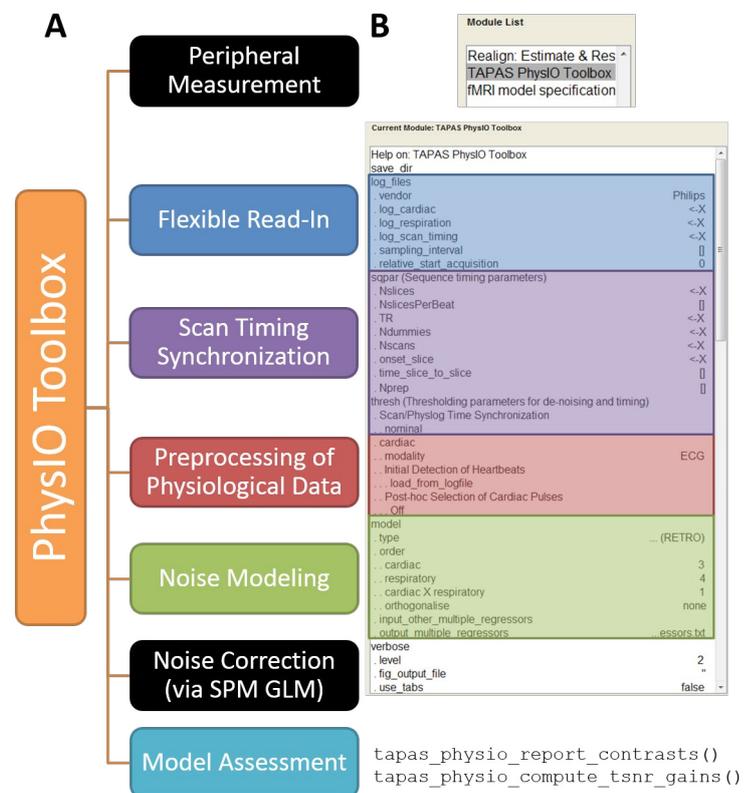
In a collaborative project led by Lars Kasper from the Translational Neuromodeling Unit (TNU) and the Institute for Biomedical Engineering at the University of Zurich and ETH Zurich together with National Imaging Facility (NIF) Fellow Steffen Bollmann from the Centre for Advanced Imaging (CAI), The University of Queensland, a new open source toolbox for improving fMRI data analysis has been developed.

The physIO toolbox simplifies the workflow of incorporating physiological noise correction in fMRI analyses by providing robust pre-processing, fully automated modelling and a user-friendly performance assessment for group studies. All of this is tightly integrated in the open source toolbox SPM, the most widely used software for analysing fMRI data.

The project was started by Lars Kasper to access physiological data, i.e. breathing and heartrate from a Philips MRI scanner. Soon, he extended the toolbox to perform analysis of the physiological data and implemented various noise modelling methods. Steffen Bollmann joined the project in 2013 when he wanted to apply the algorithms to data collected during his PhD on a GE MRI scanner. The toolbox was not compatible with the GE data format and Steffen contributed routines for reading in data from this vendor and developed an algorithm for detecting ECG peaks more robustly. This was required due to poor data quality at times, as Steffen worked with children with Attention Deficit Hyperactivity Disorder (ADHD), who had a hard time lying still in the MRI scanner.

“New features for the toolbox were often developed on weekends when we met and discussed problems and possible solutions. The toolbox and our understanding of the problems we had solved grew during this time and we had more and more people testing it on their data and reporting problems they faced. Now, more than five years after the first lines of code, we have read-in routines for all major MRI vendors and a large repertoire of noise correction methods has been tested and implemented”, Steffen said.

Saskia Bollmann, former Master student of Lars Kasper and now PhD student at CAI, uses the toolbox in her research where she investigates the influence of physiological noise on fast fMRI data. She shows how the analysis of single-subject fMRI data acquired at ultra-high field can profit from physiological noise modelling and how statistical inference and, hence, the interpretation can be improved.



