Using multi-modal neuroimaging to characterise social brain specialisation in infants

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Introduction

- Interactive specialisation posits that functional specialisation emerges through a competition between brain regions[1]

- Functional specialisation is typically indexed through **unitary** imaging modalities focusing on

Spatial selectivity
Measuring changes in oxygenated blood using fNIRS and fMRI

OR

Temporal selectivity
Measuring neural activity using EEG

- **Energetic constraints** (such as energy metabolism) may also contribute to the emergence of functional specialisation, this requires the investigation of

Coupling between neuronal demand and energetic supply

Introduction

- Broadband near-infrared spectroscopy (bNIRS) can be used to obtain measurements of **changes in redox state of mitochondrial enzyme cytochrome-c-oxidase (oxCCO)** thereby providing measures of ***cellular energy metabolism***, alongside changes in haemodynamics.

- In this study, we performed **simultaneous bNIRS and EEG** measurements in 4-to-7-month-old infants to investigate

Neurovascular coupling (coupling between neural oscillations and haemodynamic activity)

Neurometabolic coupling (coupling between neural oscillations and metabolic activity)

- We expected differential coupling between neural oscillatory activity, haemodynamic and metabolic activity, modulated by naturalistic social content.

Methods

- 42 **typically developing (TD)** infants; 4-to-7-months old

- **Social** Experimental condition (8-12s):
  - Videos of women singing nursery rhymes; “incy-wincy spider” and “wheels on the bus”
- **Non-social** Experimental condition (8-12s):
  - Videos of mechanical toys

- Baseline consisted of static transport images e.g. cars (8-9s)

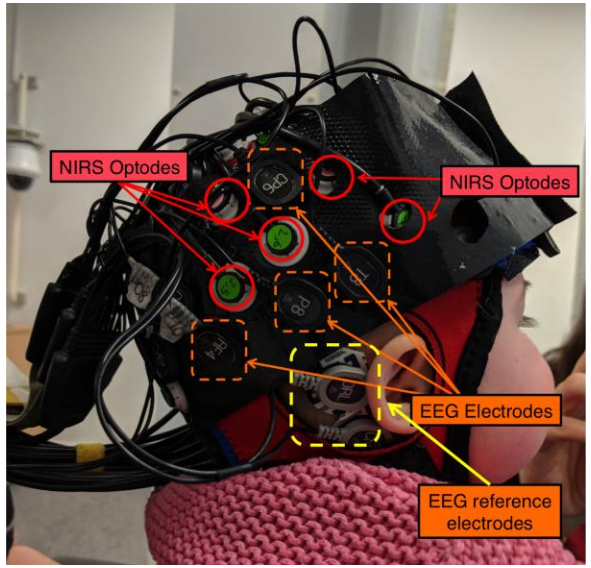
Methods

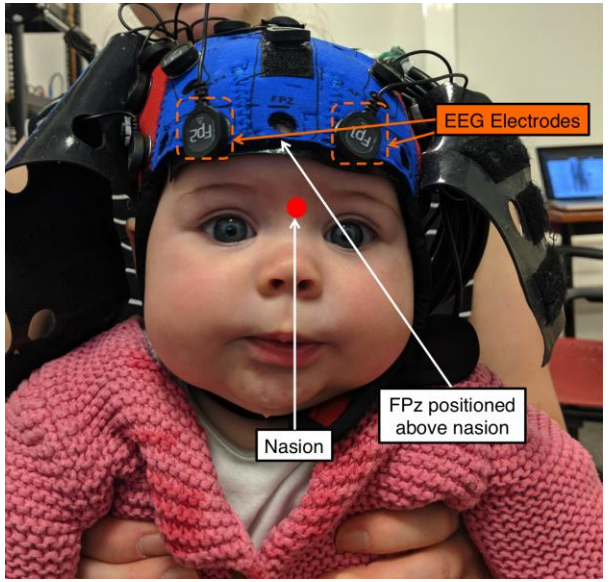
- **UCL multi-channel broadband NIRS system[2]** with 19 channel – 10 channels over the occipital cortex, 9 channels over the right hemisphere (s/d 2.5 cm, sampling rate 1s, 120 wavelengths between 780 – 900 nm)

- **Neuroelectrics Enobio wireless 32 channel EEG** system

- Custom-built headgear containing bNIRS optodes and EEG electrodes.

