



Neurophotronics

Optical-EEG

Prospective cohort study investigating neurovascular coupling in the newborn brain.

Investigators	Maria Chalia (MD student), Topun Austin
Collaborators	UCL BORL
Funding	Action Medical Research (2012-2014)/Evelyn Trust Fellowship
Start date	October 2012
End date	October 2016
Portfolio	not adopted
Study Population	term, preterm, neonatal encephalopathy
Recruitment	63



The relationship between blood flow and electrical activity in the neonatal period is poorly understood in health and disease, however, underpins a number of phenomena, including functional brain activation and possibly on going hypoxic brain injury following seizures. Neonatal seizures remain difficult to detect using conventional tools.

The aim of this study is to investigate the relationship between cerebral haemodynamics and electrical activity in preterm and term neonates at risk of brain injury, by using the technique of diffuse optical imaging (DOI) and video electroencephalography (EEG).

The project aims to address the following specific questions:

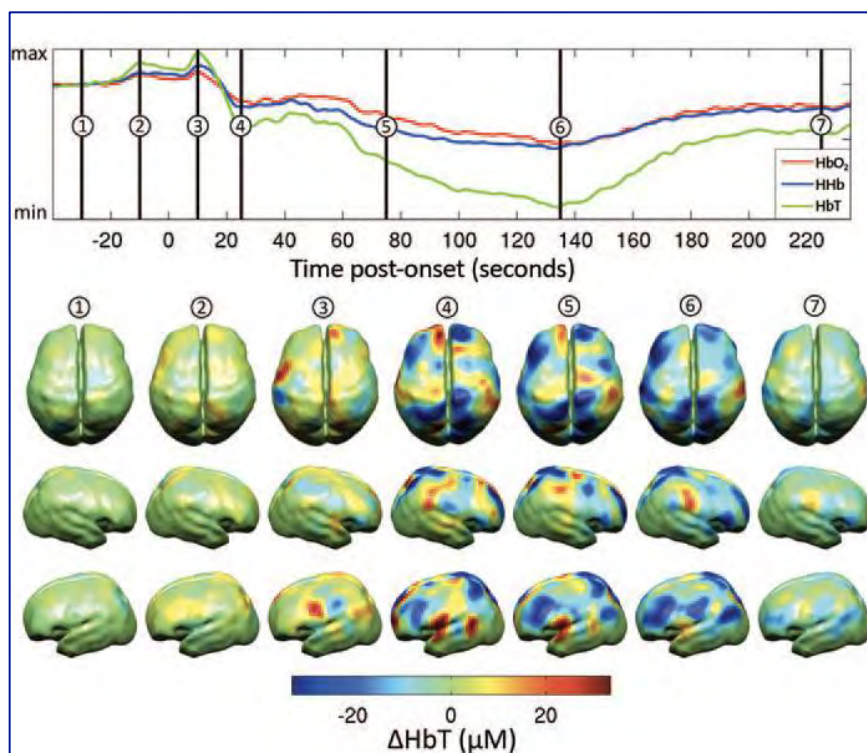
- Do transient haemodynamic events correlate with electrographic seizures (apparent on scalp EEG)?
- Do these events correlate with clinical seizure activity not seen on scalp EEG; i.e. are they a more sensitive index of seizure activity?
- Are transient electrical activities seen in term and preterm infants related with specific haemodynamic events?

Key outputs of the project to date have been:

- 1) Development of a novel flexible cap with integrated optical and electrical sensors for use in term and preterm infants.
- 2) Identification for the first time in infants with seizures, repeated 'haemodynamic transients', consisting of episodes of a small increase in cortical oxygenation followed by a profound decrease.
- 3) Reconstruction of the first ever images of changes in regional blood volume that occur with seizure activity – which demonstrated significant and prolonged falls in blood volume associated with electrical seizures.
- 4) Reconstruction of images of changes in regional blood volume associated with burst suppression.
- 5) Identification reduced low frequency haemodynamic oscillations associated with perinatal arterial-ischaemic stroke.

Publications

- Cooper RJ, Hebden JC, O'Reilly H, Mitra S, Michell A, Everdell NL, Gibson AP, Austin T. Transient haemodynamic events in neurologically compromised infants: A simultaneous EEG and diffuse optical imaging study. *Neuroimage* 2011;**55**:1610-6.
- Singh H, Cooper RJ, Lee CW, Dempsey L, Edwards AD, Brigadoi S, Airantzis D, Everdell N, Michell A, Holder D, Hebden JC, Austin T. Mapping cortical haemodynamics during neonatal seizures using diffuse optical tomography: a case study. *Neuroimage Clin.* 2014;**5**:256-65.
- Singh H, Cooper RJM, Lee CW, Dempsey L, Brigadoi S, Edwards A, Airantzis D, Everdell N, Michell A, Holder D, Austin T, Hebden JC. Neurovascular interactions in the neurologically compromised neonatal brain. *Adv. Exp. Med. Biol.* 2016;**876**:485-92.
- Chalia M, Lee CW, Dempsey LA, Edwards AD, Singh H, Michell AD, Everdell NL, Hebden JC, Cooper RJ, Austin T. The haemodynamic response to burst-suppressed and discontinuous EEG activity in infants with hypoxic-ischaemic encephalopathy. *Neurophotronics* 2016; **3**:031408.