Workflow of the PhysIO Toolbox.  
(A) The different modules of the Toolbox in processing order.  
(B) SPM12 Batch Editor interface of the toolbox; parameters color-coded according to corresponding modules.

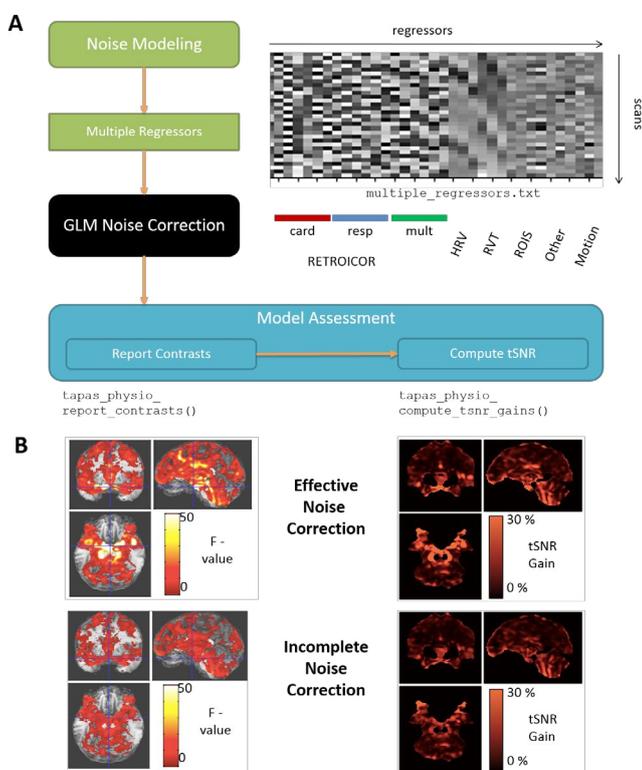


Encouraged by its successful application in several studies including hundreds of volunteers, the team hopes that this open source toolbox will find useful application in future neuroimaging studies of health and disease, particularly in areas strongly affected by physiological noise such as the brainstem.

To download the toolbox, refer to <https://www.tnu.ethz.ch/en/software/tapas.html> and for more information, contact Dr. Steffen Bollmann ([steffen.bollmann@cai.uq.edu.au](mailto:steffen.bollmann@cai.uq.edu.au)).

Collaborators

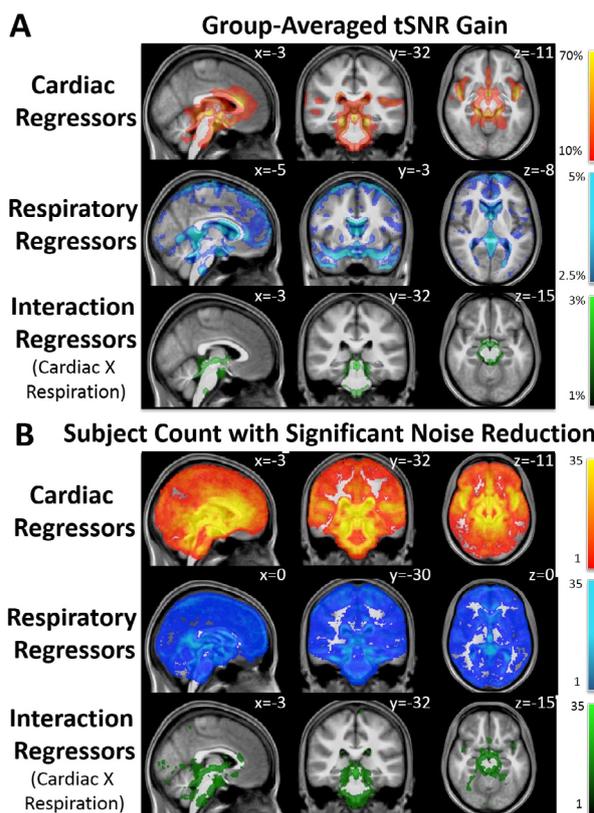
Translational Neuromodeling Unit (TNU), Institute for Biomedical Engineering, University of Zurich and ETH Zurich, Switzerland  
Institute for Biomedical Engineering, ETH Zurich and University of Zurich, Switzerland  
Centre for Advanced Imaging, University of Queensland, Brisbane, Australia  
Wellcome Trust Centre for Neuroimaging, University College London, London, UK  
Max Planck University College London Centre for Computational Psychiatry and Ageing Research, London, UK  
Department of Psychiatry and Psychotherapy, Campus Mitte, Charité Universitätsmedizin, Berlin, Germany  
Department of Neurology, Schulthess Clinic, Zurich, Switzerland  
Max Planck Institute for Metabolism Research, Cologne, Germany