- bNIRS array positioned over the right hemisphere, according to a NIRS-MRI co-registration map[3]

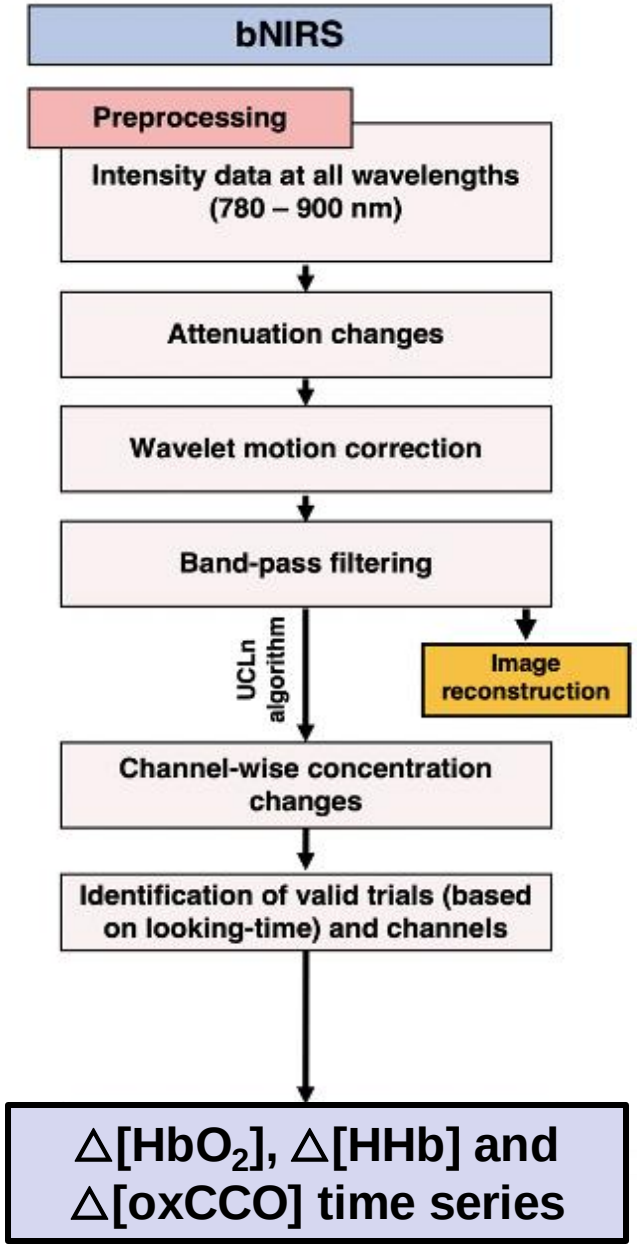




[2]Phan et al, 2016 (Biomedical Optics Express)

