Cambridge Centre for
Perinatal Neuroscience

neoLAB
infant functional brain imaging
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Diffuse Optical Imaging of Resting State Functional Connectivity in Infants

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INTRODUCTION

The growing number of surviving preterm infants has led to an emerging public health problem as these children face lifelong disability.

Subtle changes of preterm brain injury can be missed by conventional structural brain-imaging methods.

Functional brain imaging methods can be used to evaluate spontaneous brain activity known as resting state functional connectivity (RSFC) that could provide an early biomarker of brain development to facilitate timely neuroprotective strategies to optimise neurodevelopmental potential.

DIFFUSE OPTICAL IMAGING (DOI)

DOI is a safe and non-invasive functional brain-imaging modality that uses near-infrared light to produce images of cerebral haemodynamics. The system is silent and does not require sedation of infants making it ideal for serial monitoring of sick infants at the cot-side.

The NTS optical topography system (Gowerlabs, London, UK), is a multichannel DOI device that uses 16 pairs of light emitting sensors (780nm and 850nm) and 16 light detectors which are placed on the head over areas of interest.

The system has been used by the neoLAB group (Cambridge Centre for Perinatal Neuroscience and University College London Biomedical Optics Research Laboratory collaboration) to study RSFC in the developing brain.

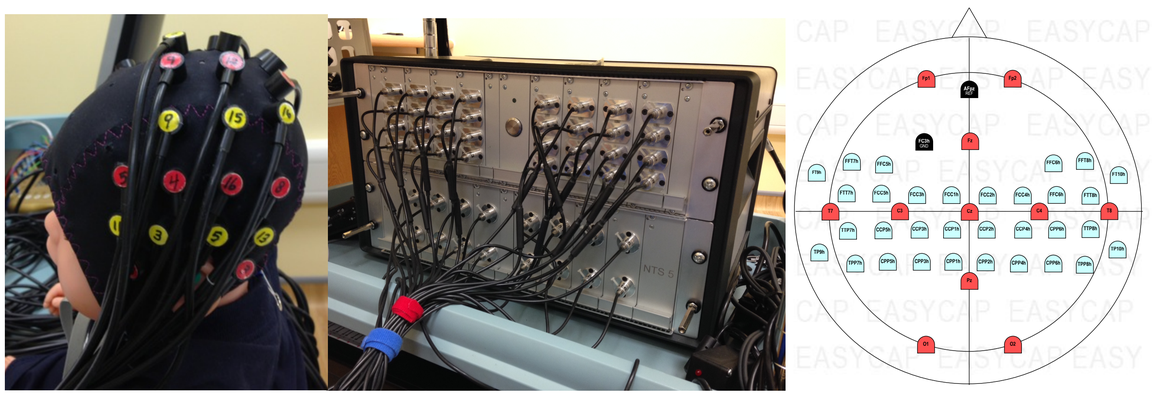

Figure 1: a. *A cap (EasyCap, Germany) is used to hold the optical sensors on the head, red: light emitting sensors, yellow: light detectors (left)*; b. The *NTS Optical Topography system, GowerLabs, London (middle); c. The cap design layout of the DOI sensors (blue) defined using the international 10-5 positions (right).*

METHODS

DATA COLLECTION: 19 healthy term infants were recruited from the postnatal ward in the Rosie Hospital, Cambridge University Hospitals NHS Foundation Trust. Infants were scanned for 1 hour, while asleep after a feed, in a quiet, dimly lit room in the Evelyn Perinatal Imaging Centre, Rosie Hospital. A bespoke cap (EasyCap, Germany) was used to hold the DOI sensors over the temporal and sensorimotor regions of the head.

ANALYSIS: DOI images of oxyhaemoglobin concentration changes were reconstructed using an age appropriate neonatal head atlas[1] and a multispectral approach with the TOAST forward modelling and image reconstruction package[2] .

Seed-based analysis and Pearson's cross correlation coefficient r were used to identify RSFC temporal and premotor networks in the functional connectivity frequency range 0.009 – 0.08Hz. Correlation coefficient r values were normalised using the Fisher Z transformation for group analysis. The inverse mean Z-scores produced mean r values that were used to create group images.

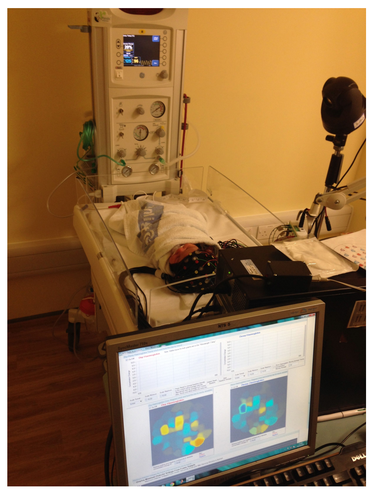

Figure 2: *A DOI scan of an infant in the Evelyn Perinatal Imaging Centre, Roise Hospital*

RESULTS

DOI images were reconstructed from a total of 15 subjects (median gestational age at birth: 40 weeks). Four subjects were excluded due to motion artifacts in their data. DOI scans were performed within the first week of life (mean: 2 days). Group analysis revealed bilateral RSFC resembling homotopic temporal and premotor networks (FIGURE 3).