(A) Performance evaluation of physiological noise modeling. PhysIO outputs a multiple regressors-matrix, combined with movement parameters for e.g. SPM fMRI design specification. After model estimation, the toolbox creates F-contrasts and tSNR maps to assess noise correction and report output figures automatically via different Matlab functions.

(B) Example F-contrast and tSNR maps for 7T ECG + breathing belt data set. Effective noise correction (Top row): using preprocessed ECG recordings with iterative template-matched peak detection; Incomplete noise correction (Bottom row): using trigger signal saved in vendor logfile from prospective peak detection. Characteristics of the spatial distribution are less pronounced (F-contrast, left) and the overall efficacy of the noise correction is reduced (tSNR increase through RETROICOR correction, right).

[Abbreviations for regressor sets: Card = cardiac, Resp = Respiratory, mult = multiplicative (Card x Resp) interaction of RETROICOR; HRV = Heart Rate Variability; RVT = Respiratory Volume per Time; ROISdouble bond; length as m-dashNoise Region of interest mean and principal components; Other = custom-made other regressors from text file; Motion = Motion model from realignment parameters]



Automatization of PhysIO usage in an fMRI group study (N = 35).

(A) Average tSNR gain map over the entire group. Considerable noise reductions (up to 70%) are realized in the whole group through RETROICOR noise modeling.

(B) Subject count of significant physiological noise correction for each voxel in individual 1st level analyses (peak level FWE-corrected  $p < 0.05$ ). Robustness of the toolbox is confirmed via the high subject count in noise-sensitive areas (cf. (A)). Beyond group results, noise correction for individual subjects can improve sensitivity in all regions of the brain.

NEWS

Access to world-class research infrastructure is critical to high quality R&D activities. The National Collaborative Research Infrastructure Strategy (NCRIS) provides cutting-edge instruments, facilities and expertise to enable public and private research activities. In order to support Small-Medium sized Enterprise (SME)'s and improve Australia's overall innovation output, National Imaging Facility (NIF) along with four other NCRIS capabilities (Australian Phenomics Network, Bioplatfroms Australia, Australian Microscopy & Microanalysis Research Facility, and Australian National Fabrication Facility) and with the support of AusIndustry, organized a free workshop in Sydney to engage SME's in MedTech & Pharma Industry.

In this workshops, representatives from Innovation Connections and NSW State Government presented State-based Grants & Assistance Programmes, and the 5 NCRIS capabilities introduced their unique facilities and how they can be accessed to solve R&D problems.

Australian-wide collaborative network of imaging infrastructure, NIF merges world-class imaging technologies with highly specialized expertise from 10 universities and research institutes, along with ANSTO, to provide research communities and industry with access to state-of-the-art imaging capability of human, animals, plants, and materials.



