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neoLAB infant functional brain imaging
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Imaging Auditory Function in the Newborn Brain

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INTRODUCTION

Advances in neonatal care have led to increased survival rates of preterm births. Preterm infants are at risk of brain injury and developing motor, cognitive or behavioural impairment. Early diagnosis and safe monitoring remains a major challenge in this vulnerable patient group.

Functional neuroimaging methods can be used to evaluate mechanisms of brain injury and assess functional cerebral development. How the developing brain perceives auditory information can provide important information on early cerebral function and processing[1-3].

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 UCL Optical Imaging System, is a multichannel DOI device that uses 16 pairs of light emitting sensors (780nm and 850nm) and 16 light detectors via optical fibre optodes 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 infant brain function.

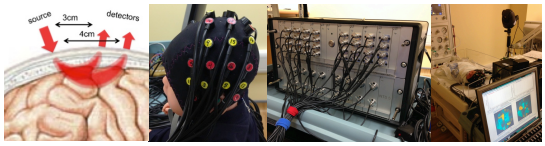


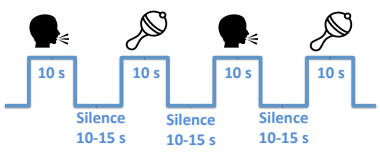
Figure 1 (from left): *a. Distribution of near-infrared light in the human brain at different source-detector distances in DOI[4]; b. A cap (EasyCap, Germany) is used to hold source and detector optodes on the head, red: light emitting sensors, yellow: light detectors;* c. The *NTS Optical Topography system (GowerLabs, London); d. A DOI scan of an infant in the Evelyn Perinatal Imaging Centre, Rosie Hospital.*

DATA COLLECTION

23 healthy term infants were recruited from the postnatal ward in the Rosie Hospital, Cambridge University Hospitals NHS Foundation Trust. Infants were scanned while asleep or at rest 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 to measure response to auditory stimuli.

Infants were presented vocal and non-vocal auditory stimuli as illustrated in the diagram below (figure 2). The volume of background noise during silence periods was ~30dB and during stimuli 55-60dB.

Figure 2 : *DOI auditory function experiment setup*



Vocal Stimuli: combination of coughing, laughing, crying (X4 different recordings)

Non-Vocal Stimuli: combination of rattle, bell, running water (x4 different recordings)

IMAGE RECONSTRUCTION

Mean regional changes in total haemoglobin (HbT = HbO and HbR) in response to each stimulus type were calculated for 5 seconds preceding and 10 seconds after the stimulus. Using a gestational age-matched head atlas, structurally registered images of the mean cortical HbT changes were reconstructed using a multispectral approach with the TOAST forward modelling and image reconstruction package[4] .

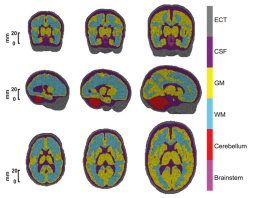


Figure 3: *Multilayered volumetric tetrahedral meshes from average MRIs at 29, 35 and 44 weeks PMA[5].*

RESULTS

DOI images were reconstructed from a total of 21 subjects (median gestational age at birth: 40 weeks). Motion affected trials were excluded from each subject. Two subjects were excluded due to severe motion artifact in their data. DOI scans were performed within the first week of life (mean: 2.5 days, range: 1-6 days). Group DOI images show an increase in HbT mainly over the temporal regions in response to auditory stimuli. Presenting non-vocal sounds demonstrated a delayed response compared to vocal sounds.

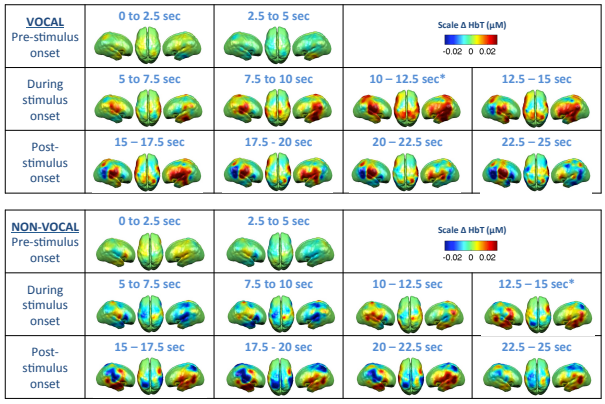


Figure 4: *Group images from N=21 subjects. Images reconstructed in 2 sec windows for the HbT signal relative to a baseline defined as the mean period 5 seconds prior to the Vocal or Non-Vocal stimuli. *Indicates time window of maximum increase in HbT response.*

FUTURE WORK

Our work demonstrates the potential use of DOI as a clinical neuroimaging tool. Further analysis will investigate response differences to each stimulus type. Moving forward, we are using DOI with EEG to image brain function in infants with brain injury to assess neurodevelopment.

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