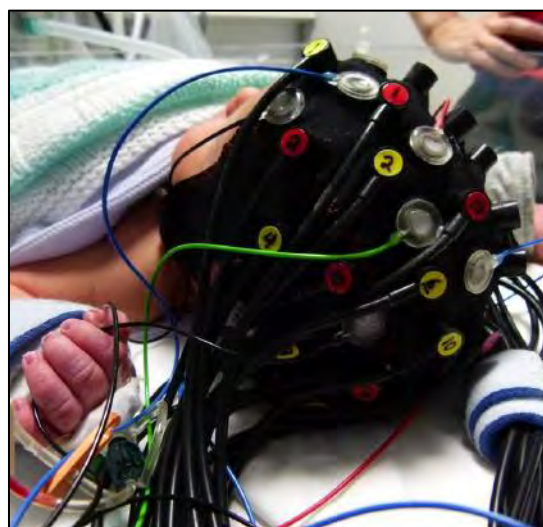
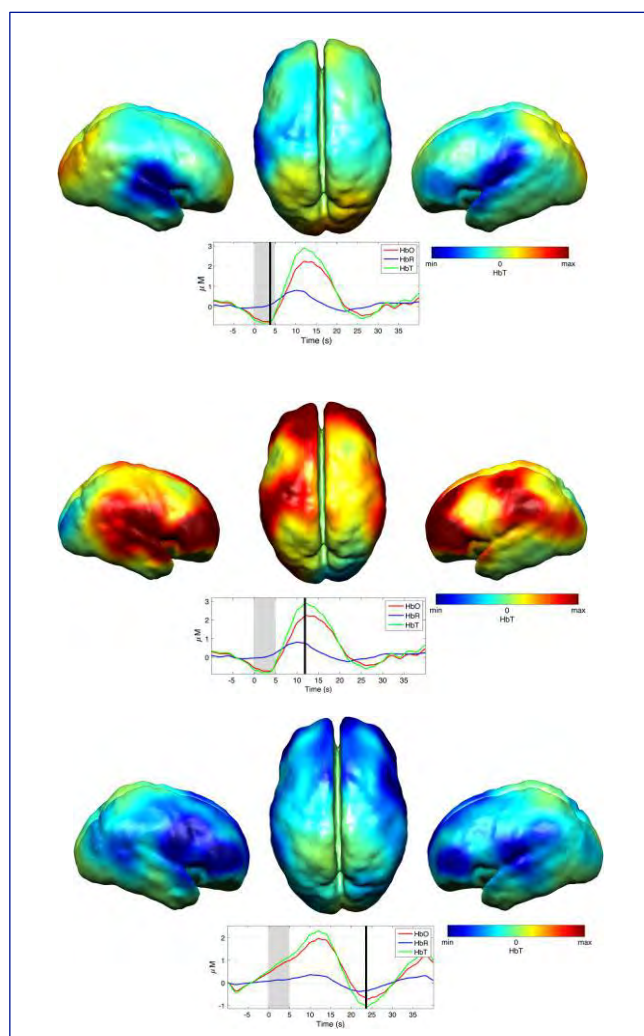


A sequence of images showing the changes in total haemoglobin (HbT) associated with a clinical seizure in an infant. The upper axes show the changes in haemoglobin concentration spatially averaged across the cortical surface. Seven distinct time points are identified and the associated reconstructed images of the changes in HbT concentration are shown in dorsal and left and right lateral views. All data are changes relative to a baseline defined as the mean of the period between 60 and 30 seconds prior to the electrographic seizure onset.

Adapted from Singh et al. *Neuroimage Clin.* 2014; 5:256-65.

Key: HbO₂ = oxyhaemoglobin, HHb = deoxyhaemoglobin, HbT = total

haemoglobin.



Optical-EEG cap on a baby on the NICU

Changes in HbT associated with EEG bursts in one infant. *The burst duration is shown in the grey shaded area and the time of image reconstruction represented by the black line at 4, 12 and 24 seconds from the onset of the burst.*

Adapted from Chalia et al. *Neurophotonics*. 2016; 3:031408.

Fast Optical Tomography On Neonates (FOTON)

Prospective cohort study investigating functional activation, resting state cortical networks and neurovascular coupling in infants with acquired brain injury using fast optical tomography

Investigators Andrea Edwards, Laura Dempsey (PhD student), Rob Cooper, Topun Austin, **Jem Hebden**

Collaborators UCL BORL

Funding Engineering and Physical Sciences Research Council (EPSRC)

Start date October 2014

End date January 2018

Portfolio Adopted

Study population 20 healthy term/20 healthy preterm/10 HIE/10 seizures/20 preterm with brain injury (total 80)



Fast optical tomography (FOT) involves acquiring measurements of light transmitted across the full thickness of tissue in order to generate 3D images of blood volume and oxygenation using sophisticated image reconstruction algorithms. UCL's 32-channel time-resolved optical tomography system (MONSTIR II) uses time-correlated single photon counting technology to measure the flight times of photons as they are transmitted between points on the surface. In 2015 MONSTIR II was brought to Cambridge.

The aims of this project are to:

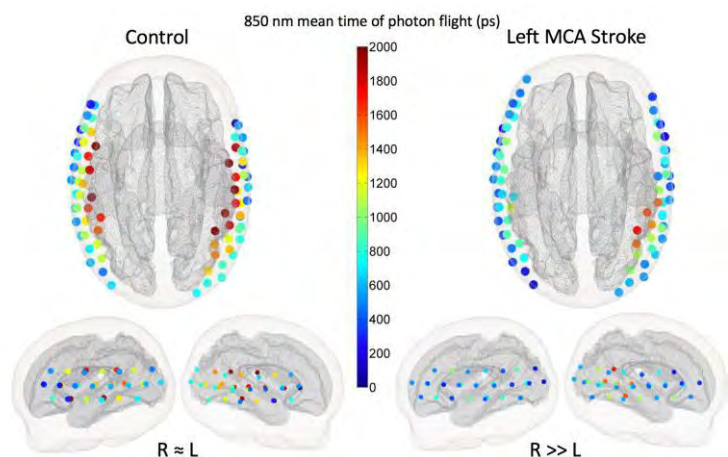
- 1) Assess functional activation using FOT in healthy infants and infants with structural parenchymal brain injury.
- 2) Obtain measurements of resting state functional connectivity in both healthy and sick newborn infants, using FOT.
- 3) Observe the deep haemodynamic changes in infants with brain injury at risk of seizures.

Key outputs of the project to date:

1. Successful testing of dynamic phantom and pilot studies for optimal wavelength selection.
2. Successful pilot scans on control infants and term infants with brain injury on NICU.
3. Preliminary data reconstruction from term infant with perinatal arterial ischaemic stroke.

Publications

- Dempsey LA, Cooper RJ, Roque T, Correia T, Magee E, Powell S, Gibson AP, Hebden JC. A data-driven approach to optimum wavelength selection for diffuse optical imaging. *J Biomed Opt.* 2015;**20**:16003.



MONSTIR II scan on the NICU (left); Preliminary time of flight responses from a term infant with left middle cerebral artery (MCA) stroke; there is a reduction in the amount of photon counts on the side of the haemorrhage (far right).

Behaviour and Resting state Activation In Newborns (BRAIN)

Prospective cohort study investigating newborn behaviour and development of resting state cortical networks in healthy infants and infants at risk of brain injury.