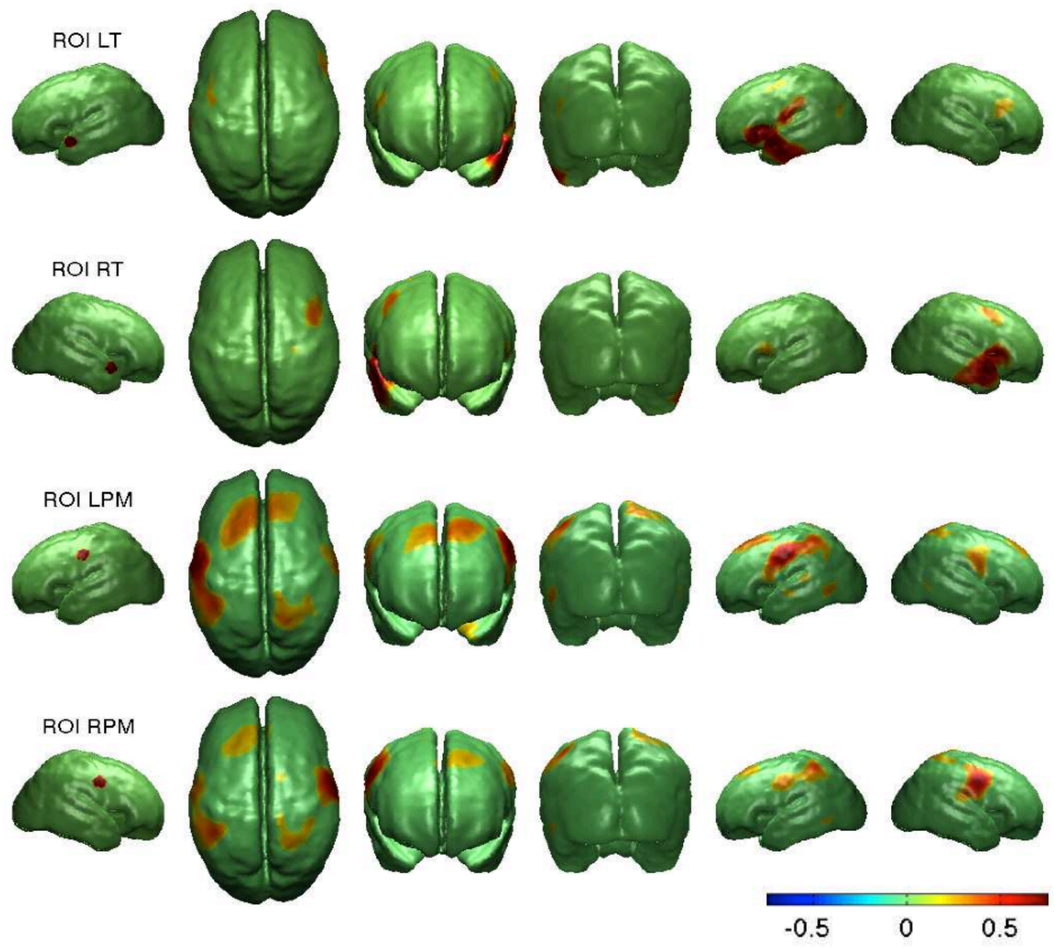

Figure 3: *Group images from N=15 subjects. The first column indicates the location of the 'region of interest' in red (ROI). Correlated regions are highlighted in orange-red colour along the corresponding row (colour threshold r > 0.2, colour bar is located at bottom right corner of figure). The image views for each column are: 2nd = caudal, 3rd = frontal, 4th = occipital, 5th = left temporal, 6th = right temporal. LT = left temporal; RT = right temporal; LPM = left premotor; RPM = right premotor.*

FUTURE WORK

Our work demonstrates the potential use of DOI as a clinical neuroimaging tool. We are currently imaging sick infants in the neonatal intensive care unit with brain injury (e.g. hypoxic ischaemic encephalopathy) and infants at risk of developing brain injury (e.g. extreme preterm infants).

Our next step is to develop a robust biomarker of brain function by combining DOI RSFC with resting-state EEG and imaging preterm infants longitudinally to complement clinical assessment of infant neurobehaviour.

References

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2. Arridge SR, Schweiger M, Hiraoka M, Delpy DT. 2000. A finite element approach for modeling photon transport in tissue. *Med. Phys.* 20(2 Pt 1):299–309

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