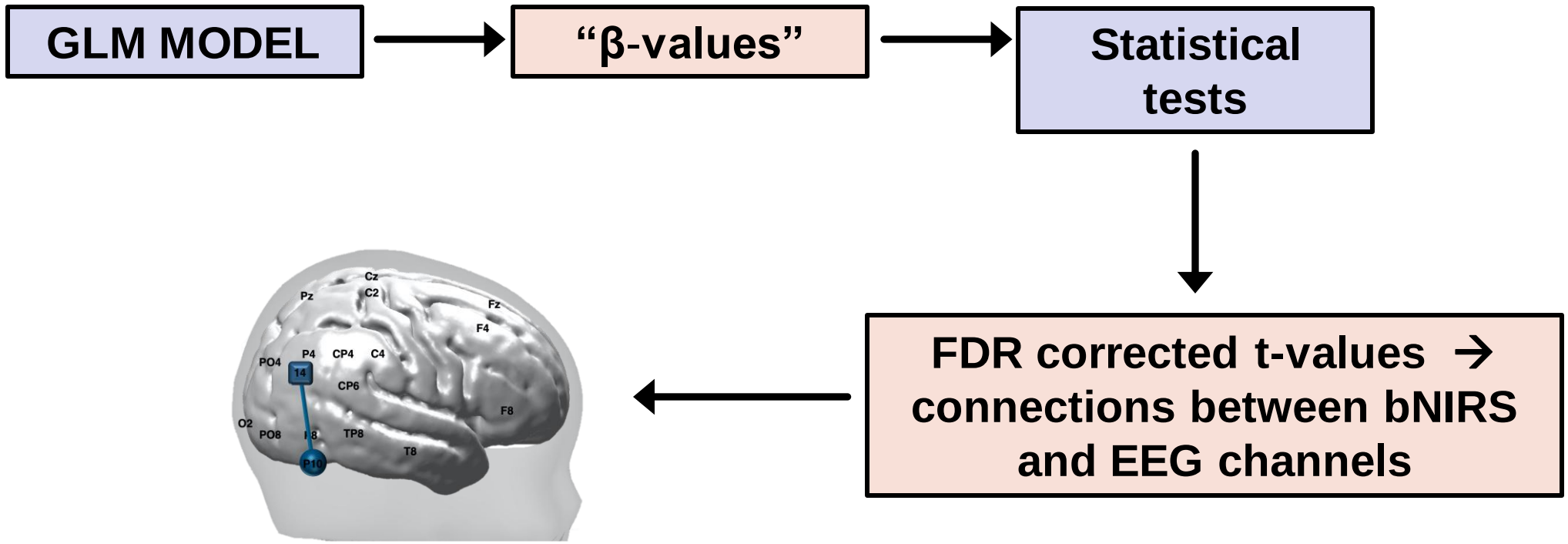
[3]Lloyd-Fox et al, 2014 (Neurophotonics)

Data analysis



Combined bNIRS – EEG

- **GLM approach**

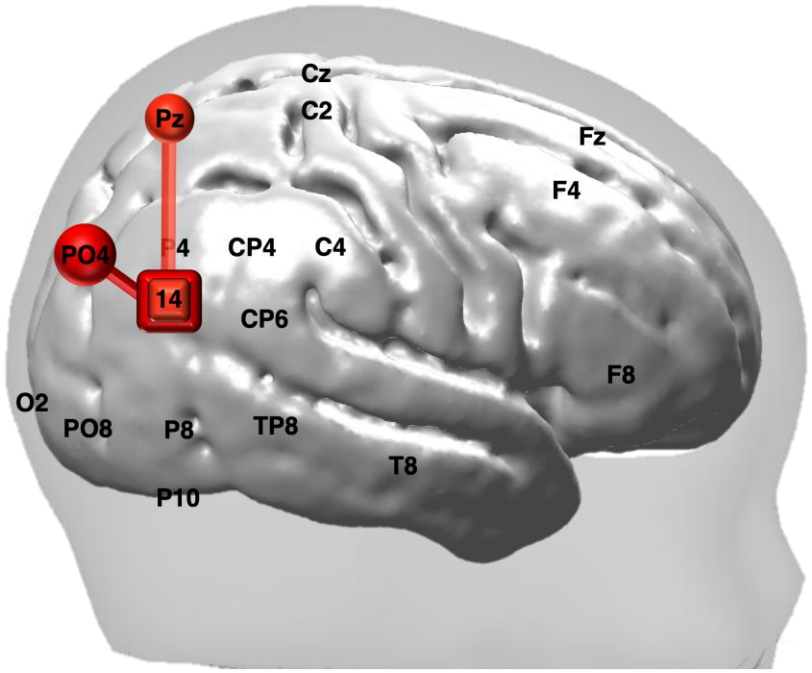


- Model applied for each frequency band (theta, alpha, beta & gamma), for each bNIRS signal (HbO_2, HHb and oxCCO), between each bNIRS channel and EEG electrode (over the right hemisphere)