Investigators Chuen Wai-Lee (PhD student), Topun Austin
Collaborators UCL BORL
Funding Evelyn Trust Fellowship/Medical Research Council
Start date March 2014
End date September 2016
Portfolio Adopted



Study population healthy term/healthy preterm/extremely preterm/term brain injury/preterm brain injury
Recruitment 29 healthy term/4 extremely preterm/5 term brain injury/2 preterm brain injury

This study investigates neonatal brain function through measures of infant behaviour with cerebral functional connectivity. Using a novel flexible cap with integrated optical and electrical sensors, simultaneous haemodynamic and electrical brain activity will be measured in order to assess resting state functional connectivity. A standardised clinical examination of infant behaviour, the Neonatal Behavioural Assessment Scale (NBAS), will be used to see if disruption to the development of normal brain connectivity relates to abnormal behaviour indicating brain injury. The aims are to:

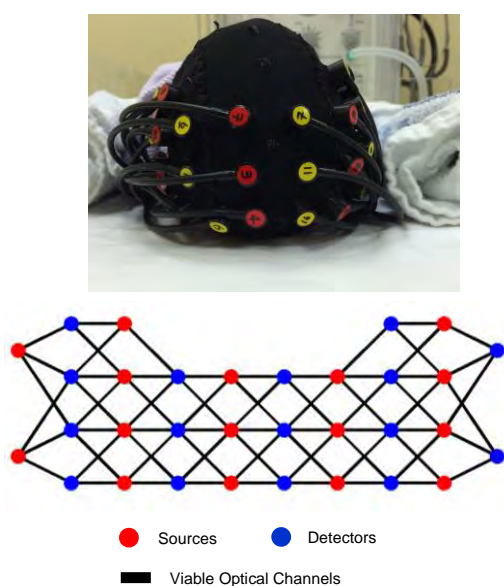
1. Characterise the early development of neonatal brain function as assessed using diffuse optical imaging (DOT) and electroencephalography (EEG).
2. Identify abnormal RSFC and its relationship to behaviour and brain structure in infants at risk of brain injury.

Key outputs of the project to date:

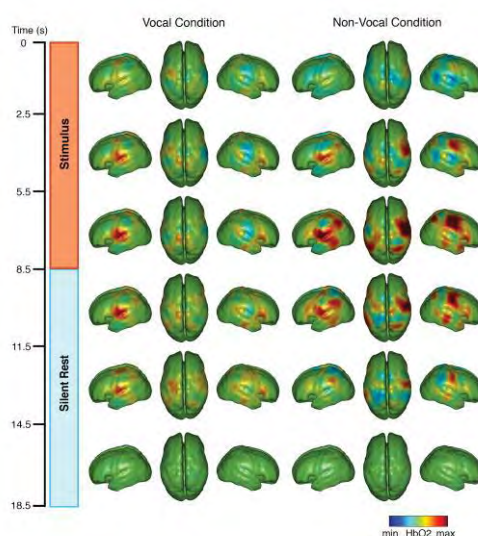
1. Development of a novel flexible cap with integrated optical and electrical sensors for use in term and preterm infants.
2. Images of cortical haemodynamic responses to vocal and non-vocal auditory stimuli from term infants reconstructed (*figure below*).
3. Identification of resting state functional networks with differences observed in different sleep states.

Publications

- Lee CW, Lloyd-Fox S, Blasi A, Chalia M, Everdell NL, Hill RW, Hebden JC, Cooper RJ, Austin T. Imaging the cortical hemodynamic response to vocal and non-vocal auditory stimuli in the newborn brain using diffuse optical tomography. *Submitted to Neurophotonics, Jan 2017*



Optical array over the parietal and temporal lobes (top)
Location of optical source and detector fibres and viable optical channels (bottom)



DOT images of the group average HbO response for the vocal (first column) and non-vocal conditions (second column) in $N = 9$ subjects. Images are reconstructed to display the cortical average HbO response over 2.5-4 s time bins from the start of the stimulus presentation to 10 s after the end of the stimulus during the silent rest period. Lee et al. *Submitted to Neurophotonics*, 2017.

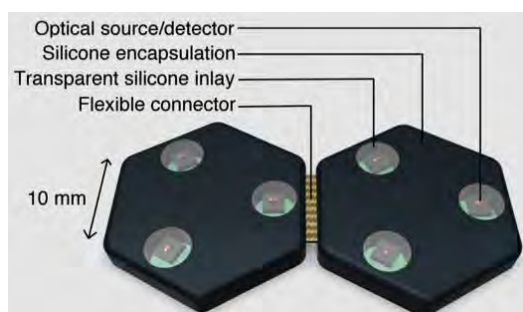
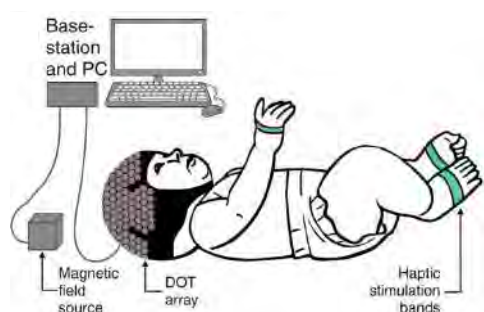
ANIMATE

WEARABLE NEUROIMAGING OF INFANT MOVEMENT



EPSRC fellowship to develop a miniaturized, wearable, high-density optical neuroimaging technology that exploits flexible electronics and advanced motion tracking to provide the precision, resolution, patient comfort and motion tolerance necessary to monitor the sensorimotor functional development of the vulnerable infant at the cot-side.

Investigators Rob Cooper, Hubin Zhao
Collaborators Topun Austin, UCL BORL, Gowerlabs
Funding Engineering and Physical Sciences Research Council (EPSRC)
Start date August 2016
End date July 2021
Portfolio N/A



STORK

Early identification of perinatal arterial ischaemic stroke using near-infrared spectroscopy and diffuse optical imaging

Prospective cohort study to assess optical technologies to diagnose neonatal stroke

Investigators Topun Austin, Jem Hebden, David Rowitch, Elham Nabavi, Emma Porter
Collaborators UCL BORL
Funding Evelyn Trust
Start date April 2017
End date March 2019
Portfolio N/A



Study Population 40 infants with neonatal encephalopathy (10 with PAIS)

This study aims to answer two questions in the evaluation of NIRS and TR-DOI as an early diagnostic tool for perinatal arterial ischaemic stroke (PAIS)

- Can optical methods be used to reliably diagnose PAIS?
- With its inherent spatial and depth resolution is TR-DOI superior to NIRS in diagnosing PAIS?