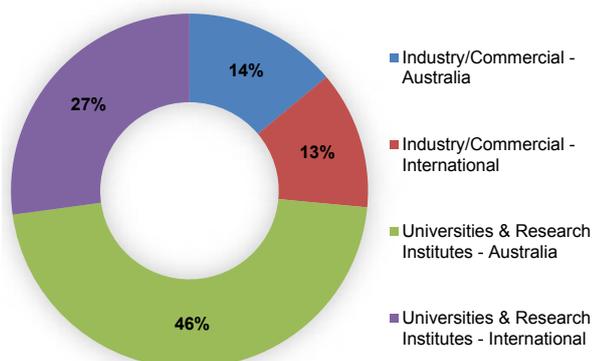
NIF supports all users, including SMEs, with

- Project Design Consultation including advice on most appropriate technologies,
- Animal Handling and Ethics,
- Optimisation of Image Acquisition parameters,
- Data Analysis & Interpretation, and
- Data management and curation.

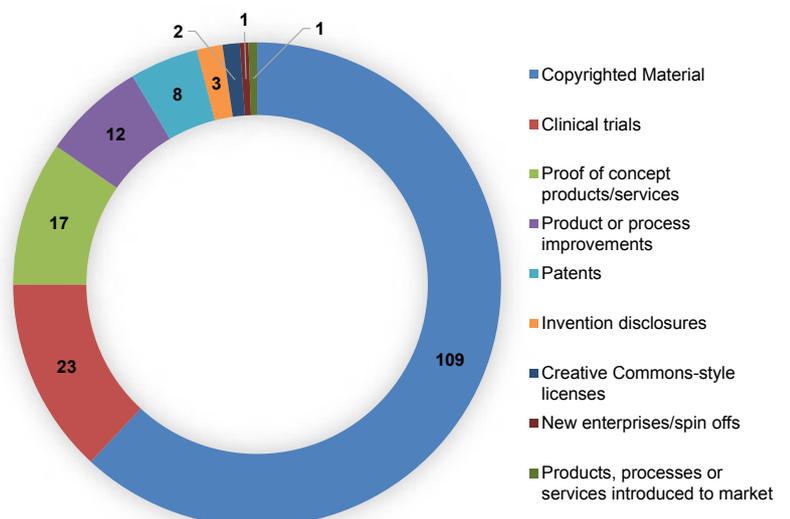
The workshop was well received by the attendees and formed new discussions for potential collaborations and partnerships.

## A QUICK LOOK AT NIF COLLABORATIONS & IP/COMMERCIALISATION - 2015

### Collaborations



### IP/Commercialisation





# HEALTH MINISTER VISITS UQ NODE OF NIF



Dr Gary Cowin, NIF Fellow, discussing how imaging contributes to targeting cancer with Minister Ley



From left: Dr. Gary Cowin, The Hon. Susan Ley MP, Prof. David Reutens, Prof. Peter Høj, Prof. Ian Brereton

On Monday 24<sup>th</sup> of October the Honourable Susan Ley MP, Federal Minister for Health & Aged Care and Minister for Sport visited The University of Queensland (UQ) node of National Imaging Facility (NIF) at the Centre for Advanced Imaging (CAI). She was met by Professor Peter Høj, Vice-Chancellor and President of UQ, and introduced to Professor David Reutens, Director of CAI; Professor Ian Brereton, Director of Research and Technology at CAI and NIF UQ Node Director; Dr Celia Webby, Deputy Director Operations, CAI and Dr Gary Cowin, NIF Facility Fellow at CAI.

Minister Ley was escorted on a tour of the CAI and NIF facilities including the Human 7T MRI, cyclotron and multimodal MR/PET and PET/CT animal imaging laboratories. Some of the research programs including sports injury and comparative oncology were discussed and a few examples were presented. Finally, NIF and its role in enabling access to internationally leading scientists and world-class instrumentation for the Australian research community and industry was highlighted.

Following the tour, CAI hosted a morning tea with research group leaders, where funding sources, research programs, and a broader discussion of Medical Health research funding in Australia formed. Some of the challenges with NH&MRC funding were raised and discussed with the Minister. Minister Ley highlighted the potential of the Government's Medical Research Future Fund as an indication of the Australian Government's commitment to medical research.





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