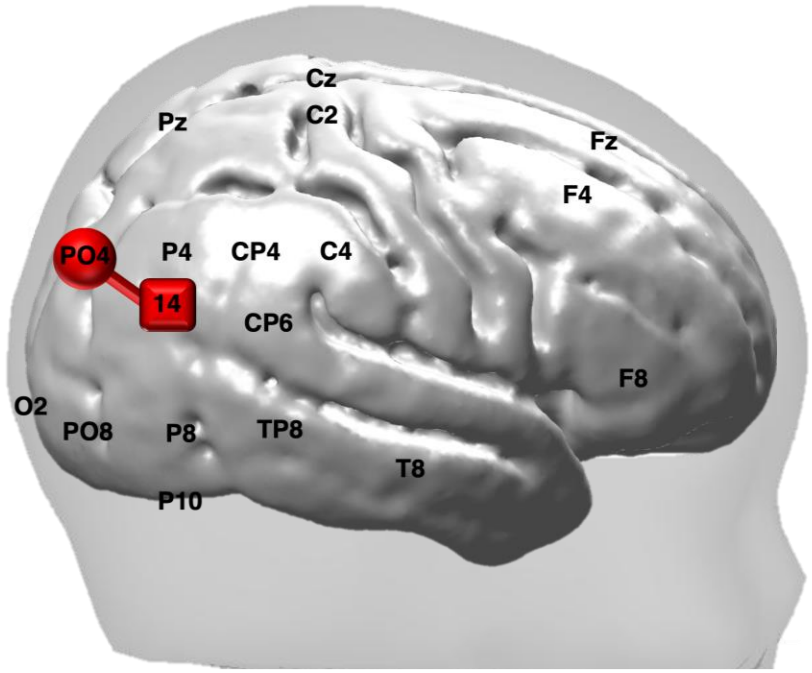
Results - Social

Gamma power

HbO_2



oxCCO

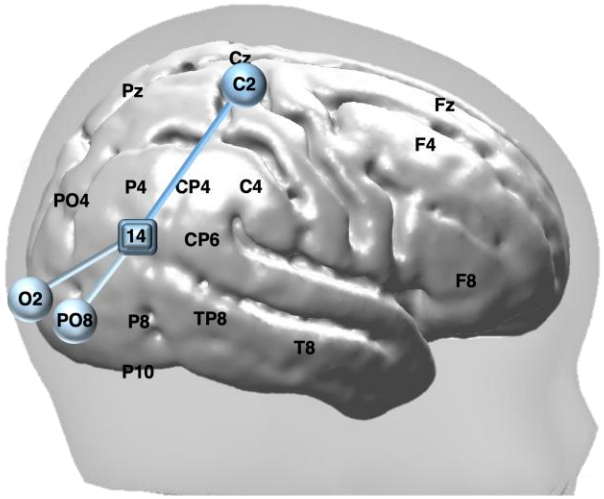


Significant **coordinated increase** in ***gamma power*** and ***HbO_2 & oxCCO*** over the ***temporo-parietal region***

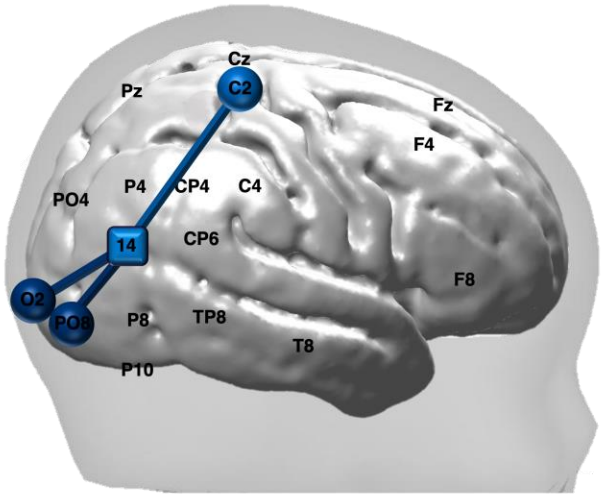
Results – Non-social

Beta power

HHb



oxCCO



Significant **coordinated increase** in ***beta power*** and ***HHb & oxCCO*** over the ***parieto-occipital region***

Conclusion

- Performed simultaneous bNIRS and EEG in 4-to-7-month-old infants during functional activation
- Demonstrated task- and frequency-dependent coupling between neural oscillatory activity, haemodynamics and metabolism.
- This is a novel approach critical for advancing our understanding of early brain physiology and cognitive function.

Thank you for listening!

Poster: Using multi-modal neuroimaging to characterise social brain specialisation in infants

Full publication:

SCAN ME

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