Developmental Psychology

SPELL Identifying Neuro-Genetic Oscillatory Biomarkers of Dyslexia Risk in Neonates

Prospective pilot cohort study investigating neurooscillatory and genetic markers of dyslexia in the newborn infant

Investigators Topun Austin, Peppar Cyr (MPhil student), Liana Amunts, Laura Brightman, Gusztav Belteki, Vicky Leong

Collaborators Department of Psychology

Funding Rosetrees Trust

Start date August 2015

End date July 2017

Portfolio N/A

Study population Term infants: 25 control, 25 'at risk' for dyslexia



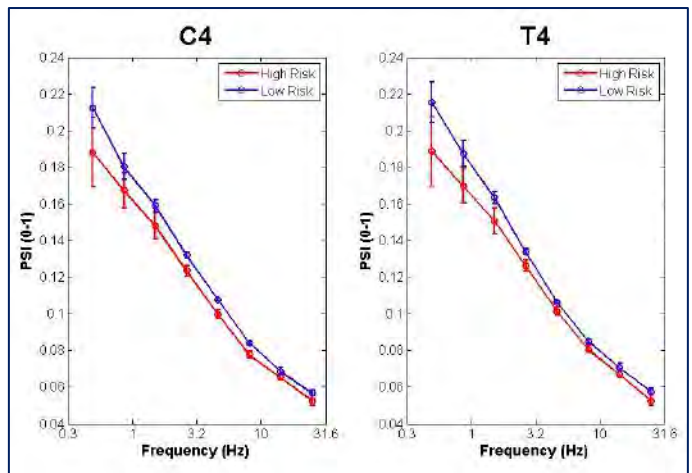
This study aims to identify oscillatory biomarkers that distinguish between high-risk and low-risk infants, and to elucidate specific genotypes that are associated with these oscillatory deficits. Oscillatory encoding of speech will be assessed in 25 high-risk and 25 low-risk (control) infants using electroencephalography (EEG). Infants will be genotyped for 16 single nucleotide polymorphisms in 4 major dyslexia susceptibility loci (DCDC2, KIAA0319, ROBO1 and DYX1C1). Regression models will be developed to assess the relationship between genotype and oscillatory biomarkers that are indicative of high dyslexia risk.

Key outputs of the project to date:

1. Preliminary data found a significant difference in brain oscillations to rhythmic speech (n=12) and association with ROBO1 genotype.
2. Successful defence of MPhil thesis (Peppar Cyr).
3. Award of Rosetrees PhD studentship to commence in 2017



Infant being tested in the Evelyn Perinatal Imaging Centre



Preliminary results on 10 infants (5 high risk, 5 low risk). The phase synchronisation index (PSI) represents how accurately the neural response tracks the speech pattern; the lower the value the more asynchronous. There is a significant divergence between the two groups at lower frequencies of speech. Cyr et al. Unpublished



BRIGHT BBrain Imaging for Global Health

A prospective longitudinal study to establish standard curves of brain function for age and to use these to identify early biomarkers of disrupted neurocognitive development.

Investigators Topun Austin, Anna Blasi, Laura Kischkel, Sarah Lloyd-Fox, Sophie Moore, Maria Rozhko, **Clare Elwell**

Collaborators UCL, Birkbeck, MRC Human Nutrition Unit

Funding Bill & Melinda Gates Foundation

Start date August 2015

End date December 2019

Portfolio N/A

Study population 80 healthy term infants

**BILL & MELINDA
GATES foundation**

The aim of this study is to chart the nature and pace of neurocognitive development in UK infants between birth and 18 months of age. Infants will be studied longitudinally using functional neuroimaging, behavioral, growth and socio-demographic measures. These measures will be used to establish typical trajectories of neurocognitive development in UK infants, as well as providing a valuable cross-cultural reference for studies in other populations.

Infants will be recruited at birth and then studied within the first month and then at 4, 8, 12 and 18 months of age. A range of measures to provide markers of infant brain function will be used, including functional near infrared spectroscopy (fNIRS) and electroencephalography (EEG), as well as assessment of behaviour and growth; with this data brain function for age curves will be created which will inform on typical brain development in UK infants. We will also investigate which measures provide the most robust and reliable markers of brain development capable of providing an early indicator of atypical function.

This study is part of a larger project investigating brain development in African infants at risk of under nutrition, but its findings will have impact in a number of studies focused on developing strategies to which are targeted at protecting the developing brain, and hence reduce the individual and global burden of long term neurocognitive deficit.



Infants being tested for the BRIGHT study in the Evelyn Perinatal Imaging Centre

CHILD Cambridge Human Infant Longitudinal Development study

Prospective pilot cohort study investigating the different effects of prenatal and postnatal hormones on brain development and behaviour in typically developing children and siblings of children with a diagnosis of autism.

Investigators	Topun Austin, Bonnie Auyeung, Ezra Aydin, Sarah Hampton, Rosemary Holt, Simon Baron-Cohen
Collaborators	Autism Research Centre
Funding	Autism Research Trust
Start date	October 2016
End date	TBC
Portfolio	N/A



This study will focus on understanding the different effects of prenatal and postnatal hormones on brain development and behaviour in typically developing children and in siblings of children with a diagnosis of autism and parents with autism.

The aims of the study are:

- To understand how prenatal and postnatal exposure to hormone levels are linked to early brain development.
- To examine how early brain growth is related to the development of behavioural traits.

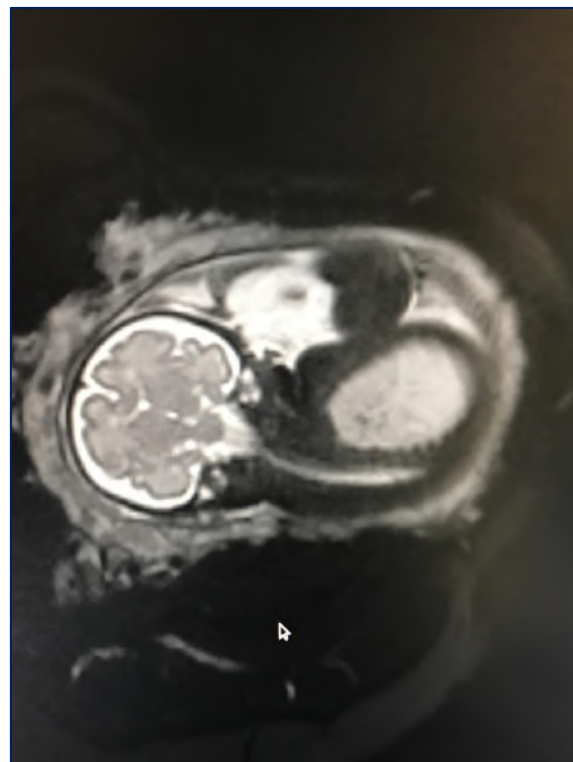
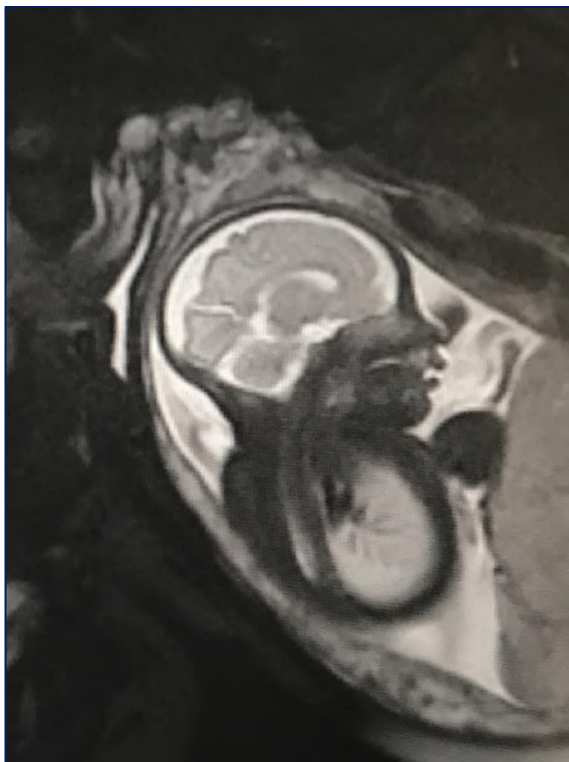
This study will focus on assessment in the fetal newborn period and at 18 months of age. Key investigations in will be:

1. Fetal and neonatal MRI brain imaging data
2. Looking preference for social vs non-social stimuli
3. Use of Guthrie blood spot test to measure sex steroid hormone levels
4. Assessment of growth

At 18 months the families will be contacted again and they will be asked to complete a number of developmental questionnaire's either by post or online.

Key outputs of the project to date:

1. First fetal MRI scans carried out in the Evelyn Perinatal Imaging Centre, January 2017 (below)



Appendix 1: Grants

- 1) Evelyn Trust, 2009-2012: Cerebral autoregulation in the newborn. £42K
- 2) Health Foundation, 2010-2012: Neonatal neuroprotection in the East of England. £435K
- 3) Danish Council for Strategic Research, 2011-2015 (Consortium Partner): SafeBoosC - Safeguarding the brain of our smallest children. DK11.1M – UK award. £26K
- 4) Action Medical Research, 2012-2014: Seizure detection in the newborn infant using integrated optical imaging and electroencephalography. £130K
- 5) Evelyn Trust, capital award: Evelyn Trust Perinatal Imaging Centre. £315K
- 6) Evelyn Trust, 2013-2015: Evelyn Trust Research Fellowship in Perinatal Neuroscience. £164K
- 7) Engineering and Physical Sciences Research Council (with UCL-BORL), 2012-2016: Fast optical tomography for imaging seizure detection in newborn infants. £887K
- 8) SPARKS, 2013-2015: SAMBA – Study of Autoregulatory Monitoring in BABies. £115K
- 9) Sir Jules Thorne Charitable Trust, 2013, equipment award: Development of a neonatal neurocritical care service in Cambridge. £181K.
- 10) MRC Fellowship, 2014-2016: BRAIN - Behaviour and Resting state Activation In Newborns. £130
- 11) Nick Haan Neonatal neurocritical care nurse secondment, 2015. £20
- 12) Rosetrees Trust (with Vicky Leong, Psychology), 2015-2016: Identifying neuro-genetic oscillatory biomarkers of dyslexia risk in neonates. £11k
- 13) Bill & Melinda Gates Foundation (with UCL-BORL, Birkbeck BabyLab, University of London), 2015-2017: BRIGHT - BRain Imaging and Global HealTh. \$2.5M
- 14) Addenbrooke's Charitable Trust/Biomedical Research Centre Nurses, Midwives & Allied Healthcare Professional Research Training Fellowships, 2015-2016. £44k
- 15) Evelyn Trust, 2017-2019: Early identification of perinatal arterial ischaemic stroke using near-infrared spectroscopy and diffuse optical imaging. £98.5k

Appendix 2: Publications

Original Papers

- 1) Cooper RJ, Hebden JC, O'Reilly H, Mitra S, Michell A, Everdell NL, Gibson AP, Austin T. Transient haemodynamic events in neurologically compromised infants: A simultaneous EEG and diffuse optical imaging study. *Neuroimage* 2011;**55**:1610-6.
- 2) Hyttel-Sørensen S, Austin T, van Bel F, Benders M, Claris O, Dempsey EM, Fumagalli M, Gluud C, Hagmann C, Hellström-Westas L, Lemmers P, Naulaers G, van Oeveren W, Pellicer A, Pichler G, Roll C, Støy LS, Wolf M, Greisen G. Clinical use of cerebral oximetry in extremely preterm infants is feasible. *Dan Med J.* 2013;**60**:A4533.
- 3) Hyttel-Sørensen S, Austin T, van Bel F, Benders M, Claris O, Dempsey EM, Fumagalli M, Greisen G, Grevstad B, Hagmann C, Hellström-Westas L, Lemmers P, Naulaers G, van Oeveren W, Pellicer A, Pichler G, Roll C, Skoog M, Winkel P, Wolf M, Gluud C. A phase II randomized clinical trial on cerebral near-infrared spectroscopy plus a treatment guideline versus treatment as usual for extremely preterm infants during the first three days of life (SafeBoosC): study protocol for a randomized controlled trial. *Trials* 2013;**14**:120.
- 4) Pellicer A, Benders M, Claris O, Dempsey EM, Fumagalli M, Gluud C, Greisen G, Hagmann C, Hellström-Westas L, Hyttel-Sørensen S, Lemmers P, Naulaers G, Pichler G, Roll C, van Bel F, van Oeveren W, Skoog M, Wolf M, Austin T. The SafeBoosC phase II randomized clinical trial: a treatment guideline for targeted near-infrared derived cerebral tissue oxygenation in extremely preterm infants. *Neonatology* 2013;**104**:171–178.
- 5) Chaudhary R, Farrer K, Broster S, McRitchie L, Austin T. Active versus passive cooling during neonatal transport. *Pediatrics* 2013;**132**:841-6.
- 6) Dassios T, Austin T. Respiratory function parameters in ventilated newborn infants undergoing whole body hypothermia. *Acta Paediatrica.* 2014;**103**:157-161.
- 7) Mitra S, Czosnyka M, Smielewski P, O'Reilly H, Brady K, Austin T. Heart rate passivity of cerebral tissue oxygenation as an indicator of cerebrovascular reactivity in preterm infants. *Acta Paediatr.* 2014;**103**(9):e374-82.
- 8) Singh H, Cooper RJ, Lee CW, Dempsey L, Edwards AD, Brigadoi S, Airantzis D, Everdell N, Michell A, Holder D, Hebden JC, Austin T. Mapping cortical haemodynamics during neonatal seizures using diffuse optical tomography: a case study. *Neuroimage Clin.* 2014;**5**:256-65.
- 9) Cooper RJ, Magee E, Everdell N, Magazov S, Vaerla M, Airantzis T, Gibson AP, Hebden JC. MONSTIR II: A 32-channel, multispectral, time-resolved optical tomography system for neonatal brain imaging. *Rev Sci Instrum.* 2014;**85**(5):053105
- 10) Brigadoi S, Aljabar P, Kuklisova-Murgasova M, Arridge SR, Cooper RJ. A 4D neonatal head model for diffuse optical imaging of preterm to term infants. *Neuroimage.* 2014;**100**:385-94.

- 11) Dempsey LA, Cooper RJ, Roque T, Correia T, Magee E, Powell S, Gibson AP, Hebden JC. A data-driven approach to optimum wavelength selection for diffuse optical imaging. *J Biomed Opt.* 2015;**20**:16003.
- 12) Hyttel-Sørensen S, Pellicer A, Alderliesten T, Austin T, van Bel F, Benders M, Claris O, Dempsey EM, Franz AR, Fumagalli M, Glud C, Grevstad B, Hagmann C, Lemmers P, Naulaers G, van Oeveren W, Pichler G, Plomgaard AM, Riera J, Sanchez L, Winkel P, Wolf M, Greisen G. Cerebral near infrared spectroscopy oximetry in extremely preterm infants: phase II randomised clinical trial. *BMJ* 2015;**350**:g7635.
- 13) Costa CS, Czosnyka M, Mitra S, Smielewski P, Austin T. Monitoring of cerebrovascular reactivity allows determination of optimal blood pressure in preterm infants. *J Pediatr.* 2015;**167**:86-91.
- 14) Plomgaard AM, Hagmann C, Alderliesten T, Austin T, van Bel F, Claris O, Dempsey E, Franz A, Fumagalli M, Glud C, Greisen G, Hyttel-Sorensen S, Lemmers P, Pellicer A, Pichler G, Benders M. Brain injury in the international multicenter randomized SafeBoosC phase II feasibility trial: cranial ultrasound and magnetic resonance imaging assessments. *Pediatr Res.* 2016;**79**:466-72.
- 15) Riera J, Hyttel-Sorensen S, Bravo MC, Cabañas F, López-Ortego P, Sanchez L, Ybarra M, Dempsey E, Greisen G, Austin T, Claris O, Fumagalli M, Glud C, Lemmers P, Pichler G, Plomgaard AM, van Bel F, Wolf M, Pellicer A. The SafeBoosC phase II clinical trial: an analysis of the interventions related with the oximeter readings. *Arch Dis Child.* 2015;**101**:F333-8.
- 16) Plomgaard AM, van Oeveren W, Petersen TH, Alderliesten T, Austin T, van Bel F, Benders M, Claris O, Dempsey E, Franz A, Fumagalli M, Glud C, Hagmann C, Hyttel-Sorensen S, Lemmers P, Pellicer A, Pichler G, Winkel P, Greisen G. The SafeBoosC II randomised trial: treatment guided by near-infrared spectroscopy reduces cerebral hypoxia without changing early biomarkers of brain injury. *Pediatr Res.* 2016;**79**:528-35.
- 17) Singh H, Cooper RJM, Lee CW, Dempsey L, Brigadoi S, Edwards A, Airantzis D, Everdell N, Michell A, Holder D, Austin T, Hebden JC. Neurovascular interactions in the neurologically compromised neonatal brain. *Adv. Exp. Med. Biol.* 2016; **876**: 485-92.
- 18) Chalia M, Lee CW, Dempsey LA, Edwards AD, Singh H, Michell AD, Everdell NL, Hebden JC, Cooper RJ, Austin T. The haemodynamic response to burst-suppressed and discontinuous EEG activity in infants with hypoxic-ischaemic encephalopathy. *Neurophotonics* 2016; **3**:031408.
- 19) de Boode WP, Singh Y, Gupta S, Austin T, Bohlin K, Dempsey E, Groves A, Eriksen BH, van Laere D, Molnar Z, Nestaas E, Rogerson S, Schubert U, Tissot C, van der Lee R, van Overmeire B, El-Khuffash A. Recommendations for neonatologist performed echocardiography in Europe: consensus statement endorsed by European Society for Paediatric Research (ESPR) and European Society for Neonatology (ESN). *Paediatr. Res.* 2016;**80**:465-71.
- 20) Plomgaard AM, Alderliesten T, Austin T, van Bel F, Benders M, Claris O, Dempsey E, Fumagalli M, Glud C, Hagmann C, Hyttel-Sorensen S, Lemmers P, Pellicer A, Petersen TH, Pichler G, Winkel P, Greisen G. Early biomarkers of brain injury and cerebral hypo- and hyperoxia in the SafeBoosC II trial. *PLoS One.* 2017;**12**(3):e0173440
- 21) Costa CS, Placed MM, Czosnyka M, Cabella B, Kasproicz M, Austin T, Smielewski P. Complexity of brain signals is associated with outcome in preterm infants. *JCBFM* Jan 1:271678X16687314. doi: 10.1177/0271678X16687314.

Invited contributions, commentaries and review articles

- 1) Austin T, Copper RJ. Combining EEG and diffuse optical imaging: a new approach to monitoring neonatal seizures? *Advances in Clinical Neurosciences and Rehabilitation* 2010;**10**:42-44.
- 2) Austin T, O'Reilly H. Advances in imaging the neonatal brain. *Expert Opinion in Medical Diagnostics* 2011;**5**:95-107.
- 3) Dyson C, Austin T, Lees C. NICE, cardiotocography and long term cognitive impairment. *BMJ* 2011;**31**:342.
- 4) Austin T, Mitra S. Optical imaging of the neonatal brain *European Paediatrics* 2011;**5**:13-18.
- 5) Arthurs A, Edwards AD, Austin T, Graves MJ, Lomas DJ. The challenges of neonatal magnetic resonance imaging. *Pediatr Radiol.* 2012;**42**:1183-94.
- 6) Austin T, Shanmugalingam S, Clarke P. To cool or not to cool? Hypothermia treatment outside trial criteria. *Archives of Diseases in Childhood.* 2013; **98**(5):F451-3.
- 7) Austin T, O'Hare SS. Neurocritical care for hypoxic-ischaemic encephalopathy: cooling and beyond. *Infant* 2013;**9**:135-38.
- 8) O'Hare SS, Austin T. Protecting the brain of term infants; from bench to bedside. *Pediatrics and Child Health.* 2014; **24**(9):390-396.
- 9) Austin T. Measurement of cerebral oxygenation in preterm infants: is it useful? *Developmental Medicine and Child Neurology.* 2015;**57**:404-5.
- 10) da Costa C, Greisen G, Austin T. Is NIRS clinically useful in the preterm infants. *Arch Dis Child* 2015;**100**:F558-61.
- 11) Lee CW, Cooper R, Austin T. Diffuse optical tomography to investigate the newborn brain. *Pediatric Research* 2017: in press.

Abstracts

- 1) O'Reilly H, Mitra S, Cooper RJ, Michell A, Everdell NL, Gibson AP, Hebden JC, Austin T. Simultaneous Optical Imaging and Electroencephalography in the Neonate. *Presentation at the Neonatal Society meeting, London, UK, November 2010.*
- 2) O'Reilly H, Mitra S, Cooper RJ, Michell A, Everdell NL, Gibson AP, Hebden JC, Austin T. Simultaneous Optical Imaging and Electroencephalography in the Neonate. *Poster presentation at the The 6th International Conference on Brain Monitoring & Neuroprotection in the Newborn, Amsterdam, Netherlands, February 2011.*
- 3) Walston FE, Baron MK, Broster S, Shanmugalingam S, Austin T. Therapeutic hypothermia in the neonate – from best research to best practice. *Arch Dis Child Fetal Neonatal Ed* 2011;**96**:Fa26.
- 4) Mitra S, O'Reilly H, Czosnyka M, Smielewski P, Austin T. Cerebrovascular reactivity in preterm infants measured by near-infrared spectroscopy and transcranial cerebral Doppler – a pilot study. *Pediatric Research* 2011;**70**:260.
- 5) Walston FE, Baron MK, Farrer KF, Austin T. A regional approach to the early management of infants with hypoxic-ischaemic encephalopathy in the United Kingdom. *Presentation at Neonatal Society meeting, London, UK, November 2011.*
- 6) Mitra S, O'Reilly H, Czosnyka M, Smielewski P, Austin T. A novel index to assess cerebrovascular reactivity in preterm infants. *Presentation at Neonatal Society meeting, London, UK, November 2011.*
- 7) Walston FE, Baron MK, Farrer KF, Austin T. A regional approach to the early management of infants with hypoxic-ischaemic encephalopathy in the United Kingdom. *Poster presentation at the Pediatric Academic Societies meeting, Boston, USA, April 2012.*
- 8) Mitra S, O'Reilly H, Czosnyka M, Smielewski P, Austin T. A novel index to assess cerebrovascular reactivity in preterm infants. *Poster presentation at the Pediatric Academic Societies meeting, Boston, USA, April 2012.*
- 9) Walston FE, Baron MK, Crowhurst W, O'Mara C, Clarke P, Shanmugalingam S, Austin T. Development of a regional neonatal neuroprotection service in the UK. *Poster presentation at the International Forum of Quality and Safety in Healthcare, Paris, June 2012.*
- 10) Gangadharan V, Mitra S, O'Reilly H, Austin T, Gibson AP. Improving specificity of clinical event detection in the neonatal intensive care unit. *Poster presentation at European Academy of Paediatric Societies meeting, Istanbul, Turkey, October 2012.*
- 11) Chaudhary R, Broster S, Farrer KF, T. Austin. Active versus passive cooling during neonatal transfer. *Presentation at the Neonatal Society meeting, London, UK, November 2012.*
- 12) Costa CS, Mitra S, O'Reilly H, Czosnyka M, Smielewski P, Pickard JD, Austin T. Defining optimal blood pressure based on a novel cerebrovascular regulation index in preterm infants. *Presentation at the Neonatal Society meeting, Edinburgh, UK, June 2013.*
- 13) Costa CS, Mitra S, O'Reilly H, Czosnyka M, Smielewski P, Pickard JD, Austin T. Defining optimal blood pressure based on a novel cerebrovascular regulation index in preterm infants. *Presentation at the European Society for Paediatric Research, Porto, Portugal, October 2013.*
- 14) Dempsey L, Lee CW, Cooper RJ, Singh H, Bridadoi S, Edwards AD, Hebden JC, Austin T. Assessment of neurovascular coupling in neonates using simultaneous DOI and EEG. *Presentation at the European Society for Paediatric Research, Porto, Portugal, October 2013.*
- 15) Dassios T, Austin T. Respiratory function parameters in ventilated newborn infants undergoing whole body hypothermia. *Presentation at the European Society for Paediatric Research, Porto, Portugal, October 2013.*
- 16) Pal S, O'Hare SS, Austin T. Post-haemorrhagic ventricular dilatation in preterm infants: interventions and outcomes in a UK neurosurgical centre. *Presentation at the European Society for Paediatric Research, Porto, Portugal, October 2013.*
- 17) Lee CW, Dempsey L, Cooper RJ, Singh H, Edwards AD, Hebden HC, Austin T. Developing a new clinical tool to diagnose seizures in the newborn. *Presentation at SET for Britain 2014. Houses of Parliament, London, UK, March 2014.*
- 18) Cooper RJ, Singh H, Lee CW, Dempsey L, Edwards AD, Everdell NL, Austin T, Hebden JC. Diffuse optical imaging of neonatal seizures. *Presentation at Optical Society of America (Biomed) Meeting, Miami, USA, April 2014.*
- 19) Lee CW, Austin T, Cooper RJ, Dempsey L, Edwards AD, Hebden JC, Singh H. Investigating neurovascular coupling in infants with brain injury and seizures. *Presentation at Human Brain Mapping Meeting, Hamburg, Germany, June 2014.*
- 20) Lee CW, Dempsey L, Cooper RJ, Singh H, Brigadoi S, Edwards AD, Hebden HC, Austin T. Behaviour and resting-state activity in newborns (BRAIN) study. *Presentation at the 14th World Congress of Infant Mental Health, Edinburgh, UK, June 2014.*
- 21) Singh H, Cooper RJ, Lee CW, Dempsey L, Edwards AD, Everdell NL, Austin T, Hebden JC. Cerebrovascular interactions in the neonatal brain during seizures. *Presentation at the International Society on Oxygen Transport to Tissue, London, UK, June 2014.*
- 22) Cooper RJ, Powell S, Dempsey L, Arridge SR, Hebden JC. *Time Resolved Whole-Head Diffuse Optical Tomography: How Fast Can We Go? Poster at fNIRS 2014, Montreal, Canada, October 2014.*
- 23) Ng I, Costa CS, Stevenson GN, Austin T. Determining the relationship between thresholds of cerebral tissue oxygenation and adverse outcomes in preterm infants. *Presentation at the Neonatal Society, London, November 2014.*
- 24) Ng I, Costa CS, Stevenson GN, Austin T. Determining the relationship between burden of deviations of cerebral tissue oxygenation and adverse outcomes in preterm infants. *Presentation at the Royal Medical Society Student Conference, Edinburgh, March 2015.*
- 25) Lee CW, Cooper R, Dempsey L, Chalia M, Brigadoi S, Everdell N, Hebden J, Austin T. Diffuse optical imaging of resting state functional connectivity in infants. *Poster at Cambridge Neuroscience Seminar: The Making and Breaking of the Mind, March 2015.*
- 26) Dempsey L, Cooper R, Powell S, Edwards A, Lee CW, Brigadoi S, Everdell N, Arridge S, Gibson A, Austin T, Hebden J. Whole-head functional brain imaging of neonates at cot-side using time-resolved diffuse optical tomography. *Oral presentation at European Conference on Biomedical Optics, June 2015.*
- 27) Chalia M, Cooper R, Dempsey L, Lee CW, Edwards A, Michell A, Brigadoi S, Everdell N, Hebden J, Austin, T. Investigating the neurovascular coupling of burst suppression in infants with hypoxic ischaemic encephalopathy. *Poster at Cambridge*

Neuroscience Symposium: Imaging the Nervous System, September 2015.

- 28) Dempsey L, Cooper R, Powell S, Edwards A, Lee CW, Brigadoi S, Everdell N, Arridge S, Gibson A, Austin T, Hebden J. Time-resolved diffuse optical tomography for cot-side neonatal functional brain imaging. *Poster at Cambridge Neuroscience Symposium: Imaging the Nervous System, September 2015.*
- 29) Lee CW, Cooper R, Chalia M, Dempsey L, Brigadoi S, Everdell N, Hebden J, Austin T. Imaging auditory function in the newborn brain. *Poster at Cambridge Neuroscience Symposium: Imaging the Nervous System, September 2015.*
- 30) da Costa CS, Czosnyka M, Smielewski P, Stevenson G, Kemp C, Austin T. Optimal mean arterial blood pressure in preterm infants less than 24 hours of age. *Oral presentation at the Joint European Neonatal Societies meeting (ESPR), Budapest, Hungary, September 2015.*
- 31) Stevenson G, da Costa CW, Czosnyka M, Smielewski P, Austin T. A prospective study into the generation of individualised optimal mean arterial blood pressure (MABP) measurements using near-infrared spectroscopy (NIRS) in the preterm neonate. *Oral poster presentation at the Joint European Neonatal Societies meeting (ESPR), Budapest, Hungary, September 2015.*
- 32) Lee CW, Cooper RJ, Dempsey LA, Chalia M, Brigadoi S, Everdell N, Hebden JC, Austin T. Diffuse optical imaging of resting state functional connectivity in infants. *Oral poster presentation at the Joint European Neonatal Societies meeting (ESPR), Budapest, Hungary, September 2015.*
- 33) Chalia M, Cooper RJ, Dempsey L, Edwards AD, Lee CW, Brigadoi S, Everdell N, Hebden JC, Austin T. Prospective study of the cerebral haemodynamic correlate of burst suppressed or discontinuous electroencephalographic activity in hypoxic-ischaemic encephalopathic infants. *Poster presentation at the Joint European Neonatal Societies meeting (ESPR), Budapest, Hungary, September 2015.*
- 34) Chalia M, Cooper RJ, Lee CW, Edwards AD, Michell A, Dempsey L, Brigadoi S, Everdell N, Hebden J, Austin T. Prospective study of the cerebral haemodynamic response of burst suppressed or discontinuous electroencephalographic activity in infants with hypoxic ischaemic encephalopathy. *Poster presentation at the 9th International Conference of Brain Monitoring and Neuroprotection in the newborn (BMN), Cork, Ireland, October 2015.*
- 35) da Costa CS, Stevenson G, Smielewski P, Czosnyka M, Ng I, Cabella B, Austin T. *Determining the relationship between thresholds of cerebral hypoxia and adverse outcome in preterm infants. Poster presentation at the 9th International Conference of Brain Monitoring and Neuroprotection in the newborn (BMN), Cork, Ireland, October 2015.*
- 36) Lee CW, Cooper RJ, Dempsey LA, Chalia M, Brigadoi S, Everdell N, Hebden JC, Austin T. Diffuse optical imaging of resting state functional connectivity in infants. *Oral presentation at the 9th International Conference of Brain Monitoring and Neuroprotection in the newborn (BMN), Cork, October 2015.*
- 37) da Costa CS, Czosnyka M, Smielewski P, Stevenson G, Austin T. Optimal mean arterial blood pressure in preterm infants less than 24 hours of age. *Oral presentation at World Congress of Perinatal Medicine, November 2015.*
- 38) Chalia M, Cooper RJ, Lee CW, Dempsey L, Edwards AD, Michell A, Brigadoi S, Everdell N, Hebden J, Austin T. Investigating the cortical haemodynamic response of burst suppressed or discontinuous electroencephalographic activity in infants with hypoxic-ischaemic encephalopathy. *Oral presentation at Neonatal Society, London, November 2015.*
- 39) Lee CW, Cooper RJ, Dempsey LA, Chalia M, Brigadoi S, Everdell N, Hebden JC, Austin T. Diffuse optical imaging of resting state functional connectivity in infants. *Oral presentation at Neonatal Society, London, November 2015.*
- 40) Lee CW, Lloyd-Fox S, Blasi A, Chalia M, Hebden JC, Cooper RJ, Austin T. Imaging early auditory function in the newborn brain using diffuse optical imaging. *Poster presentation at the Anglo-French Neonatal Society Meeting, Cambridge, June 2016.*
- 41) da Costa CS, Placek MM, Czosnyka M, Smielewski P, Cabella B, Kaspruwicz M, Austin T. Complexity of brain signals is associated with outcome in preterm infants. *Oral presentation at the Anglo-French Neonatal Society Meeting, Cambridge, June 2016.*
- 42) Chalia M, Cooper RJ, Lee CW, Dempsey L, Hebden JC, Austin T. Can diffuse optical tomography provide early detection of perinatal arterial ischaemic stroke (PAIS) at the cot side? *Oral presentation at the Anglo-French Neonatal Society Meeting, Cambridge, June 2016.*
- 43) Dempsey L, Cooper RJ, Chalia M, Powell S, Lee CW, Edwards AD, Everdell NL, Airantzis D, Michell A, Gibson A, Arridge S, Austin T, Hebden JC. Time-resolved diffuse optical tomography of the infant brain during neuropathological events and passive arm movements. *Oral presentation at fNIRS Meeting, Paris, October 2016.*
- 44) Lee CW, Chalia M, Dempsey L, Austin T, Cooper RC. Investigating superficial layer effects of fNIRS signals in the term-age infant. *Poster presentation at fNIRS Meeting, Paris, October 2016.*
- 45) Costa CS, Placek MM, Czosnyka M, Cabella B, Kaspruwicz M, Austin T, Smielewski P. Complexity of brain signals is associated with outcome in preterm infants. *Poster presentation at fNIRS Meeting, Paris, October 2016.*
- 46) Chalia M, Cooper RJ, Lee CW, Dempsey LA, Hebden JC, Austin T. Can diffuse optical tomography provide early detection of perinatal arterial ischaemic stroke at the cotside. *Poster presentation at fNIRS Meeting, Paris, October 2016.*

